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Initial assessment and nutritional status of hybrid *eucalyptus* sp. in the municipality of Colorado Do Oeste, Rondônia State - Brazil

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The objective of this research was to determine the initial growth, nutrition and soil fertility of *Eucalyptus* plantation in Rondônia State, Brazil. The treatments consisted of four hybrids (VM1, H13, GG100 and I144) and four replications, each plot contained 30 plants, totaling 480 plants. The VM1 clone was obtained from the hybrid of *Eucalyptus urophylla* x *Eucalyptus camaldulensis*, and the others, from the hybrid of *E. urophylla* x *Eucalyptus grandis,* all of which are minicutting source courtesy of a nursery in the region. The experiment was a completely randomized block design, as the area is homogeneous. Biometric evaluations consisted of measuring the BD (base diameter), total height and survival at six and 10 months of age. In September 2014, 20 newly mature leaves of every tree were collected from branches located halfway up the canopy, addressed to the quarter cardinal points. In this analysis, 10 trees of each working area of the plots, of each treatment, formed 16 composite samples for the analysis of macro- and micronutrients. Once collected, the leaves were placed in paper bags and sent for laboratory analysis. Hybrids showed no differences in the concentration of Fe, Mn and B (P> 0.05). The hybrid VM1 exhibited higher concentrations of K, Ca, Mg, S and N and intermediate concentration of P. Clones of *E. camaldulensis* x *E.urophylla* presented higher survival, height and diameter than clones of *E. urophylla* x *E. grandis.* There were differences between treatments for the height at six and 10 months after planting. For the base diameter, there was no significant difference at six months, but at 10 months, a significant difference was detected between treatments. The differences identified in this study for height growth, nutritional status, base diameter and survival in the seedling stage suggest the possibility of selecting genotypes of this crop for the region.

Key words: Development, genotypes, survival, clone, *Eucalyptus.*

INTRODUCTION

Silviculture, part of forest science, aims to the production and maintenance of forest stands in order to achieve the proposed goals within the prescribed period, to provide the benefits of forestry. The demand for forest products

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has existed since the dawn of history, whether to obtain energy, resins and pigments, and for the construction of houses. Consumption of wood and its derivatives is increasing and requires the introduction of reforestation using forest species with high productivity, enabling a cutting cycle within a short period of time. In this context, *Eucalyptus* sp. represents an alternative to supply this need. It is important to seek information to achieve better productivity in eucalyptus, noting the great diversity clones and hybrids used in different regions, which may generate different results. According to Pinto et al. (2011), the high number of species and clones of eucalyptus provides a high possibility of geographic and economic expansion, since these genetic materials are adapted to many different environmental and soil conditions and meet numerous types of economic exploitation. A large part of eucalyptus plantations is in degraded areas with low fertility, which requires a proper nutrient balance to achieve high productivity. The increase in productivity is related to breeding, system management and nutritional balance. Forest species differ in the ability to uptake, translocate, accumulate and use nutrients that influence their growth. These differences occur between species, origins, progenies, and even between clones of a given species (Godoy and Rosado, 2011). Among the species of eucalyptus, *Eucalyptus urophylla* and *Eucalyptus grandis* are the most used in controlled breeding program, which generate a commonly called genotype "urograndis", which allows the combination of the good traits of both in the segregating generation (Muro_Abad, 2000). According to Silva and Matos (2003), 11% of eucalyptus forest plantations are formed by hybrid *Eucalyptus urophylla* and *Eucalyptus grandis*.

Brazil has about 7.2 million hectares of planted forests, especially with species of *Eucalyptus* and *Pinus*, representing 92.8% of the total. This area corresponds to only 0.84% of the country area and 1.55% of the total area of forests (Abraf, 2013). Businesses in the Amazon region have few studies on eucalyptus, especially those intended for energy purposes, and the existing information is rarely released. Thus, the research of genetic materials is essential for the success of the activity in the region (Matos et al., 2012). In 2012, the Rondônia State, consumption of sawn logs was 2,234,206 m^3 and production was 1,328,945 m^3, generating a deficit of 905,261 m^3 (IBAMA, 2012). The distribution of forests planted with *Eucalyptus* and *Pinus* in the Rondônia State not even appeared in the surveys of ABRAF (2013), base year 2012, on the other hand the need for timber is evident. This observation demonstrates the need to strategically prepare the region for the foreseeable future, so that this can at least supply its domestic market. As a strategy to solve this problem, effective mechanisms in research and technology should be taken into, such as the Socio-Economic-Ecological Zoning -ZEE of the state. According to the ZEE Law of the Rondônia State (2000), Article 7 – The zone 1 composed of areas intended for agriculture, agroforestry and forest covers 120,310,48 km^2, equivalent to 50.45% of the total area of the State. These areas are preferably intended for forest plantations, mainly because they are classified as fragile soils of low fertility. Another point underlined in this law is the incentive to develop primary activities on deforested or inhabited lands, so the eucalyptus farming, as well as any other primary activity should not be encouraged in areas of natural forests but in areas already disturbed. In this way, it is important to evaluate the initial development of seedlings of *Eucalyptus* sp. and the concentration of nutrients in these for future soil amendment and guidance on the best hybrids for commercial planting in line with local conditions. Given the above, this study evaluated the initial development and nutritional status of seedlings of *Eucalyptus* sp. at six and 10 months old, in the Rondônia State.

MATERIALS AND METHODS

This work was conducted in the experimental limited to geographic coordinates 13°06'56"S and 60°29'22", municipality of Colorado do Oeste, Rondônia State, Brazil. The climate, according to Köppen classification, is Aw (Alvarez et al., 2013), tropical hot and humid, the months with higher rainfall are from January to March, with an average annual rainfall of 2,234 mm. The average annual temperature is 24°C, maximum of 36°C and minimum of 12ºC. The soil in the area is Red Argisol (EMBRAPA, 2006). The characterization of chemical properties and the particle size analysis was performed for 20 sampling points, wherein each five collections formed a composite sample for each depth collected (0-10, 10-20, 20-40, 40-60 cm), taken at random 30 days before planting (Table 1) and then sent for laboratory analysis.

Four hybrids of *Eucalyptus* were used, namely GG100 (Gerdau Group), I144 (Acesita) and VM1 (Vallourec and Mannesmann Brazil) and H13 (IP). The VM1 clone was obtained from the hybrid of *Eucalyptus urophylla* x *Eucalyptus camaldulensis*, and the others, from the hybrid of *Eucalyptus urophylla* x *Eucalyptus grandis,* all of which are minicutting source courtesy of a nursery in the region. The experiment was a completely randomized block design, as the area is homogeneous. The treatments consisted of four hybrids (VM1, H13, GG100 and I144) and four replications, each plot had 30 plants, totaling 480 plants. The distance between rows in the tree rows was 3 m, and the distance between the tree rows (number of trees arranged in the same row) of 10 m (distance chosen so that the machinery available in the institution could freely move in cases of cultural managements), with 2.5 m distance between trees in the row and three rows per tree rows. Biometric evaluations consisted of measuring the BD (base diameter), total height and survival at six and 10 months of age. In September 2014, 20 newly mature leaves of every tree were collected from branches located halfway up the canopy, addressed to the quarter cardinal points. In this leaves analysis, 10 trees of each working area of the plots, of each treatment, formed 16 composite samples for the analysis of macro and micronutrients. Once collected, the leaves were placed in paper bags and sent for laboratory analysis.

Regarding the elements N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn and B, chemical analyses were performed at private laboratories after sulfuric digestion of nitrogen, dry digestion of boron and perchloric digestion of the other elements. Nitrogen was determined by micro-Kjeldahl method, P and B elements were determined by

Table 1. Chemical characteristics of the soil used in the experiment, pH (hidrogenionic potential), OM (Organic Matter), P, K, Ca, Mg, Al, H + Al, S.B (sum of bases), CTC (Cation Exchange Capacity), V (base saturation), Cu, Fe, Mn, Zn.

Chemical characteristic	Unit	Depth (cm)			
		0-10	10-20	20-40	40-60
pH (in H_2O)	pH	6.40	6.40	6.60	6.60
OM*	g kg^{-1}	34.00	33.00	19.00	13.00
P	mg dm^{-3}	14.40	12.70	9.70	3.30
K	cmolc dm^{-3}	89.00	87.00	89.00	87.00
Ca	cmolc dm^{-3}	15.21	13.24	9.73	8.28
Mg	cmolc dm^{-3}	2.29	2.21	2.20	1.75
Al	cmolc dm^{-3}	0.00	0.00	0.00	0.00
H+Al	cmolc dm^{-3}	3.00	3.00	1.50	1.88
S.B.	cmolc dm^{-3}	17.70	15.70	12.20	10.30
CTC (pH 7.0)	cmolc dm^{-3}	20.70	18.70	13.70	12.10
V	%	85.50	83.90	89.00	84.50
Cu	mg dm^{-3}	6.50	7.20	6.80	5.40
Fe	mg dm^{-3}	155.00	176.00	119.0	109.00
Mn	mg dm^{-3}	88.70	88.30	86.50	80.90
Zn	mg dm^{-3}	15.20	18.60	11.20	9.00
Sand	g kg^{-1}	507.00	507.00	461.0	446.00
Silt	g g^{-1}	161.00	176.00	177.0	161.00
Clay	g kg^{-1}	332.00	317.00	362.0	393.00

* Recommendations for nitrogen fertilization is given by the percentage of organic matter in the area.

Table 2. Growth in diameter (GD) and height (H), survival (Surv) of origins of *Eucalyptus urophylla* × *Eucalyptus grandis* and *Eucalyptus urophylla* × *Eucalyptus camaldulensis* at six and 10 months of age, in Colorado do Oeste, Rondônia State.

Clone	GD (cm)		H (cm)		Surv (%)	
	6 months	10 months	6 months	10 months	6 months	10 months
VM1	13.41^a	23.57^a	122.12^a	189.05^a	100.00^a	99.16^a
GG100	10.67^a	14.51^b	92.44^b	123.63^b	100.00^a	99.19^a
H13	9.09^a	13.20^b	76.01^b	98.89^b	90.83^b	88.35^a
I144	10.78^a	14.32^b	81.68^b	104.71^b	91.66^{ab}	89.16^a
Mean	10.98	16.4	93.06	129.07	95.63	94.79
CV(%)	12.85	18.66	24.60	15.81	4.47	6.89

colorimetry, K by flame photometry and S by turbidimetry. Ca, Mg, Fe, Cu, Mn and Zn were determined by atomic absorption spectrophotometry indicated by Malavolta et al. (1997). Data were subjected to analysis of variance by F test (5%). Differences between the means were tested by Tukey's test at 5% probability.

RESULTS AND DISCUSSION

In the field, the clones showed a mean survival over 94% in the evaluation period (Table 2), indicating that they showed excellent ability to adapt to the environmental conditions of the site. These values are similar to those observed by Matos et al. (2012), who evaluated the initial development and nutritional status of eucalyptus clones in the northeastern Pará State at five and 18 m of age and found 3% mortality at five months and 11% at 18 m.

The lowest survival of the clones H13 and I144, which are genetic materials of *E. grandis* × *E. urophylla*, may be related to difficulties in adapting to the environmental conditions in the region or indicating that the water deficiency, common in the study region from April to October, was more limiting to the development of these genetic materials. Table 2 shows that the growth in height and base diameter revealed significant variations. In general, clones of *E. camaldulensis* × *E. urophylla* presented average height, base diameter and survival rate superior to those obtained in clones *E. grandis* × *E. urophylla.* Considering all the clones, values of mean height at six and 10 months were 0.93 and 1.29 m, respectively. Matos et al. (2012) found average height at

Table 3. Concentration of micronutrients in hybrids of eucalyptus VM1 (*E. urophylla* x *E. camaldulensis*) and H13, GG100, I144 (*E. urophylla* x *E. grandis*).

Hybrid	Micronutrients (mg kg^{-1})					
	B	Cu	Fe	Mn	Na	Zn
VM1	30.77[a]	2.12[b]	56.50[a]	228.7[a]	100[b]	23.65[a]
H13	32.37[a]	3.75[a]	87.25[a]	186.42[a]	377.7[a]	19.20[b]c
GG100	51.17[a]	3.33[ab]	75.25[a]	181.27[a]	371.5[a]	15.32c
I144	71.10[a]	2.42[ab]	72.25[a]	310.35[a]	296.7[a]	20.17[ab]
CV[a] (%)	46.99	23.99	25.84	40.29	29.40	9.67

Means followed by different letters in the same column are significantly different by Tukey's test at 5%. [a]Coefficient of variation, B, Cu, Fe, Mn, Na and Zn.

five months of 0.96 m, a result similar to the present study.

Accordingly, Macedo et al. (2000) stated that the potential capacity of establishment of fast-growing species can be usually found in the field in the first post-planting periods, evaluated by their survival percentage. Under field conditions, in general, seedlings of different tree species differ in their phenotypic expressions of adaptation and vigor. For Macedo et al. (2006), the differences observed between the average heights of clones evidence that they have different genetic capacities for exploiting the productive potential of the *habitat* of introduction, being probably related to their phenotypic plasticity. Martinez et al. (1993) point out that the different behavior as for the growth of plants of different varieties, grown under the same conditions, may indicate differences in the internal factors responsible for the nutritional efficiency of these genetic materials.

The hybrids presented different concentration of the micronutrients Cu, Na and Zn (P <0.05). The lowest concentration of Zn was found in GG100, followed by I144 and H13, which maintained an intermediate concentration of this element (Table 3). The lowest concentration of Zn may be because such micronutrient has low mobility in the plant, and may be at appropriate levels in soil and plant. Sgarbi et al. (1999) verified similar results when examined biomass production in eucalyptus species under deficiency of B and Zn, in which although Zn presents low mobility in the plant, the amount supplied until the first years was enough to maintain the concentration of this micronutrient at adequate levels in leaves.

The VM1 had lower concentration of Na and intermediate of Cu. The low content of Na can be associated with the traits related to use and uptake of nutrients, and thus the plant can absorb greater amounts of other nutrients. Caldeira et al. (2004) reported that Na has relatively low efficiency of use compared to other micronutrients, due to the high concentration in green leaves and internal translocation, returning to the soil through leaf litter, and again integrated into the biogeochemical cycle. Hybrids did not show differences in the concentration of Fe, Mn and B (P>0.05). This result is similar to that observed by Silva et al. (2008), which analyzed nutrients in eucalyptus treated with sewage sludge and reported no significant difference for Fe content in leaves between treatments. These results can be attributed to greater dilution of the element in the biomass of eucalyptus and the ability of trees to maintain a balance between the levels of this nutrient in the leaves, even with higher availability of the element in soil.

Boron (B) is very important for eucalyptus crops, because part of the plantations is intended to low fertility areas, with low boron concentration in the soil. Hybrids studied did not differ in relation to the concentration of that element, on the contrary to that observed by Barretto et al. (2007), who studied clones of *E. grandis x E. urophylla* and detected differences in boron use efficiency, with variation among clones and differently in each concentration of boron applied. This may be related to the concentration of this nutrient in soil; in this study area it can be properly distributed in the planting site, being absorbed uniformly by hybrids.

Moreover, there were differences in the concentrations of P, K and Ca (P<0.05) between hybrids (Table 4). The highest concentration of P and Ca and the lowest of K were found in the hybrid GG100. The Hybrid I144 showed lower absorption of P and K, followed by the hybrid H13 with intermediate values for P and K, both coming from *E. urophylla x E. grandis*. These variations may be related to the difference in absorption and translocation of nutrients among eucalyptus species, since they may behave differently according to soil and climatic conditions of the site chosen for planting.

As to macronutrients, the hybrid VM1 exhibited higher concentrations of K, Ca, Mg, S and N and intermediate concentration of P, compared to the other hybrids. This hybrid has its origin from the crossing between *E. urophylla* and *E. camaldulensis*, indicating that this species reached a better adaptation to the planting site, efficiently absorbing the nutrients available in the soil. For Pinto et al. (2011), regarding the translocation of nutrients to the shoot, VM1 stood out among the other eucalyptus clones, with the highest efficiency in the translocation of

Table 4. Concentration of macronutrients in hybrids of eucalyptus VM1 (*E. urophylla* x *E. camaldulensis*) and H13, GG100, I144 (*E. urophylla* x *E. grandis*).

Hybrid	Macronutrients (g kg^{-1})					
	N	P	K	Ca	Mg	S
VM1	12.92^{a}	1.7^{ab}	12.75^{a}	12.17^{a}	3.67^{a}	0.80^{a}
H13	15.00^{a}	1.6^{ab}	10.85^{ab}	9.17^{b}	3.17^{a}	0.75^{a}
GG100	15.35^{a}	2.12^{a}	9.97^{b}	11.95^{a}	2.92^{a}	0.47^{a}
I144	16.55^{a}	1.47^{b}	9.37^{b}	13.90^{a}	3.05^{a}	0.57^{a}
CV^{a} (%)	14.5	16.35	9.41	11.14	42.22	51.89

Means followed by different letters in the same column are significantly different by Tukey's test at 5%. [a]Coefficient of variation, N, P, P, Ca, Mg and S.

all macronutrients for the shoots of seedlings. In this sense, Zákia et al. (1983) studied the concentration of nutrients in eucalypt canopy and observed factors that could explain the differences in nutrient concentrations between the conventional and improved species, leading to the belief that improved trees compete strongly for water and light. This as in agroforestry systems, the trees are under constant competition, and so despite the high availability of nutrients from fertilization, only certain trees would have been able to metabolize them, and these trees are better adapted to the climate and soil conditions.

For N, Mg and S, there were no differences between hybrids (P> 0.05). In this way, the results may be related to the age of the plants, in which in the early years of development, the plants absorb more nutrients for the initial development. N is a key element for the initial development of the crop, accompanied by Mg that is part of the chlorophyll molecule and is essential for the photosynthesis and the development of the species. Cunha et al. (2009) point out that the assessment of nutritional status of eucalyptus under the influence of different genetic materials and the age of the tree showed that N deficiency is greater at the beginning of the crop cycle and it is required in higher concentrations, especially in division and cell elongation processes. Similar results were registered by Pinto et al. (2011), where clones with high efficiency in the uptake and translocation of nitrogen and sulfur are the hybrids GG100, I144 and VM1.

Conclusions

The differences identified in this study for growth in height, base diameter and survival at the seedling stage suggest the possibility of selecting genotypes of this crop for the region. The hybrid *E. urophylla* x *E. camaldulensis* showed better results for uptake of macronutrients, height, base diameter and survival compared to the other hybrids. The differences identified in this study as to the concentration of nutrients of *Eucalyptus* clones at the seedling stage allow the selection of genotypes for different conditions of soil fertility.In conclusion, there are differences in the uptake of micronutrients by the different hybrids studied; some of them have better ability to use these nutrients available in the soil. Thereby, adequate fertilization and proper management prevent the uptake of the nutrient pool of the soil by plants, with an efficient control of hybrids for the different regions.

Conflict of Interest

The authors have not declared any conflict of interest.

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