Performance of Two Hybrid Clones of *Eucalyptus* Planted under Five Spacings in the Araripe Plateau, Pernambuco, Brazil

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Abstract

This study aimed to evaluate the effects of different spacings on wood productivity of two hybrid clones of *Eucalyptus*, namely *E. brassiana* × *E. urophylla* and *E. grandis* × *E. camaldulensis*, in the Araripe Plateau. The field trials were established in February 2006 at the Experimental Station of Araripina (latitude: 7°27'50"S; longitude: 40°24'38"W, altitude: 828 m), belonging to the Agronomic Institute of the State of Pernambuco - IPA. Five spacings were tested: 3.0×2.0, 3.0×2.5, 3.0×3.0, 3.0×3.5 and 3.0×4.0 m. The experimental design adopted for both trials was randomized blocks with four replications and plots of 64 plants. The effective areas ranged from 216 to 432 m², and the total experimental area of 11,520 m². At the age of four years it was found that there were no statistical differences among the means for the variables evaluated in *E. brassiana* × *E. urophylla*. For survival, total height, DBH, wood production and mean annual increment the means were 93%, 14.8 m, 12.3 cm, 98.7 m³ ha⁻¹ and 24.7 m³/ha y⁻¹, respectively. For *E. grandis* × *E. camaldulensis*, the means for the same variables previously described were 89.4%, 13.9 m, 12 cm, 83.3 m³ ha⁻¹ and 20.8 m³/ha y⁻¹, respectively. Differently from the first, for this hybrid only the survival and height means did not differ significantly from each other. Specifically for DBH, it was noted that the highest value of 13.2 cm, corresponding to the spacing 3.0×4.0 m, did not differ statistically of 12.9 cm obtained from the spacing of 3.0×3.5 m. Nevertheless, these values were significantly different from the others. The highest production of wood was 105 m³ ha⁻¹ at the spacing 3.0×2.0 m, however, there is no significant difference comparing to 86.3 m³ ha⁻¹ achieved at the spacing 3.0×2.5 m. Likewise, the mean annual increment (MAI) increased inversely to the spacing. We concluded that the number of plants per hectare plays an emphatic role in increasing the wood productivity of these two hybrids at this stage of development.

INTRODUCTION

The Araripe Plateau constitutes an important geological formation situated at the border of the States of Pernambuco, Piauí and Ceará, Brazil, which is inserted within the “Caatinga” Biome (Steppe-Savannah). In terms of vegetation, several types of ecosystems in different proportions are found, such as Ombrophylous Forest, Deciduous Seasonal Forest, Savannah and “Carrasco” (similar to a dense Savannah) forming a typical mosaic. This complexity results a prominent environmental heterogeneity, modeled in the course of several geological periods (Giulietti et al., 2004).

Mineral reserves of gypsum are concentrated in that region and occupy approximately 20% (18,000 km²) of the surface of the State of Pernambuco. This is the largest production area of gypsum in Latin America and the second one in the world,
supplying roughly 95% of the domestic market. The gypsum processing is responsible for 93% of all energy consumption based on biomass and represents the main economic activity of the region.

Taking into account the local needs of energy, including calcinations of gypsum, timber for multiple uses and other kinds of utilization of the wood, studies were performed to get new options for wood production as an attempt to minimize the impact of human activities over the native vegetation. Recent numbers indicate that approximately 65% of the vegetation of the Araripe Plateau was suppressed by 2009. This imposes the immediate need of planting new energetic forests in order to reduce the pressure over the natural vegetation that remains still preserved. In this sense, deforested areas are the first candidates to be planted in order to attend the increasing regional energy and timber demands.

_Eucalyptus_ species are cultivated by approximately 100 countries around the world, but a few ones are planted extensively. Probably not more than 20 genetic materials, including pure species and some interspecific hybrids, have been used on a commercial basis in these countries (Pinto Junior and Ahrens, 2010). According to Global (2009) there are more than 20 million hectares of eucalyptus plantations in the world, distributed in the following proportions by the continents: Asia (40.78%), Americas (36.41%), Africa (11.65%), Europe (6.31%) and Oceania (4.85%). Brazil occupies the first position in the globe (21%), followed by India (19%) and China (13%).

Based on a recent survey done by the Brazilian Ministry of Environment, the nation had 519.5 million hectares of native forests, representing its different biomes and 6.9 million hectares of planted forests, from which 4.75 million hectares are _Eucalyptus_ (Abraf, 2011). The _Eucalyptus_ species have been commonly grown in Brazil, due to its fast growth, ease of management and good adaptation to different climate conditions of the country (Berger et al., 2002).

These features indicate that _Eucalyptus_ is a promising alternative for supplying the demand of wood in the Araripe Plateau, especially when hybrids of high potential of productivity are cultivated in association with the use of spacings properly fitted to the local conditions.

From the silvicultural point-of-view, the choice of an appropriate spacing for a given plant species or clone is very important because of its effect over the amount of natural resources available for each plant, which influences the survival, growth rate and wood productivity, modifying as a result the management and harvesting practices and also the forest production costs (Silva, 2005).

Another important factor in determining the spacing is the purpose of the plantation. In the case of production of pulpwod, fence posts or energy - firewood and charcoal - smaller spacings can be used and a rotation age of seven years is usual. For the production of saw logs, transmission poles and other more valuable products, larger spacings are useful. This requires that the technological level must be compatible, including the correct choice of the species to be planted, the use of selective thinning and the delay for clear cutting the trees, normally done when the plants reach at least 12 years of age (Creastana and Moreira, 2009).

This study aimed to evaluate the effects of five different spacings on survival, rate of growth and wood production of two hybrids of _Eucalyptus_ in the region of Araripe Plateau, State of Pernambuco, Brazil.

**MATERIAL AND METHODS**

The field trials were established in February 2006 at the IPA’s Experimental Station, located in the municipality of Araripina-PE (latitude: 7°27’50”S; longitude: 40°24’38”W, altitude: 828 m). The mean annual rainfall of the region is 752 mm, concentrated between February and April. For temperature, evaporation and relative humidity, the annual means are 24°C, 1,127 mm and 55%, respectively. The spacings tested were: 1) 3.0×2.0 m, 2) 3.0×2.5 m, 3) 3.0×3.0 m, 4) 3.0×3.5 m and 5) 3.0×4.0 m. The genetic materials utilized were two hybrid clones of _Eucalyptus: E. brassiana ×
E. urophylla (Fig. 1) and E. grandis × E. camaldulensis (Fig. 2).

The clonal seedlings were produced by the nursery of the company Suzano Papel e Celulose (Suzano Pulp and Paper Co.). The experimental design for both trials was randomized blocks with four replications. The experimental area was submitted to the following operations prior to planting: plowing, harrowing and subsoiling up to 40 cm depth within the row; application of 2 ton ha⁻¹ of lime, incorporated into the soil; and finally, the addition of 150 g per plant of NPK (06:24:12) as basal fertilization. Each plot was formed by 64 plants, whose effective areas ranged from 216 to 432 m², depending on the spacing used, and totaling 11,520 m² of experimental area. At four years of age the trees were measured for survival (%), total height (m) and diameter at breast height - DBH (cm). The data were then submitted to analysis of variance and the means compared by using the Tukey test at 5% of probability level.

RESULTS AND DISCUSSION

The means for survival (%), total height (m), DBH (cm), wood production (m³ ha⁻¹) and mean annual increment - MAI (m³ ha⁻¹ y⁻¹) of the hybrid E. brassiana × E. urophylla at different spacings did not differ statistically each other (Table 1). It was also observed that the survival was 93%, ranging from 89 to 97% for the spacings 3.0×2.5 m and 3.0×3.5 m, respectively. The mean growth in height, 14.8 m, ranged from 14.2 to 15.1 m and this variable showed to be very uniform. For DBH, whose overall mean was 12.3 cm, the values ranged from 11.6 cm (3.0×2.0 m) to 13.4 cm (3.0×4.0 m). The wood production tended to be higher for the smallest spacing (3.0×2.0 m), resulting a volume of 121 m³ ha⁻¹, equivalent to a mean annual increment of 30.4 m³ ha⁻¹ y⁻¹, while the largest spacing (3.0×4.0 m) the wood production obtained was 86.7 m³ ha⁻¹, corresponding to a MAI of 21.7 m³ ha⁻¹ y⁻¹. Based on these findings, it is feasible to say that there is no serious competition among the plants in this phase of their development.

The Table 2 shows the results for the hybrid E. grandis × E. camaldulensis at the same age. The survival and height means did not differ significantly from each other. For these variables, the overall means were 89.4% and 13.9 m, respectively. Specifically for DBH, it was noted that the highest value of 13.2 cm, corresponding to the spacing 3.0×4.0 m, did not differ statistically of 12.9 cm obtained from the spacing of 3.0×3.5 m. Nevertheless, these values were significantly different from the others. The wood production of 105 m³ ha⁻¹ from the spacing of 3.0×2.0 m was the best one and superior to the other spacings, even though no significant difference was found when comparing to the value of 86.3 m³ ha⁻¹ achieved in the spacing 3.0×2.5 m. Likewise, the mean annual increment (MAI) increased inversely to the spacings. It was also noted that the number of plants per hectare was of a primordial importance for increasing productivity at this stage of development.

ACKNOWLEDGEMENTS

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Literature Cited

Agricultura “Luiz de Queiroz”. Universidade de São Paulo, Piracicaba.


**Tables**

**Table 1.** Survival, growth, wood production and productivity at the age of 4 years old for the hybrid *E. brassiana × E.urophylla* planted in the Araripe Plateau, Pernambuco, under five spacings.

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Survival (%)</th>
<th>Total height (m)</th>
<th>DBH (cm)</th>
<th>Wood production (m³ ha⁻¹)</th>
<th>MAI (m³/ha y⁻¹)</th>
</tr>
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<td>3.0×2.0 m</td>
<td>89 a</td>
<td>15.0 a</td>
<td>11.6 a</td>
<td>121.6 a</td>
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<td>3.0×2.5 m</td>
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<td>14.6 a</td>
<td>11.7 a</td>
<td>104.7 a</td>
<td>26.2 a</td>
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<tr>
<td>3.0×3.0 m</td>
<td>93 a</td>
<td>14.2 a</td>
<td>11.8 a</td>
<td>86.8 a</td>
<td>21.7 a</td>
</tr>
<tr>
<td>3.0×3.5 m</td>
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<td>15.1 a</td>
<td>12.8 a</td>
<td>93.6 a</td>
<td>23.4 a</td>
</tr>
<tr>
<td>3.0×4.0 m</td>
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<td>15.0 a</td>
<td>13.4 a</td>
<td>86.7 a</td>
<td>21.7 a</td>
</tr>
<tr>
<td>Mean</td>
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<td>14.8</td>
<td>12.3</td>
<td>98.7</td>
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<td>5.2</td>
<td>7.3</td>
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<td>25.3</td>
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</table>

* Values followed by the same letter in the column are statistically not different by the Tukey test at 5% of probability level.

**Table 2.** Survival, growth, wood production and productivity at the age of 4 years old for the hybrid *E. grandis × E. camaldulensis* planted in the Araripe Plateau, Pernambuco, under five spacings.

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Survival (%)</th>
<th>Total height (m)</th>
<th>DBH (cm)</th>
<th>Wood production (m³ ha⁻¹)</th>
<th>MAI (m³/ha y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0×2.0 m</td>
<td>91.3 a</td>
<td>14.0 a</td>
<td>11.0 b</td>
<td>105.0 a</td>
<td>26.2 a</td>
</tr>
<tr>
<td>3.0×2.5 m</td>
<td>97.2 a</td>
<td>13.4 a</td>
<td>11.0 b</td>
<td>86.3 ab</td>
<td>21.6 ab</td>
</tr>
<tr>
<td>3.0×3.0 m</td>
<td>92.0 a</td>
<td>13.6 a</td>
<td>11.7 b</td>
<td>78.2 b</td>
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<td>3.0×3.5 m</td>
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<td>73.9 b</td>
<td>18.5 b</td>
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<tr>
<td>3.0×4.0 m</td>
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<td>14.1 a</td>
<td>13.2 a</td>
<td>73.2 b</td>
<td>18.3 b</td>
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<td>12.0</td>
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<td>4.9</td>
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</table>

* Values followed by the same letter in the column are statistically not different by the Tukey test at 5% of probability level.
Figures

Fig. 1. Four-year-old hybrid of *E. brassiana* × *E. urophylla* growing in the Araripe Plateau, Pernambuco, Brazil.

Fig. 2. Four-year-old hybrid of *E. grandis* × *E. camaldulensis* growing in the Araripe Plateau, Pernambuco, Brazil.