

Eucalypt Clonal Hybrid Influence The Carbon Amount of Below-ground Biomass in Oxisol, Brazil [†]

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Abstract: The objective of this study was to evaluate whether there is the influence of different clonal hybrids of *Eucalyptus urophylla* on the carbon concentration and amount in below-ground biomass in trees cultivated in Oxisol, Brazil. Stumps and roots of three different eucalypt hybrid clones, AEC 0144, AEC 0223, and VM01, were selected, weighed immediately after removing from the ground, and sampled for carbon determination and moisture content at the laboratory. The Shapiro-Wilk's and Bartlett tests were used to evaluate data distribution and the homogeneity of variances, respectively. Analysis of variance (ANOVA) complemented by the Scott-Knott test was used to evaluate the effects of specie/hybrid on the below-ground biomass (dry matter) and carbon amount per stump. The hybrid type of *Eucalyptus urophylla* does not influence the carbon concentration; however, there is a difference in below-ground biomass production and carbon amount being higher for *Eucalyptus urophylla* x *Eucalyptus camaldulensis* when compared to the species *Eucalyptus urophylla* and hybrid *Eucalyptus urophylla* x *Eucalyptus grandis*.

Keywords: stump; root system; bioenergy

1. Introduction

In the world, there are about 131 million hectares of plantation forest [1], where 20 million of these are eucalypt plantations [2], being 5,7 million hectares in Brazil [3]. These intensively managed plantations represent 1.5% of the forested areas of the world, and those destined to forestry with eucalyptus are among the most productive [4].

With the advance of genetic improvement in Brazil since the 1960s, the hybridization technique allowed the improvement of characteristics and expansion of the possibilities of cultivation of *Eucalyptus* spp., where a great highlight is addressed to *Eucalyptus urophylla* S.T. Blake, due to ecophysiological plasticity, resistance to diseases and productivity, and the possibility of multiple uses of its forest products [5-9]. The hybridization of *Eucalyptus urophylla* are options available to wood producers, and there are present across Brazil, especially in the southeast and central west.

The fast growth of *Eucalyptus urophylla* and its clonal hybrids allows a replacement of genetic material to attend a new generation of seedling in the market with superior performance. Thus, the stumps and coarse roots have been pulled from out the ground, obtaining a clean and homogeneity area. These residues have been used like raw-material for many purposes, such as cellulose, charcoal, biomass [10-12]. The purpose of forest plantations is not only tied to the production of wood for the

generation of energy, pulp, paper, but also to the function of allocating carbon extracted from the atmosphere used in the metabolic processes of the plant. Carbon (C) is incorporated into the different biomass components above and below ground [13-14], and the accumulated quantity may vary depending on the species/hybrid and age of the tree [15-16]. In this sense, forestry emerges as one of the economic activities that are viable alternatives to mitigate the increase in CO₂ concentration in the atmosphere [15].

The objective of this study was to evaluate whether there is the influence of different clonal hybrids of *Eucalyptus urophylla* on the carbon concentration and amount in below-ground biomass in trees cultivated in Oxisol, Brazil.

2. Material and Methods

This study was carried out in Ribas do Rio Pardo, Mato Grosso do Sul state in the Midwest region of Brazil (central point 20°19'14"S and 53°17'28"W). The average elevation is 380 m a.s.l., the average annual precipitation is 1,252 mm year⁻¹ and the annual average temperature is 24.9 °C [17-18]. The dominant soil was an Oxisol (2.5 % silt, 13.75 % clay, 83.75 % sand) with 5.1 pH and 4.9 g kg⁻¹ of organic matter.

This experiment was conceived and implemented for other academic researches [10], being later used for the present study. We analyzed the carbon amount of below-ground biomass from three commercial clones – *Eucalyptus urophylla* AEC 0144, *Eucalyptus urophylla* × *Eucalyptus grandis* AEC 0224, and *Eucalyptus urophylla* × *Eucalyptus camaldulensis* VM01, which were described in Table 1.

Table 1. Silvicultural and dendrometric characteristics of the evaluated stands.

	Clone		
	AEC 0144	AEC 0224	VM01
Stand age (years)	6.8	6.6	6.3
DBH (cm) ¹	17.8 ± 2.9	18.8 ± 3.0	16.7 ± 2.9
Height (m)	23.5 ± 2.9	24.1 ± 4.0	19.9 ± 2.9
No. stumps per ha	987.0 ± 42.0	933.0 ± 30.0	1049.0 ± 59.0
Basal area (m ² ha ⁻¹)	25.3 ± 1.2	26.6 ± 0.4	23.7 ± 0.8
Volume (m ³ ha ⁻¹)	279.9 ± 12.1	285.6 ± 6.1	210.3 ± 3.5
Wood basic density (kg m ⁻³)	410.8 ± 8.3	444.8 ± 7.6	495.3 ± 5.1

Note: Average ± standard deviation, derived from the measurement of five plots with 500 m² in each planting.

¹ DBH: diameter at breast height.

Five plots of 500 m² were randomly selected for each combination of clone and rotation, totaling 20 plots. In each plot has measured the diameter at breast height (DBH) and the total height of all trees (55 trees per plot). So, twenty-five trees of all diameter classes were sampled and weighted per treatment to evaluate the below-ground biomass.

In the field, the stump and coarse roots were removed with a front-wheel loader simulating a commercial-scale operation commonly used in rural forest areas in Brazil. Thus, this biomass was weighed with a 600 kg maximum load capacity portable dynamometer (Figure 1).



Figure 1. Stumps pulled off the ground and weighted with a portable dynamometer.

To determine the carbon content were used only five stumps and coarse roots per treatment. Specifically, three different fractions of below-ground biomass were sampled with the support of chainsaw: 1. the stump (up to 0.15 m above the ground); 2. the upper taproot (represented majority by crown root – immediately below the surface soil), and 3. the lower taproot (including the coarse roots, which are those exceeding 5 mm in diameter [19]).

From the center of each stump region, one 3 cm thick disk was taken for representative sampling and laboratory analyses. Every disk was divided into quadrants, four similar wedges centered in the medulla of the wood disc. Each quadrant was used to determine the physical and chemical properties.

In the laboratory, the moisture content (MC – wet basis) was performed after a complete kiln-dry process in a 105 °C air forced oven until constant weight mass, according to the ASTM E871 – 82 [20]. The carbon concentration (C) was obtained at the elemental analyzer model 2400 Parkin Elmer by the modified Pregl-Dumas method. The biomass (dry matter) was obtained by the weighted arithmetic average, and the moisture content of samples. Thus, the carbon amount of stump biomass was obtained multiplying the biomass with the carbon concentration.

Statistical analysis was performed using [21]. The Shapiro-Wilk’s and Bartlett tests were used to evaluate data distribution and the homogeneity of variances, respectively. Analysis of variance (ANOVA) complemented by the Scott-Knott test was used to evaluate the effects of specie/hybrid on the below-ground biomass (dry matter) and carbon amount per stump. The results were analyzed with $p < 0.05$ representing statistical significance. The clones were close in age, and this effect was not considered in the statistical analysis.

3. Results

The carbon concentrations in below-ground biomass do not differ between *Eucalyptus urophylla* (AEC 0144) and its hybrids; however, there is a more generous amount of biomass produced and, consequently, higher carbon amount in the hybrid *Eucalyptus urophylla* × *E. camaldulensis* (VM01) (Table 2). Both in the species *Eucalyptus urophylla* and its hybrids, on average, carbon makes up half of the amount of below-ground biomass produced.

Table 2. Carbon concentration and amount (average ± standard deviation) of stumps in a hybrid of *Eucalyptus urophylla*.

	Below-ground biomass ¹	Carbon	
		Concentration	Amount
Clone	(kg stump ⁻¹)	(g kg ⁻¹)	(kg stump ⁻¹)

AEC 0144	36.0 ± 1.6b ²	483.5 ± 0.8 ^{ns}	17.4 ± 0.7c
AEC 0224	39.3 ± 0.8b	478.4 ± 1.3 ^{ns}	18.8 ± 0.4b
VM01	41.2 ± 0.7a	485.1 ± 0.3 ^{ns}	20.0 ± 0.3a

¹Published in [00]; ²Average values marked by different letters were shown to be significantly different by the Scott-Knott test ($p < 0.05$); ns = non-significant by *F* test ($p < 0.05$) in the analysis of variance.

The type of *Eucalyptus urophylla* hybrid does not influence the carbon concentration; however, there is a difference in the production of below-ground biomass and in carbon amount, which is higher in the trees of the hybrid *Eucalyptus urophylla* × *E. camaldulensis* when compared to the species *Eucalyptus urophylla* and hybrid *Eucalyptus urophylla* × *E. grandis*.

By producing a higher amount of mass with the same carbon concentration observed for the species *Eucalyptus urophylla* and hybrid *Eucalyptus urophylla* × *E. grandis*, the hybrid *Eucalyptus urophylla* × *E. camaldulensis* is more efficient of below-ground biomass conversion.

4. Discussion

Biomass production above and below ground varies according to species and can be influenced, especially by the water and nutritional availability of the site [22]. In the case of the present study, where the trees were cultivated under the same edaphoclimatic conditions, the highest biomass production below the ground of the hybrid *Eucalyptus urophylla* × *E. camaldulensis* occurs mainly due to intrinsic characteristics of this genetic material. One of the factors that result in higher biomass production is wood density, which is higher in the stump and roots of *Eucalyptus urophylla* × *E. camaldulensis*, compared to other clones evaluated (Table 1).

The higher biomass production below the ground of the hybrid *Eucalyptus urophylla* × *E. camaldulensis* was not related to higher productivity of the forest settlement (Table 1). The higher biomass production below ground, combined with the lowest productivity, are indicative results that the hybrid *Eucalyptus urophylla* × *E. camaldulensis* may present some limitations concerning site the edaphoclimatic conditions, besides that the nutritional requirements of this genetic material may not have been fully met. In situations of adequate availability of nutrients in the soil, trees invest more energy for the production of stem wood; on the contrary, the priority is to ensure the survival of the plant, which is promoted by the expansion of the root system [23], consequently, there is an increase in the amount of below-ground biomass and lower productivity.

In comparison with native forest ecosystems, fast-growing eucalyptus stands have a higher proportion of below-ground biomass and carbon, which is necessary for the production and maintenance of roots and mycorrhizas [24]. However, one of the main objectives of forestry is to maximize the production of above-ground biomass, and below-ground biomass can act as a carbon stock in the soil in the long term or be used as a bioenergy source, replacing fossil fuels [25]. Waste management should consider several aspects, as stump harvesting affects the carbon stock, which can cause an immediate reduction in the soil C amount, and also increase the CO₂ emission of soil organic matter through aeration and exposure of new surfaces [26].

The carbon concentration is directly related to the amount of biomass produced by the trees, representing in this and several studies [27, 15, 14, 13] on average, half of the structural composition of tree components (leaves, branches, stemwood, stembark, stump, and roots). In the present study, no variation in carbon content stems from *Eucalyptus urophylla* and hybrids (Table 2), as these clones were evaluated at the same age. The age factor of the trees is determinant for detecting the variation in carbon concentrations in biomass, which are evidenced in evaluations over time [15, 16].

On the other hand, the carbon amount determined according to biomass production was influenced by the type of hybrid (Table 2). The hybrid *Eucalyptus urophylla* × *E. camaldulensis* is also more efficient to mitigate atmospheric CO₂ emissions, due to the higher allocation of C in below-ground biomass. Consequently, it will incorporate a more significant amount of organic matter and carbon into the soil after stump and roots decomposition [26].

5. Conclusions

The hybrid type of *Eucalyptus urophylla* does not influence the carbon concentration; however, there is a difference in below-ground biomass production and carbon amount being higher for *Eucalyptus urophylla* × *Eucalyptus camaldulensis* when compared to the species *Eucalyptus urophylla* and hybrid *Eucalyptus urophylla* × *Eucalyptus grandis*.

Supplementary Materials: The following are available online at http://www.fepaf.org.br/Cont_Default.aspx?pub=1492.

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