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Litter balance in areas of *Eucalyptus urograndis* (Clone H13) in a Cerrado–Amazon transition of Mato Grosso state, Brazil

Balanço de serrapilheira em áreas de Eucalyptus urograndis (Clone H13) na transição Cerrado-Amazônia de Mato Grosso

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Abstract

The growing demand for products of forest origin in the middle north region of Mato Grosso, Brazil has been increasing the production of the genus eucalyptus. This study aimed to assess the deposition and decomposition rates of litter at the central plot areas of Eucalyptus urograndis (Clone H13) areas of three, five, seven and nine years of age. In five and seven-year areas, the interfaces (borders) eucalyptus–crop and eucalyptus–native forest, and further, native forest remnant areas were assessed. Litter collectors with 1 m2 area were installed and the deposited material was collected monthly. For quantifying the decomposition rates, collections were carried out at 30, 60, 120, 180, 240, and 300 days after installing the decomposition bags. In the dry season, higher amounts of deposited litter were observed, with a greater representation of the leaf fraction. Bark fraction presents positive and negative correlations with wind speed and relative air humidity, respectively. The litter balance found indicates that even under a tropical climate, high deposition rates occur when compared to the litter decomposition of E. urograndis, allowing significant increases of litter in planted areas as the age increased.

Keywords: *Litter deposition. Decomposition. Litter bags. Climatic variables.*

Resumo

A crescente demanda por produtos de origem florestal vem proporcionando o crescimento da produção do gênero eucalipto. Em áreas com implantação recente, como o médio Norte de Mato Grosso, ainda é necessário conhecer os processos que regulam a serrapilheira em florestas plantadas. Objetivou-se avaliar as taxas de deposição e decomposição de serapilheira em áreas com Eucalyptus urograndis (Clone H13) aos três, cinco, sete e nove anos de idade, nas áreas centrais dos talhões. Nas áreas de cinco e sete anos, também foram avaliadas as interfaces (bordaduras) eucalipto/lavoura e eucalipto/mata nativa, e, ainda, áreas com remanescente de mata nativa. Foram instalados coletores de serrapilheira com 1m² de área, com coletas mensais do material depositado. Na quantificação das taxas de decomposição as coletas ocorreram aos 30, 60, 120, 180, 240 e 300 dias após a instalação dos litterbags (bolsas de decomposição). Na estação seca, foram observadas maiores quantidades de serapilheira depositada, com maior representação pela fração folha. A fração casca apresenta correlações positivas e negativas com a velocidade do vento e a umidade relativa do ar, respectivamente. O balanço de serrapilheira encontrado na região de transição Cerrado-Amazônica indica que mesmo possuindo um clima tropical, ocorrem altas taxas de deposição quando comparados com a decomposição da serrapilheira de E. urograndis, permitindo incrementos significativos da serrapilheira das áreas plantadas com o aumento da idade.

Palavras-chave: *Deposição de serapilheira. Decomposição. Bolsas de decomposição. Variáveis climáticas.*

1 introduccíon

In Mato Grosso State, Brazil, one of the main drivers of creation, emancipation, and establishment process of the existing cities have been the forestry sector, which has promoted the economic growth and local social development. Along with this activity, forest areas were destined for extensive cattle raising and subsequently for agriculture.

Although the numbers of the State's timber sector have suffered a significant reduction in recent years due to a reduction in native forest areas (MACEDO & ANUNCIATO, 2013), a significant increase in planted forest areas has been observed. The greatest highlight is the species of the genus *Eucalyptus*, which has been gaining space due to its easiness of adaptation in the region and diversity of products and purposes.

A growth of 23% in the planted eucalyptus area was observed between 2010 and 2015 in Mato Grosso State, increasing from 150,646 to 185,219 ha (INDÚSTRIA BRASILEIRA DE ÁRVORES, 2016). The main possibilities for using this genus are the production of paper and cellulose, biofuels, fiber and chipboards panels, plywood, lumber, essential oils, among others. However, its main use in the State can be considered the generation of heat for drying grains and in the food industry.

In addition to this potential, soil benefits are brought by growing this plant genus, which positively affects the physical, chemical (fertility), and biological characteristics of the soil by means of litter deposition, promoting a reduction in fertilizer costs. According to *Companhia Nacional de Abastecimento* (2016), the highest expenditure in the agricultural production between the 2007/08 and 2015/16 crop seasons was with fertilizers (27.82%), surpassing the expenses with agrochemicals, seeds, among others. Part of this behavior is due to differences between the nutritional efficiency of agricultural species and arboreal species.

In forest areas, one of the natural mechanisms of regulation and maintenance of soil fertility is the continuous decomposition of plant material through the positive litter balance over time, thus allowing nutrient cycling and its availability for the respective forest stand (FREITAS et al., 2013).

The litter consists of senescent materials from the aerial part of plants, being its main fractions leaves, branches, barks, flowers, and fruits. The release of these materials by plants can occur due to dispersion mechanisms, strategies to reduce water losses during the warmest periods (water stress) (ALONSO et al., 2015), and the action of abiotic factors such as wind gusts and lightning, among others. Studies on the correlation between litter deposition rates and climatic variables have been performed for the South (SCHUMACHER et al., 2013; VIERA et al., 2014), Southeast (CALDEIRA et al., 2013), and North (BARLOW et al., 2007) regions of Brazil.

Given the importance gained by genus *Eucalyptus* in Mato Grosso State and its contribution to the improvement of soil chemical and physical characteristics through organic matter deposition, as well as the information scarcity on the edaphoclimatic conditions of the Cerrado–Amazon transition region, the aim of this study was to assess the litter balance in *Eucalyptus urograndis* (Clone H13) plantations with different ages and environmental interfaces.

2 Materials and methods

2.1. Characterization of the experimental area

The experiment was carried out in three, five, seven, and nine-year-old *Eucalyptus urophylla* × *Eucalyptus grandis* (Clone H13) hybrids located in plot areas belonging to Brasil Foods S.A. located in Sorriso and Lucas do Rio Verde, Mato Grosso State, Brazil (Figure 1).

The deposition and decomposition rates were assessed at the central plot of three (EE), five, seven, and nine-year eucalyptus stands. In five and seven-year areas (average age of eucalyptus harvesting in the region), both rates were also assessed in the eucalyptus–crop (EC) and eucalyptus–native forest (EF) interfaces (borders), having as reference native forest remnant areas (F).

According to Köppen classification, the regional climate is a warm and humid climate (Aw), with average monthly temperatures above 18 °C and well-defined dry (May to September) and rainy seasons (October to April), predominating summer rains (SOUZA et al., 2013). Total precipitation, monthly averages of temperature and relative air humidity (Table 1), and daily rainfall (Figure 2) were obtained from an automatic weather station model ITWH–1080, installed with a maximum distance of 30 km between experimental areas.

Figure 1 – Map of location of experimental plots

Table 1 – Meteorological data of the study areas during the experimental period

Period	Max. T. (ºC)	Min. T. (ºC)	Avg. T. (ºC)	Max. RH (%)	Min. RH (%)	Avg. RH (%)	Rainfall (mm)
Sep./15	41.0	16.9	28.4	97	10	56	42.6
Oct./15	41.0	18.0	27.7	98	10	69	95.1
Nov./15	40.3	19.9	27.0	99	11	77	128.1
Dec./15	37.9	19.7	27.0	99	32	78	188.1
Jan./16	31.1	21.2	24.8	96	71	89	437.4
Feb./16	36.3	19.2	26.3	96	39	81	102.8
Mar./16	35.6	21.6	25.6	96	50	87	445.2
Apr./16	36.2	14.1	25.7	97	47	83	95.4
May./16	35.5	17.4	25.3	97	36	77	0.0
Jun./16	35.6	13.3	23.9	97	30	73	24.0
Jul./16	36.4	12.4	23.7	98	23	61	0.0
Aug./16	37.5	13.0	25.1	96	19	64	29.8
Sep./16	36.5	13.7	23.7	93	34	72	14.6
Annual	**37.0**	**17.0**	**25.7**	**97**	**32**	**74**	**1603.1**

T: temperature; and RH: relative humidity

In each plot, tree height was measured by using a clinometer and the circumference at chest height was measured at 1.30 m (CCH–1.30 m) by using a tape measure. Subsequently, the volume per hectare (m^3 ha^{-1}) was estimated according to the equation proposed by Miranda et al. (2015) (Table 2). In addition, the percentage of the shaded area was measured with a convex densitometer.

Figure 2 – Daily precipitation in the study areas during the experimental period

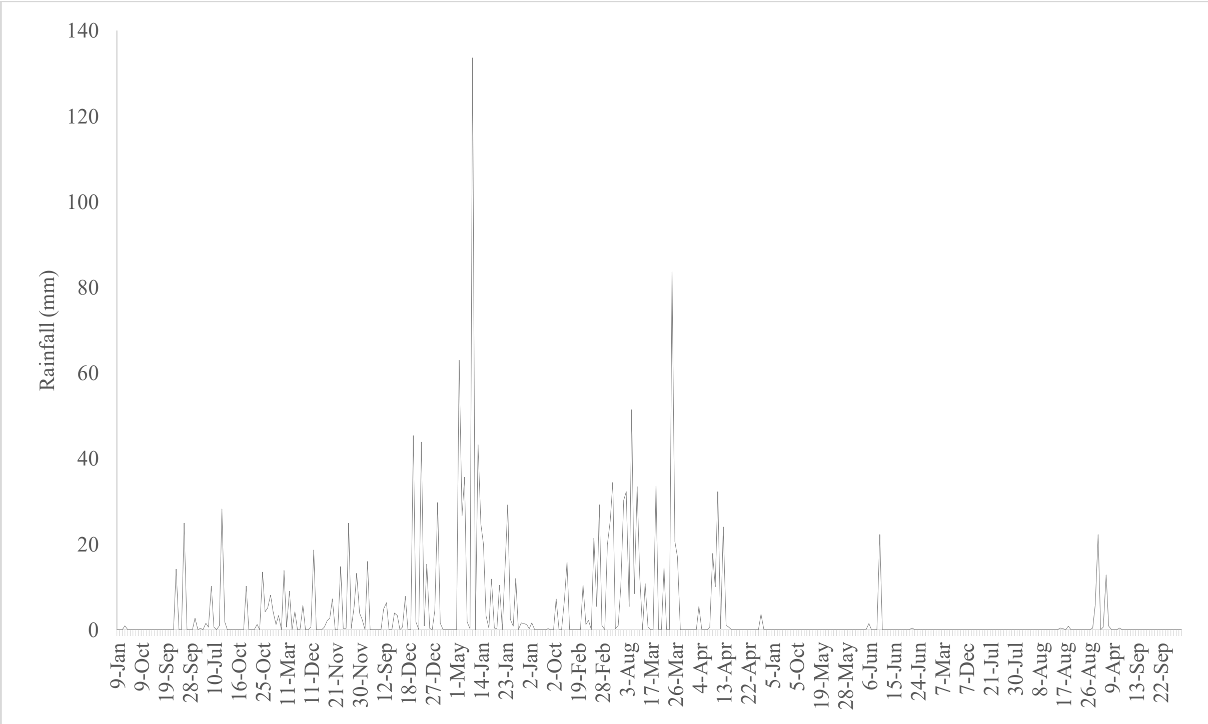


Table 2. Dendrometric parameters in areas of *E. urograndis* (Clone H13), in different ages and environment interfaces, in the transition region of Cerrado-Amazon, on 12/19/2015

Inventory data	Treatment							
	3 years	5 years	5 years	5 years	7 years	7 years	7 years	9 years
	EE	EC	EE	EF	EC	EE	EF	EE
Density (tree ha-1)	1140	920	1060	1220	320	540	570	800
Basal area (m²)	14.086	19.999	24.078	24.647	11.118	16.521	13.651	24.639
Volumetry (m³ ha-1)	104.22	239.04	288.04	292.59	126.05	182.39	139.29	357.50
Forest overstory density (%)	67.6	68.9	64.5	69.9	26.8	46.5	66.3	73.3

EE: eucalyptus-eucalyptus interface; EC: eucalyptus-crop interface; and EF: eucalyptus-native forest interface

2.2. Deposition study

Collectors made of polyolefin screens 50% shading with dimensions of 1.0 × 1.0 m were installed at 0.50 m above the ground. Four collectors were systematically distributed in demarcated plots of 50 × 20 m (sampling for inventory) on September 17, 2015 (spring).

Samples were collected monthly and all material was separated into leaves, barks, branches with a diameter of less than 0.7 cm (B1), and branches with a diameter between 0.7 and 2.4 cm (B2). This material was conditioned in paper bags properly identified, being subsequently dried in a forced air circulation oven at 65 °C until constant weight, measured in a high-precision balance (0.001 g). From the average values of monthly dry mass, the average annual litter production was estimated following the recommendations of Lopes et al. (2002).

2.3. Decomposition study

The decomposition rates were assessed in the same plots where the deposition study was carried out, being used the methodology of litterbags made of polyolefin screens 50% shading with dimensions of 0.20 × 0.40 m and mesh of 3 mm. In order to establish the relationships of pre-existing litter fractions in the experimental areas, on September 11, 2015 samples were collected randomly from the surface layer of litter, separating them according to the following fractions: leaves, barks, branches with a diameter of less than 0.7 cm (B1), and branches with a diameter between 0.7 and 2.4 cm (B2). These samples were dried in a forced air circulation oven at 65 °C until constant weight (Figure 3).

Subsequently, the proportions of 40, 20, and 40% (20, 10, and 20 g) for B1, B2, and leaves, respectively, were considered for the decomposition test. For this relationship, the initial characterizations in five and seven-year areas (including their environmental interfaces) were adopted as a reference. The analysis in five-year stands allowed the characterization in areas prior to harvesting (usually after seven years in the region). Exceptionally for native forest areas, litter was not separated into fractions, being the heterogeneous material of litter from the remnant forest added into litterbags.

The litterbags were installed in the planted areas on October 8, 2015, and collections were performed at 30, 60, 120, 180, 240, and 300 days after installation (DAI) with four replications per treatment. After the removal of litter bags from the field, soil particles adhered to the vegetal residues were removed. This material was dried in a forced air circulation oven at 65 °C until constant weight, thus obtaining the remaining dry mass.

In the analysis, we considered the different ages and environmental interfaces as treatments, subdivided in time, and with four replications. When significant, the differences between means were compared by the Tukey's test at 5% probability. For the Pearson's linear correlation (r) analysis between the different litter forming fractions in the different treatments and climatic variables, 1 and 5% probability levels were considered.

3 Results

3.1. Litter deposition

No significant difference was observed in litter production at the central stand positions (Table 3). Similarly, no significant difference was observed between the environmental interfaces in the five-year area. The interface EE presented numerically the highest production (8.28 Mg ha^{-1} year^{-1}) whereas the lowest production was observed in EF (7.46 Mg ha^{-1} year^{-1}). In seven-year areas, at nine months, the lowest accumulation occurred in EC (1.60 Mg ha^{-1} year^{-1}), not differing from the other interfaces. In native forest remnant areas, the annual litter production was 14.81 and 11.56 Mg ha^{-1} year^{-1}.

The obtained litter production is in accordance with the results found by other authors for different species of the genus Eucalyptus (CUNHA NETO et al., 2013; FREITAS et al., 2013; CORRÊA et al., 2013; INKOTTE et al., 2015). Schumacher et al. (2013) assessed the litter production for a two-year period in a stand of *E. urophylla* × *E. globulus* Maidenni with 5.6 years and found an average production of 7.44 Mg ha^{-1} year^{-1}. In a seven-year area of *E. grandis*, Balieiro et al. (2004) found a deposition of 11.84 Mg ha^{-1} year^{-1} whereas, in intercropping areas with the species *Pseudosamanea guachapele*, the authors obtained an accumulated litter production of 12.44 Mg ha^{-1} year^{-1}. Freitas et al. (2013) analyzed litter production in two agrosilvopastoral systems, one of them with corn, *E. urograndis*, *Acacia mangium*, and *Brachiaria* and the other with corn, *E. urograndis*, and *Brachiaria*, and found values of 4.45 and 4.22 Mg ha^{-1} year^{-1}, respectively.

Table 3 – Litter annual deposition of *E. urograndis* Clone H13, due to age and different environment interfaces and forest remnant, in the transition region of Cerrado-Amazon, between 09/17/2015 and 10/08/2016

Center of the stand				
Treatment	3 years EE	5 years EE	7 years EE	9 years EE
Total (Mg ha^{-1} year^{-1})	9.87a	8.28a	6.06*	8.06a
Different environment interfaces				
	5 years EC	5 years EE	5 years EF	5 years F
Total (Mg ha^{-1} year^{-1})	7.60ª	8.28a	7.46a	14.81
	7 years EC	7 years EE	7 years EF	7 years F
Total (Mg ha^{-1} year^{-1})	1.60b*	6.06a*	6.07a*	11.56

Means followed by the same letter in the line do not differ statistically from each other, by the Tukey test at the 5% probability level. *In the different interfaces of the seven-years planting, production was established after nine months, due to the harvest on August 2016

Between February and April, a high leaf fall was observed in the three-year area (Figure 4), justifying the high litter production. Perforations could be observed in the deposited leaves, which may also be an indicative of pest attack and not only an effect of the meteorological conditions. However, no further study was carried out on the type of pest responsible for the damage. Viera et al. (2014) assessed a stand of *E. urophylla* × *E. globulus* with 5.5 years in Eldorado do Sul - RS, Brazil, and found a positive correlation between litter production and planting age, being in accordance with the results found in our study.

In general, litter deposition presented a similar pattern in both water seasons of the region. At the central stand areas, higher depositions were observed in the dry season regardless of age, with a value of 4.56 Mg ha^{-1} $year^{-1}$ whereas, in the rainy season, the average deposition was 4.24 Mg ha^{-1} $year^{-1}$ (Figure 3). For five-year areas, a deposition of 4.53 and 3.25 Mg ha^{-1} $year^{-1}$ was observed during the dry and rainy seasons, respectively.

This distribution pattern is a strategy used by plants in response to water stress experienced during the dry season (May to September) since there is a decrease in leaf area in order to increase the water use efficiency by reducing the real evapotranspiration (LONGHI et al., 2011; TERROR et al., 2011; CALDEIRA et al., 2013; ALONSO et al., 2015). In addition, in order of magnitude, a higher deposition was observed for leaf fraction in the dry season considering all treatments. For the fractions bark and branches > 0.7 cm, the highest depositions occurred in the rainy season. However, no tendency of higher production of branches < 0.7 cm was observed in both seasons.

In seven-year interfaces, a high mortality of individuals due to phytosanitary problems (diseases) was observed mainly in EC, thus justifying the low litter production in this interface. The highest deposition rates of litter were registered in native forest remnant areas due to the higher species stage development. Longhi et al. (2011) studied litter production in three floristic groups of a forest in São Francisco de Paula, RS, Brazil and found deposition rates ranging from 7.02 to 8.35 Mg ha^{-1} $year^{-1}$. In Lages, SC, Brazil, Inkotte et al. (2015) found a litter production of 6.75 Mg ha^{-1} $year^{-1}$ in native forest areas. Considering the litter production in native forest areas in the Amazonian Biome, Barlow et al. (2007) found an annual production of approximately 10.5 Mg ha^{-1} $year^{-1}$. Almeida et al. (2015) found, in the Amazon-Cerrado transition areas, an average annual litter production of 9.90 Mg ha^{-1} $year^{-1}$, similarly to Sanches et al. (2009), who registered annual productions of 7.61 and 7.5 Mg ha^{-1} $year^{-1}$ in 2001 and 2003, respectively, in the same transition area.

Over the year, the leaf was the main litter forming fraction, corresponding to 52.99, 60.98, 43.27, and 55.46% of the total litter at the central plantation areas between three and nine years, respectively (Figure 4). Sequentially, at the central plot of three and five-year areas, branch fraction < 0.7 cm contributed with 26.82 and 15.74% of the total litter, respectively. Branches > 0.7 cm (28.26%) and bark (22.77%) were the second highest fraction observed for areas with seven and nine years, respectively. The distribution pattern of litter forming fractions over time has been studied by other authors and, in general, a higher participation of bark and branch fractions for litter produced has been observed from the fourth implantation year (BERNHARD-REVERSAT et al., 2001). Similarly, O'Connell & Menagé (1982) studied *E. diversicolor* with 2, 6, 9, and 40 years and observed a reduction in leaf fraction and an increase in branch and bark fractions as planting age increased.

In the different environmental interfaces in the five-year area, leaf fraction presented a variation from 51.76 to 60.99% for EF and EE, respectively (Figure 5), being branches < 0.7 cm the second most representative fraction regardless field position (15.74 and 18.71% for EE and EC, respectively). In the native forest remnant area, adjacent to five-year areas, leaf fraction represented 66.44% of the litter produced annually, followed by the fraction with branches < 0.7 cm, representing 16.86%.

For the different environmental interfaces with seven years, leaf fraction presented a variation from 43.27 to 55.70% for EE and EC, respectively (Figure 6). The second highest fraction was represented by bark in EC and EF, with values of 25.57% and 22.72%, respectively.

In EE, branches > 0.7 cm corresponded to 28.26% of the total annual litter. In an adjacent native forest remnant area, leaf and branches < 0.7 cm were the most representative litter fractions, with 74.37 and 17.08%, respectively. A higher participation of leaf fraction, followed by branches < 0.7 cm and bark, was also observed in other studies for both eucalyptus and other forest formations (BERNHARD-REVERSAT et al., 2001; LONGHI et al., 2011; CORRÊA et al., 2013; VIERA et al., 2014; ALONSO et al., 2015; INKOTTE et al., 2015).

For litter deposition in three-year areas, significant correlations at 1% were obtained for leaf fractions with precipitation and relative humidity and for bark with relative humidity whereas the fraction branches < 0.7 cm showed a significant correlation at 5% with precipitation (Table 4). In five-year areas, a significant correlation at 1% was observed only between leaf and wind speed. In the seven-year area, a positive correlation at 5% was found for bark fraction with relative humidity and temperature whereas a significant correlation at 1% was observed between bark and wind speed. Finally, in the nine-year area, a significant correlation at 5% was found for leaf with relative humidity, bark with temperature, and total deposition with precipitation and temperature whereas a significant correlation at 1% was observed for bark fraction with wind speed.

Figure 3 – Litter forming fractions of *E. urograndis* Clone H13 in the dry and rainy seasons, in the transition region of Cerrado-Amazon between 09/17/2015 and 10/08/2016, analyzed by the Tukey test at the 5% probability level within each treatment at the different seasons. (a) different ages in the central positions of the field, (b) different environment interfaces in five-years area (c) different environment interfaces in seven-years area

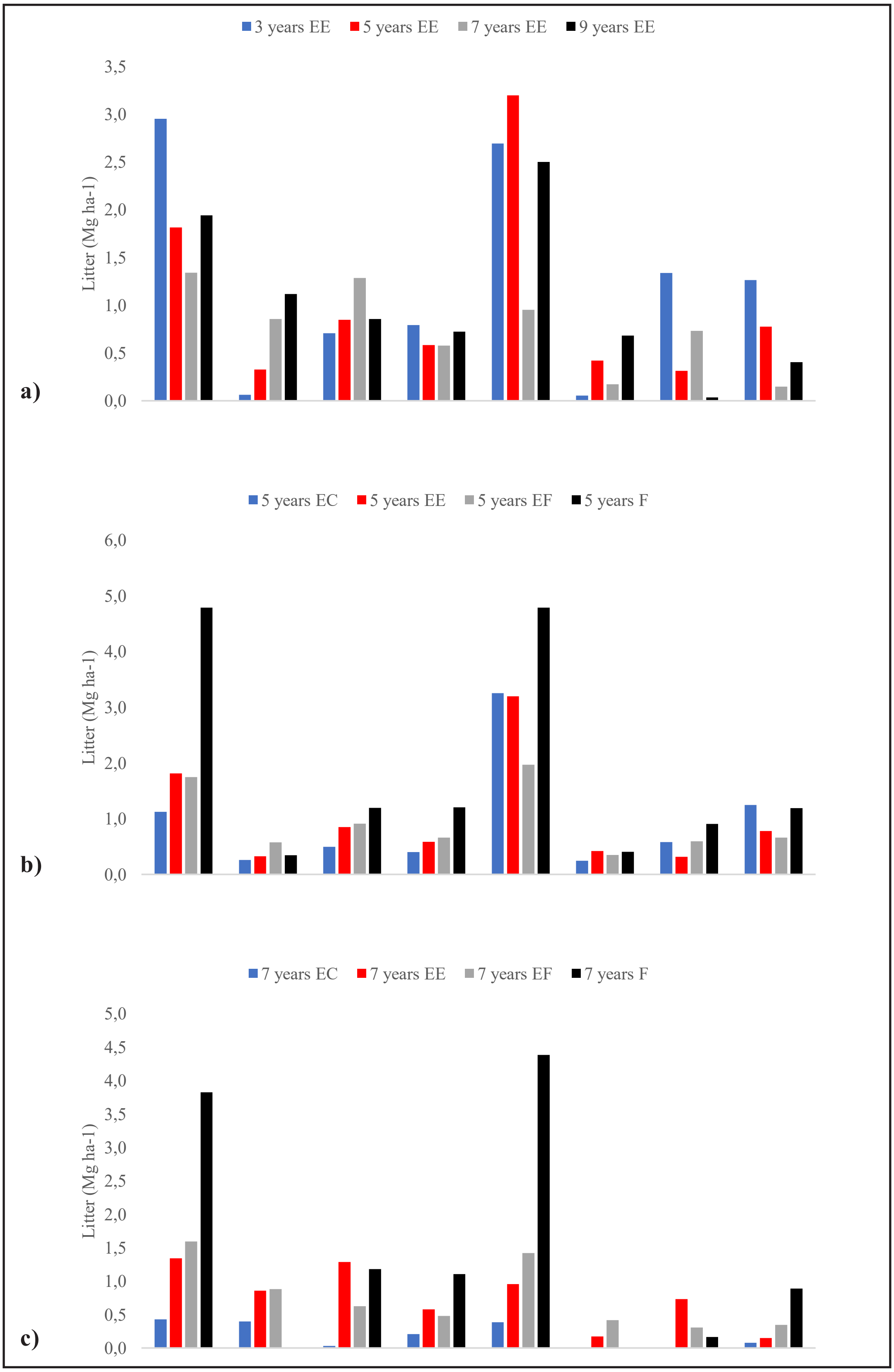


Figure 4 – Percentage of the litter forming fractions in central areas of *E. urograndis* Clone H13, in the transition region of Cerrado-Amazon. (a) three-years area, (b), five-years area, (c), seven-years area and (d) nine-years area

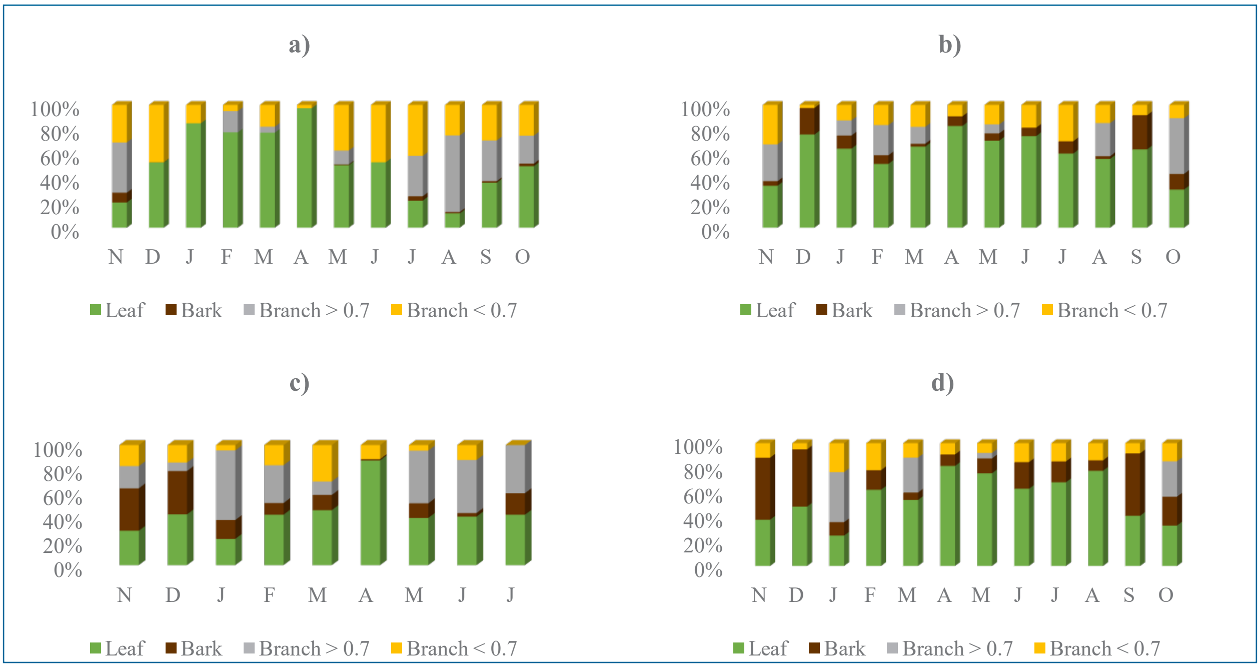


Figure 5 - Percentage of the litter forming fractions of E. urograndis Clone H13 with five years, in the transition region of Cerrado-Amazon. (a) eucalyptus-crop interface, (b) eucalyptus-eucalyptus interface, (c) eucalyptus-native forest interface and (d) native forest remnant area

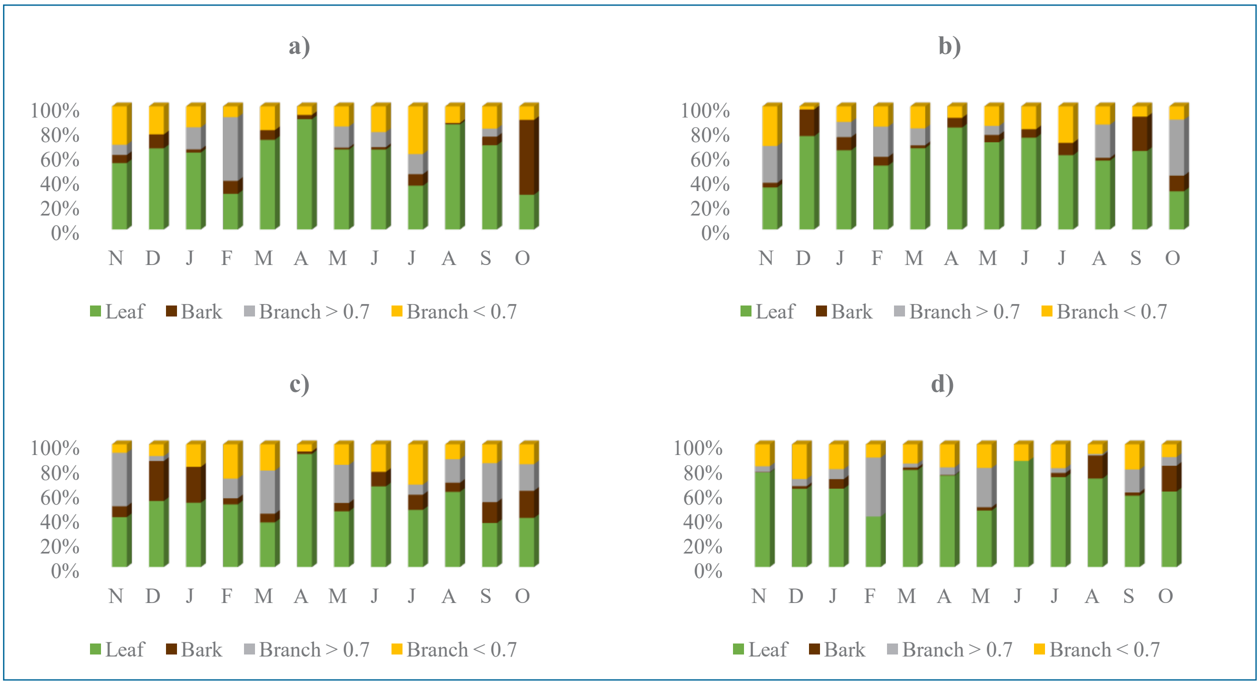


Figure 6 - Percentage of the litter forming fractions of *E. urograndis* Clone H13 with seven years, in the transition region of Cerrado-Amazon. (a) eucalyptus-crop interface, (b) eucalyptus-eucalyptus interface, (c) eucalyptus-native forest interface and (d) native forest remnant area

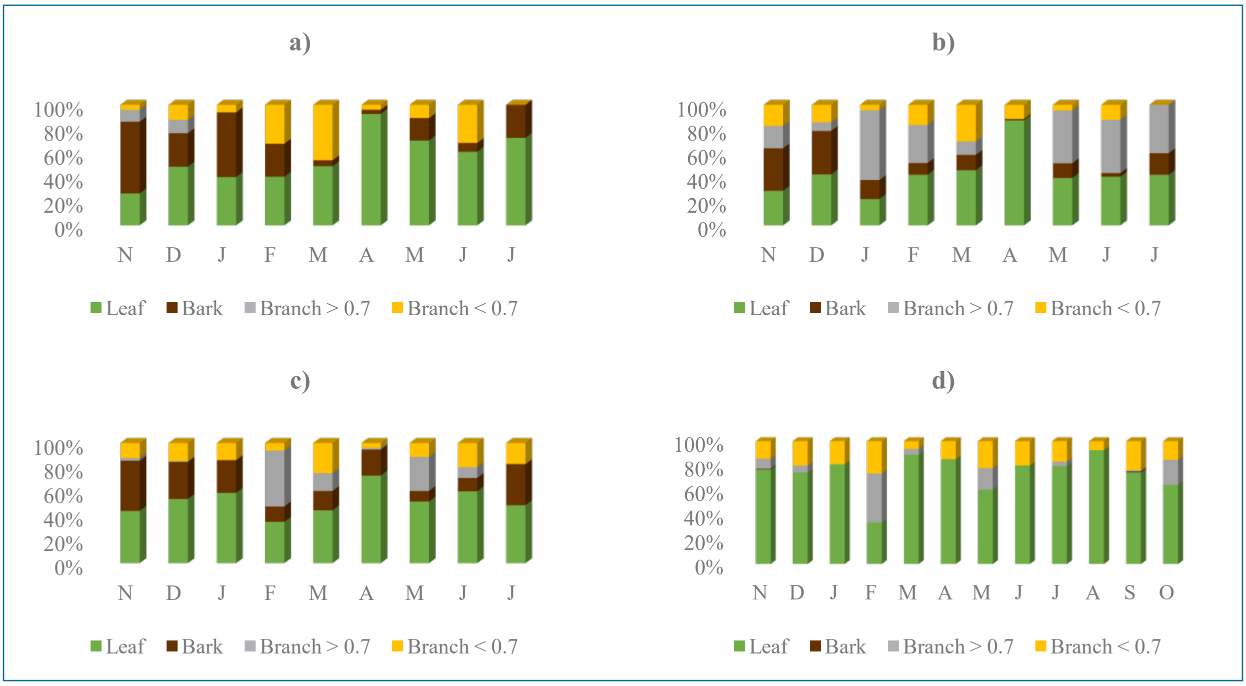


Table 4 – Pearson correlation between the litter deposition and climatic variables in central areas (EE) of the *E. urograndis* Clone H13 fields, in different ages in the transition region of Cerrado-Amazon

Treatment	Fraction	Rainfall	Relative humidity	Temperature	Wind speed
3 years	Leaf	0.82*	0.71*	-0.02	-0.29
	Branch > 0.7	-0.33	-0.51	-0.42	-0.12
	Branch < 0.7	-0.70**	-0.42	-0.29	-0.28
	Bark	-0.26	-0.71*	0.21	0.39
	Total	0.52	0.36	-0.27	-0.38
5 years	Leaf	-0.20	0.39	-0.25	-0.73*
	Branch > 0.7	0.05	-0.34	-0.23	0.18
	Branch < 0.7	-0.31	-0.31	-0.04	-0.15
	Bark	-0.23	-0.11	-0.24	0.05
	Total	-0.32	-0.03	-0.44	-0.57
7 years	Leaf	0.59	0.28	-0.03	0.11
	Branch > 0.7	0.05	-0.03	0.11	0.20
	Branch < 0.7	0.31	-0.24	0.48	0.48
	Bark	0.001	-0.77**	0.79**	0.95*
	Total	0.21	-0.27	0.42	0.56
9 years	Leaf	0.41	0.66**	0.05	-0.53
	Branch > 0.7	0.29	0.15	0.22	0.23
	Branch < 0.7	0.51	0.25	0.24	0.26
	Bark	-0.08	-0.55	0.60**	0.80*
	Total	0.66**	0.39	0.64**	0.33

*Significant at the 1% level of error probability; ** Significant at the 5% level of error probability.

Significant correlations at 5% were observed in five-year areas. In the interface EC, leaf fraction was correlated with wind speed whereas, in the interface EF, bark fraction was correlated with wind speed (Table 5). In seven-year areas, only the fraction branches > 0.7 cm presented a positive correlation in the interface EC, being significant at 1% with wind speed and significant at 5% with relative humidity and temperature. In the native forest remnant area, a significant correlation at 5% was observed between leaf and relative humidity and between the bark and relative humidity.

Among all treatments, the bark was the only fraction presenting the highest number of significant correlations for both relative humidity (negative correlation) and wind speed (positive correlation). Viera et al. (2014) reported similar results in a study with the genus *Eucalyptus* and by Schumacher et al. (2013) in a study with *E. urophylla* × *E. globulus*.

Table 5 - Pearson correlation between the litter deposition and climatic variables in *E. urograndis* Clone H13 with five and seven years in different environment interfaces and native forest remnant area, in the transition region of Cerrado-Amazon

Treatment	Fraction	Rainfall	Relative humidity	Temperature	Wind speed
5 years eucalyptus-crop	Leaf	-0.47	-0.08	-0.39	-0.64**
	Branch > 0.7	0.16	0.39	-0.28	-0.27
	Branch < 0.7	-0.44	-0.14	-0.31	-0.30
	Bark	-0.07	0.05	-0.47	-0.20
	Total	-0.38	0.02	-0.45	-0.55
5 years eucalyptus-native forest	Leaf	0.04	0.11	0.08	-0.24
	Branch > 0.7	-0.06	-0.39	0.37	0.27
	Branch < 0.7	-0.05	0.34	-0.30	-0.40
	Bark	-0.16	-0.25	0.33	0.61**
	Total	-0.08	-0.17	0.28	0.09
5 years native forest	Leaf	-0.32	-0.58**	0.11	0.09
	Branch > 0.7	0.36	0.39	-0.12	-0.09
	Branch < 0.7	-0.10	-0.22	0.43	0.35
	Bark	-0.34	-0.42	-0.56	-0.14
	Total	-0.07	-0.26	-0.05	0.04
7 years eucalyptus-crop	Leaf	0.31	0.59	-0.40	-0.38
	Branch > 0.7	-0.13	-0.70**	0.72**	*0.82
	Branch < 0.7	0.23	0.44	-0.22	-0.23
	Bark	0.30	-0.28	0.44	0.65
	Total	0.41	0.14	0.13	0.29
7 years eucalyptus-forest	Leaf	0.06	0.04	0.06	-0.19
	Branch > 0.7	0.35	0.51	-0.35	-0.24
	Branch < 0.7	-0.50	-0.28	0.12	-0.11
	Bark	0.06	-0.83*	0.56	0.71**
	Total	0.20	0.01	0.01	-0.009
7 years native forest	Leaf	-0.07	-0.57	-0.04	0.07
	Branch > 0.7	0.50	0.38	-0.13	0.02
	Branch < 0.7	0.40	0.17	-0.08	0.07
	Bark	-0.15	-0.69**	0.40	0.53
	Total	0.28	-0.16	-0.10	0.08

*Significant at the 1% level of error probability; ** Significant at the 5% level of error probability.

3.2. Litter decomposition

Mathematical parameters used to determine the remaining dry mass after a period are presented in Table 6. In the different treatments, the decomposition rate was similar to those found by other authors for the same studied hybrid. In a three and a half-year plantation, Cunha Neto et al. (2013) found a decomposition constant of 0.0028 g day^{-1}. When comparing different planting ages, the highest decomposition constant was observed in the three-year area, followed by areas of five, nine and seven years, being the results of this later out of standards when compared to the other areas since it presented a high mortality of individuals in the field.

In five-year areas, a higher decomposition constant was observed in the interfaces eucalyptus–eucalyptus, followed by eucalyptus–crop and eucalyptus–forest. On the other hand, in seven-year areas, the decomposition constants, in descending order, were eucalyptus–crop, eucalyptus–forest, and eucalyptus–eucalyptus.

Table 6 – Mathematic parameters adjusted by the simple negative exponential model of *E. urograndis* (Clone H13), for remaining dry mass depending on the age and different environment interfaces, in the transition region of Cerrado-Amazon, between 10/08/2015 and 08/09/2016

Treatment	X_0	k (g day^{-1})	Half-life time $T_{1/2}$	R^2
Central areas (EE)				
3 years	101.2768	0.00226	306.702	0.9471
5 years	99.7288	0.00163	425.244	0.9851
7 years	94.8502	0.00084	825.175	0.9639
9 years	98.4082	0.00159	435.942	0.953
Different environment interfaces				
5 years EC	100.1087	0.00137	505.947	0.9574
5 years EE	99.7288	0.00163	425.244	0.9851
5 years EF	90.6478	0.00099	700.149	0.8854
5 years F	102.1154	0.00291	238.195	0.9487
7 years EC	96.6194	0.00131	529.120	0.98
7 years EE	94.8502	0.00084	825.175	0.9639
7 years EF	94.3969	0.00097	714.585	0.9402
7 years F	94.7568	0.00312	222.163	0.9551

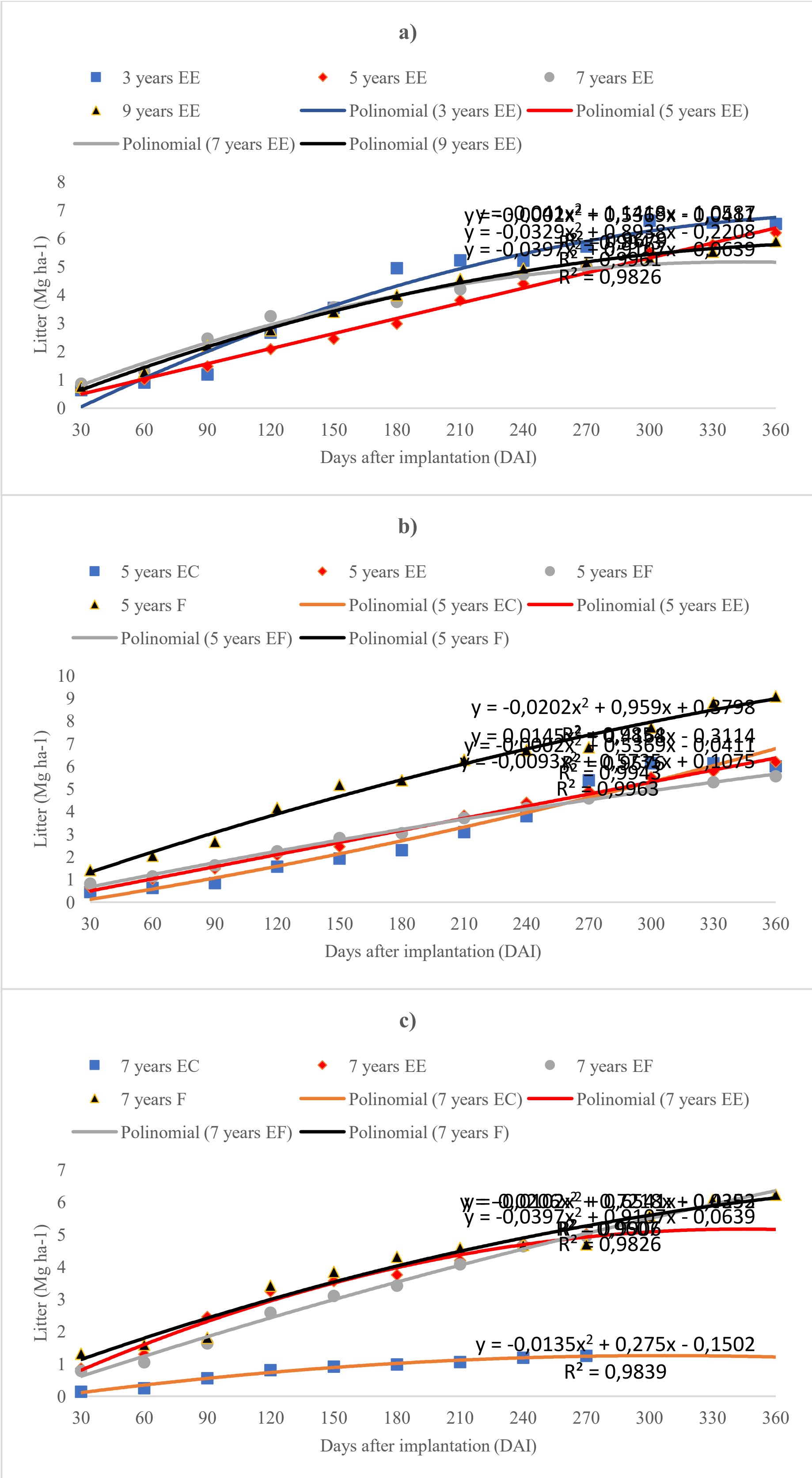
Initial dry mass (X_0), rate of decomposition (k), half-life time ($T_{1/2}$) and coefficient of determination values (R^2)

From the mathematical parameters, the percentage of mass loss was calculated at each collection month and the litter accumulation at the end of the year was determined. Additionally, the equation and coefficient of determination for the second-degree polynomial model are shown in Figure 7 for all treatments. The three-year eucalyptus presented the highest amount of accumulated litter (6.51 Mg ha^{-1}) in the central areas, followed by areas of five and nine years (6.19 and 5.90 Mg ha^{-1}, respectively). After 270 days, litter accumulation was 5.01 Mg ha^{-1} in the area with seven years. From 300 days, an equilibrium tendency of accumulated material was observed in the treatment of three years, which is due to its higher decomposition rate when compared to the other treatments, in addition to the low amount of litter deposited in those months. Cunha Neto et al. (2013) found in *E. urograndis* plantations with 3.5 years 8.83 Mg ha^{-1} of accumulated litter under the soil.

Considering the different environmental interfaces of five years, the highest accumulation occurred in the interface eucalyptus–eucalyptus, followed by eucalyptus–crop and eucalyptus–forest, with 6.19, 6.00, and 5.56 Mg ha^{-1}, respectively. The interface eucalyptus–crop presented a tendency to reduce the accumulated litter after 300 days due to the low deposition verified in the last two collection months in the treatment. After 270 days in the different interfaces of seven years, the accumulated litter presented the following order of magnitude: eucalyptus–eucalyptus, eucalyptus–forest, and eucalyptus–crop, with values of 5.01, 4.95, and 1.26 Mg ha^{-1}, respectively.

In native forest remnant areas, an accumulation of 9.08 and 6.23 Mg ha^{-1} was observed close to five and seven-year areas, respectively. When studying an Area of Relevant Ecological Interest (AREI) in Alegre, ES, Brazil, Caldeira et al. 2013 found, at the end of the rainy season, 7.00 Mg ha^{-1} of accumulated litter. Cunha Neto et al. (2013) found, in a secondary forest, a litter stock of 4.71 Mg ha^{-1}.

Figure 7 – Litter accumulation of *E. urograndis* Clone H13, in the transition region of Cerrado-Amazon between 09/17/2015 and 10/08/2016. (a) different ages in the central positions of the field, (b) different environment interfaces in five-years area and (c) different environment interfaces in seven-years area



4 Conclusions

Leaves are the main litter forming fractions in *E. urograndis* plantations and in native forest remnant areas in a Cerrado-Amazon transition domain.

For forests planted with *E. urograndis* and native forests, litter deposition has a seasonal pattern with higher intensities in the dry season.

Bark fraction presents a negative correlation with the relative humidity and a positive correlation with wind speed.

Litter balance found in the studied treatments is in accordance with the accumulated litter found in other studies.

References

ALMEIDA, E. J.; LUIZÃO, F.; RODRIGUES, D. J. Produção de serapilheira em florestas intactas e exploradas seletivamente no sul da Amazônia em função da área basal da vegetação e da densidade de plantas. Acta Amaz. 2015;45(2):157-166.

ALONSO, J. M.; LELES, P. S. S.; FERREIRA, L. N.; OLIVEIRA, N. S. A. A porte de serapilheira em plantios de recomposição florestal em diferentes espaçamentos. Ciênc. Florest. 2015;25(1):1-11.

BALIEIRO, F. C. et al. Dinâmica da serapilheira e transferência de nitrogênio ao solo, em plantios de *Pseudosamanea guachapele* e *Eucalyptus grandis*. Pesq. agropec. bras. 2004;39(6):597-601.

BARLOW, J.; GARDNER, T. A.; FERREIRA, L. V.; PERES, C. A. Litter fall and decomposition in primary, secondary and plantation forests in the Brazilian Amazon. For. Ecol. Manage. 2007;247(1-3):91-97.

BERNHARD-REVERSAT, F.; LOUMETO, J. J.; LACLAU, J. P. Litterfall, litter quality and decomposition changes with eucalypt hybrids and plantation age. In: Bernhard-Reversat, F. Effect of exotic tree plantations on plant diversity and biological soil fertility in the Congo Savanna: With special reference to eucalypts. Center for International Forestry Research. Bogor, Indonesia. 2001. 71p.

CALDEIRA, M. V. W.; SILVA, R. D.; KUNZ, S. H.; ZORZANELLI, J. P. F.; CASTRO, K. C.; GODINHO, T. O. Biomassa e nutrientes da serapilheira em diferentes coberturas florestais. Com. Sci. 2013;4(2):111-119.

COMPANHIA NACIONAL DE ABASTECIMENTO – CONAB. Evolução dos custos de produção de soja no Brasil. Compêndio de Estudos Conab. v. 2. 2016. 22p.

CORRÊA, R. S.; SCHUMACHER, M. V.; MOMOLLI, D. R. Deposição de serapilheira e macronutrientes em povoamentos de *Eucalyptus dunnii* Maiden sobre pastagem natural degradada no Bioma Pampa. Sci. For. 2013;41(97):65-74.

CUNHA NETO, F. V.; LELES, P. S. S.; PEREIRA, M. G.; BELLUMATH, V. G. H.; ALONSO, J. M. Acúmulo e decomposição da serapilheira em quatro formações florestais. Ciênc. Florest. 2013;23(3):379-387.

FREITAS, E. C. S.; OLIVEIRA NETO, S. N.; FONSECA, D. M.; SANTOS, M. V.; LEITE, H. G.; MACHADO, V. D. Deposição de serapilheira e de nutrientes no solo em sistema agrossilvipastoril com eucalipto e acácia. Rev. Árvore 2013;37(3):409-417.

INDÚSTRIA BRASILEIRA DE ÁRVORES – IBA. Relatório anual 2016. 2016. 100p.

INKOTTE, J. Deposição de serapilheira em reflorestamentos de eucalipto e florestas nativas nas regiões Planalto e Oeste do Estado de Santa Catarina. Sci. For. 2015;43(106):261-270.

LONGHI, R. V.; LONGHI, S. J.; CHAMI, L. B.; WATZLAWICK, L. F.; EBLING, A. A. Produção de serapilheira e retorno de macronutrientes em três grupos florísticos de uma floresta ombrófila mista, RS. Ciênc. Florest. 2011;21(4):699-710.

LOPES, M. I. M.; DOMINGOS, M.; VUONO, Y. S. Ciclagem de nutrientes minerais. In: Manual metodológico para estudos botânico na Mata Atlântica. Sylvestre, L. S.; Rosa, M. M. T. Seropédica: EDUR, Universidade Federal Rural do Rio de Janeiro, 2002. p. 72-103.

MACEDO, A. A.; ANUNCIATO, K. M. Participação econômica do setor madeireiro no município de Aripuanã-MT e a sua influência na geração direta de emprego e renda. Revista científica da Ajes. v. 4, n. 9, 2013.

MIRANDA, D. L. C.; JUNIOR, V. B.; GOUVEIA, D. M. Fator de forma e equações de volume para estimativa volumétrica de árvores em plantio de *Eucalyptus urograndis*. Sci. Plena 2015;11(3):1-8.

O'CONNELL, A. M.; MENAGÉ, P. M. A. Litter fall and nutrient cycling in karri (*Eucalyptus diversicolor* F. Muell.) forest in relation to stand age. Aust. J. Ecol. 1982;(7):49-62.

SANCHES, L.; VALENTINI, C. M. A.; BIUDES, M. S.; NOGUEIRA, J. S. Dinâmica sazonal da produção e decomposição de serapilheira em floresta tropical de transição. Rev. Bras. Eng. Agríc. Ambient. 2009;13(2):183-189.

SCHUMACHER, M. V.; CORRÊA, R. S.; ARAÚJO, E. F. Produção e decomposição de serapilheira em um povoamento de *Eucalyptus urophylla* x *Eucalyptus globulus maidenii*. Cerne 2013;19(3):501-508.

SOUZA, A. P.; MOTA, L. L.; ZAMADEI, T.; MARTIM, C. C.; ALMEIDA, F. T.; PAULINO, J. Classificação climática e balanço hídrico climatológico no estado de Mato Grosso. Nativa 2013;1(1):34-43.

TERROR, V. L.; SOUSA, H. C.; KOZOVITS, A. R. Produção, decomposição e qualidade nutricional da serapilheira foliar em uma floresta paludosa de altitude. Acta Bot. Bras. 2011;25(1):113-121.

VIERA, M.; SCHUMACHER, M. V.; ARAÚJO, E. F. Disponibilização de nutrientes via decomposição da serapilheira foliar em um plantio de *Eucalyptus urophylla* x *Eucalyptus globulus*. Floresta e Ambient. 2014;21(3):307-315.

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