__Original Research Article__

Litter in potential eucalypts genotypes implanted in Eldorado do Sul, Rio Grande do Sul, Brazil

ABSTRACT: The objective of this study was to estimate the amount of litter on the soil in genotypes of *Eucalyptus* at 49-month-old, located in Eldorado do Sul, Rio Grande do Sul, Brazil. For each genotype, a sampling unit of 720 m^2 was demarcated, where in each of them 15 random collections were carried out. The litter biomass ranged from 4.51 to 10.77 Mg ha^{-1}, highlighting the *E. dunnii* and and the hybrid of *E. urophylla* x *E. globulus* with the lowest and largest production respectively. The leaves corresponded, on average, between 48.56% and 73.03% of the total litter. The differentiation between the genotypes occurred as to the accumulated litter production.

Keywords: Litter biomass, Leaves, *Eucalyptus* stands, Sustainability.

1. INTRODUCTION

Tree plantations have many beneficial ecological interactions with the ecosystem, such as watershed protection, increased organic matter and soil nutritional status through the production of litter [2]. This dynamic, represented by the deposition of litter via deposition and exit via decomposition is essential to the maintenance of forests or forest stands [3], especially in highly weathered soils, where plant biomass is the main nutrient reservoir [10].

The persistence of litter on the soil causes this material to be reused in the nutrient cycle of the system, through its decomposition and the release of the constituent minerals for a later reabsorption by the roots of the plants, also increasing the organic matter content in the soil [4]. In this context, nutrient return via litter is the most important route of the biogeochemical cycle [10].

In general, an increase in litter deposition is observed until the age at which the trees reach maturity, when the crowns are closed. After this phase, a slight decrease or stabilization in the deposition may be observed [9].

The accumulation of litter varies according to the origin, species, forest cover, successional stage, age, collection season, forest type and site. In addition to these factors, others such as, edaphoclimatic conditions and water regime, climatic conditions, site, understory, silvicultural management, proportion of canopy, as well as rate of decomposition and natural disturbances such as fire and insect or artificial attack such as litter removal and crops, occurring in the forest or in the stand, also influence the accumulation of litter [5].

The litter deposition is higher in the period of greater physiological activity of the individuals, causing an intensification of foliage exchange and senescent material release to give rise to a new and photosynthetically more active foliage [13].

Knowledge of the amount of litter deposited in different eucalyptus species and provenances is of fundamental importance in order to maintain a sustainable management of soils and mineral resources [12].

The present study had as objective to estimate the biomass of litter in different *Eucalyptus* genotypes established in Eldorado do Sul, Rio Grande do Sul, Brazil.

2. MATERIALS AND METHODS

The research was developed with different genotypes of eucalypts (Table 1), in an area belonging to the company Celulose Riograndense - CMPC, in the city of Eldorado do Sul, RS, Brazil (Figure 1). The area is under the geographic coordinates of 30 ° 11'303 "south latitude and 51 ° 37'477" west longitude.

The climate is characterized as subtropical humid (Cfa), according to the climatic classification of Köppen, presenting average temperature corresponding to 19 °C. The average annual precipitation of 1,400 mm [1].

The soil in the area is classified as Red-Yellow Argisol. Table 2 presents the chemical and physical attributes of the soil a depths from 0 to 130 cm.

Table 1. Characterization of the studied genotypes

Genotypes	Age (months)	Spacing (m)	G (m^2 ha)
E. benthamii (Provenance 1)	49	3 x 3	24,4
E. benthamii (Provenance 2)	49	3 x 3	22,7
E. saligna	49	3 x 3	23,7
E. dunnii	49	3 x 3	16,7
E. uropylla x E. globulus (E. uroglobulus)	49	3 x 3	22,2
E. uropylla x E. grandis (E. urograndis)	49	3 x 3	26,4

E. benthamii (Provenance 1) is a provenance proven in Guarapuava, Paraná, Brazil; and *E. benthamii* (Provenance 2) is a source from Telêmaco Borba, Paraná, Brazil.

Figure 1. Location of the municipality of Eldorado do Sul, Rio Grande do Sul, Brazil

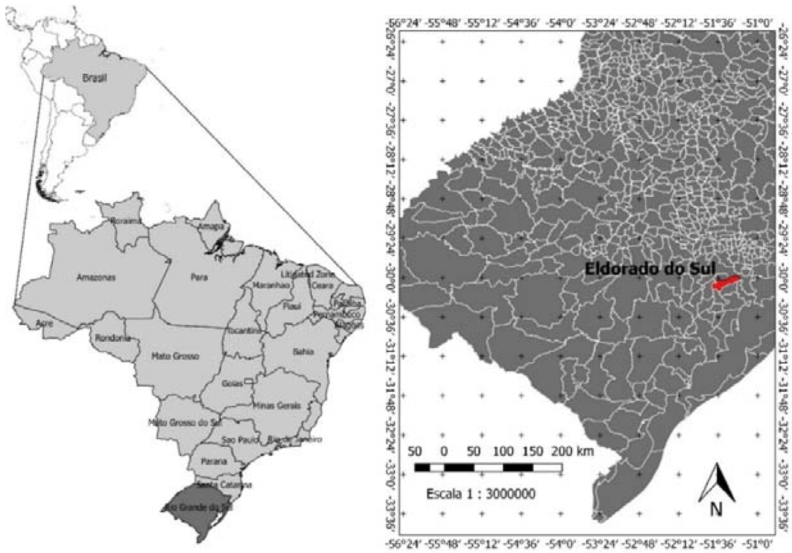


Table 2. Physical and chemical attributes of soil in the area implanted with different genotypes of *Eucalyptus*, at 49-months-old, in Eldorado do Sul, Rio Grande do Sul, Brazil

	Granulometric composition				
Depth	**Coarse sand**	**Thin sand**	**Silt**	**Clay**	**O.C**
	2-0.2	**0.2-0.05**	**0.05-0.002**	**<0.002**	
(cm)	---------------------------------mm---------------------------------				%
0-30	24.5	16.5	29.5	29.5	0.9
30-60	40.5	8.0	6.0	45.5	0.8
60-90	33.5	6.0	5.5	55.0	0.7
90-100	15.5	6.0	15.5	63.0	0.4
100-130	15.5	6.5	13.0	65.0	0.2

Depth	**V**	**m**	**T**	**pH**	**N**
(cm)	-----------------%-----------------		--cmol$_c$ dm^{-3}--	H_2O	%
0-30	35	34	10	5.0	0.1
30-60	11	71	14	4.3	0.1
60-90	15	69	15	4.4	0.1
90-100	17	64	12	4.6	0.1
100-130	20	61	10	4.7	0.0
Depth	**P**	**K**	**Ca**	**Mg**	**S**
(cm)	--mg g^{-1}--	------------------cmol$_c$ dm^{-3}------------------			mg dm3
0-30	2.0	0.1	3.3	0.9	19.4
30-60	1.6	0.1	0.9	0.5	32.5
60-90	1.0	0.1	1.0	0.8	61.7
90-100	0.7	0.1	1.0	0.9	60.9
100-130	0.6	0.1	0.9	0.9	59.0

O.C: organic carbon; V = saturation by bases; m = saturation by aluminum; T = total CTC

In the preparation of the area, the subsoiling was performed at a depth of 60 cm, and a liming treatment was applied consisting of 2 Mg ha^{-1} of limestone, and 200 kg ha^{-1} of single superphosphate. The fertilizer used during planting consisted of, 110 g plant^{-1} of N-P_2O_5-K_2O (06:30:06) + 0.3% Zn and 0.2% Cu. For coverage fertilization 200 kg ha^{-1} of N-P_2O_5-K_2O (12:00:20) + 0.7% of B were applied, and for the maintenance fertilization, 300 kg ha^{-1} of N-P_2O_5-K_2O (24:00:26) + 0,5% B were applied.

The litter collections were carried out in June 2016. To perform the work, in each of the genotypes studied, a plot of 720 m^2 was demarcated, where 15 samples were collected, randomly, totaling 90 samples.

The litter samples were collected using an iron frame (Figure 2) of 0.25 m x 0.25 m (0.0625 m^2), which was placed on the surface of the land, and all the organic material present in its soil. After collection, the sampled materials were stored in plastic bags and sent to the laboratory where they were separated into three fractions: leaves, branches and miscellaneous (peels, reproductive materials and non-identifiable residues).

Subsequently, the fractions were placed in paper containers to dry in a circulation oven and air renovation at 70 °C until weight stabilization. Finally, the samples were weighed in a precision scale (0.01 g) and the dry weights were extrapolated to values per hectare to obtain the mass of the litter.

Figure 2. A: Canopy of a stand of *Eucalyptus* sp.; Deposition of the litter on the soil; and C: Removal of the litter on the soil for quantification.

Statistical analyzes were performed with the aid of the statistical program Assistat 7.7 ® [14] at the level of 5% probability of error. The Tukey test was used for the comparison of means.

3. RESULTS AND DISCUSSIONS

In Table 3 it is possible to verify the distribution of litter for the different fractions of the studied genotypes. The litter biomass was higher in hybrid *E. urophylla x E. globulus* (10.77 Mg ha^{-1}) and lower in *E. dunnii* (4.51 Mg ha^{-1}), reaching intermediate values in *E. benthamii* (P1) (8, 38 Mg ha^{-1}).

Table 3. Litter production for the different fractions of the eucalypts genotypes at 49-months-old

Genotypes	Leaves	Miscellaneous	Branches	Total
	(Mg ha^{-1})			
E. benthamii (P1)	6.12ab *(2.15)	0.53a (0.45)	1.73bc (1.74)	8.38a (3.31)
E. benthamii (P2)	3.27cd (1.41)	0.65a (0.61)	1.14c (0.57)	5.06b (1.64)
E. saligna	4.63bc (1.26)	0.43a (0.25)	4.10a (2.59)	9.13a (3.04)
E. dunnii	2.19d (1.24)	0.95a (1.17)	1.46bc (1.35)	4.51b (2.81)
E. urophylla x E. globulus	6.72a (2.93)	0.32a (0.27)	3.82a (2.08)	10.77a (3.95)
E. urophylla x E. grandis	5.88ab (1.65)	0.53a (0.44)	3.11ab (2.03)	9.49a (2.87)
CV %	38.97	108.2	71.67	38.26

CV: Coefficient of variation.

Mean of each variable in the different treatments followed by equal letters, do not differ significantly by the Tukey test at the 5% level of error. * Values in parentheses are the standard deviation of the mean.

The litter presented a value lower than that found by [15], in a plantation of hybrid *E. urophylla* x *E. globulus* at four-years-old in Eldorado do Sul, RS, Brazil (14.0 Mg ha^{-1}); by [12], in stands of *E. grandis, E. cloesiana* and *E. urophylla*, with nine-years-old in Santa Maria, RS, Brazil (16.8, 16.5 and 12.6 Mg ha^{-1}); by [11] in a stand of *E. saligna* at four and five years of age in São Gabriel, RS, Brazil (12.76 and 12.00 Mg ha^{-1}); and by [4] in a planting of *E. uroglobulus*, with 5.5-years-old in Eldorado do Sul, RS, Brazil (19.5 Mg ha^{-1}).

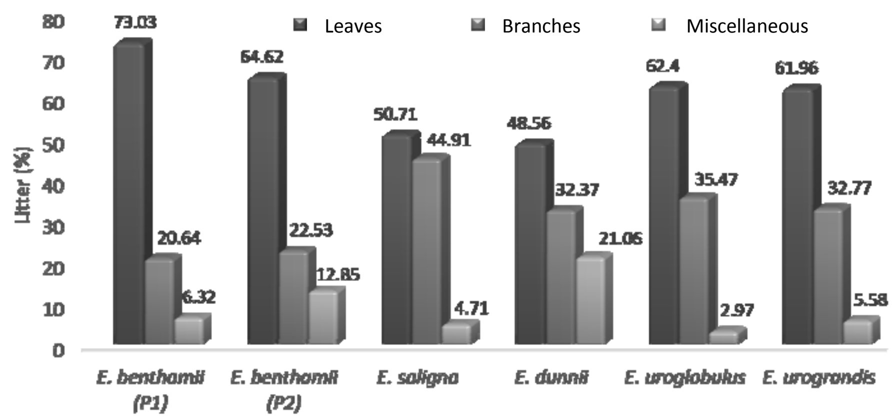
In another stand of *E. grandis*, at seven-years-old, in Seropédica, RJ, Brazil, [3], reported an amount of 11.84 Mg ha^{-1} litter. In the Southwest region of Brazil, in different forest sites, [7] evaluating litter production in eucalypts plantations, also at seven-years-old, observed that the amount of litter ranged from 4.2 to 37.6 Mg ha^{-1}. A similar result was found by [6], in a stand of *E. grandis*, at the nine-years-old, in the city of Alegrete, RS, Brazil (5.41 Mg ha^{-1}).

The production and accumulation of litter presents a great variability, which can be due to variation in the climatic conditions, the quality of the site, the age of the stand, the characteristics of the species, as well as in the inclusion of the understory litter, and the degree of forest stability [10].

In relation to total biomass, the hybrid *E. urophylla* x *E. globulus* presented a production of 58.12% and 53.02% higher than the clones *E. dunnii* and *E. benthamii* (P2). According to [6], the litter rates accumulated in forest plantation soils can vary significantly between different species in the same sites.

The leaves fraction corresponded on average, between 48.56% and 73.03% of the total litter (Figure 3). *E. dunnii* was the clone that presented the lowest percentage of leaves deposited among the species studied, and *E. benthamii* (P1) the largest. The leaves usually constitute the largest proportion of the biomass of the residues that fall to the soil. This proportion grows with age to a certain extent, and then decreases due to the increase in the fall of branches and bark [10].

Figure 3. Relative litter of different *Eucalyptus* genotypes



In this context, [8] studied the litter in a twelve-year-old eucalypts stand, observed that the branches presented greater accumulation on the ground, with 38.8%. According to the author, this occurred because the eucalypts stands suffer a more intense process of natural desrama, in relation to other species, which leads to greater accumulation of branches on the ground.

[12], studying the litter in three species of eucalypts (*E. urophylla*, *E. cloesiana* and *E. grandis*), at nine-year-old, in Santa Maria, RS, Brazil, observed that the branches fraction was the most representative in all species. According to the authors this may mean a propensity of these species for the natural desrama.

For the branches fraction, the highest yields occurred in the clones *E. saligna* and *E. uroglobulus*, with 2.48 and 2.24 Mg ha^{-1}, and lower production occurred in *E. dunnii*, with 2.19 Mg ha^{-1}. The miscellaneous fraction varied from 0.32 to 0.95 Mg ha^{-1}, the lowest value found in hybrid *E. urophylla* x *E. globulus* and the highest in *E. dunnii*, not statistically different from the other clones.

The existence of a great variability in the accumulation of organic litter blanket in relation to other works carried out with eucalypts species can be explained based on the variation of climate, sites, age and forest density, different genetic characteristics of each species and the stability achieved by the stand, depending on the time elapsed since the last intervention that may have influenced the litter. These factors will affect the balance between the amount of material deposited and the time required for its decomposition, reflecting the greater or less accumulation of litter in the forest soil and the percentage composition of the different fractions that compose it [12].

4. CONCLUSIONS

The highest production of litter occurred in hybrid *E. urophylla* x *E. globulus*, providing greater protection to the soil, in contrast the lower production of litter occurred in *E. dunnii*.

The leaf fraction presented the highest contribution in all genetic materials studied.

The differentiation between the genotypes occurred as to the accumulated litter production.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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