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ORIGINAL ARTICLE – Silviculture

Silvicultural Performance of Four Native Forest Species as a Function of Pruning Intensity

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Abstract

Basic information about growth rate and response to silvicultural treatments on potential native species are bottlenecks for the wide use of these species for forest production. In this context, the objective of this work was to evaluate the silvicultural performance of four native species as a function of pruning intensity. The experimental design was completely randomized with ten replications and one plant per plot, in a 4 x 4 factorial scheme, four forest species, and four pruning intensities. At 30 and 42 months, height (H) and diameter at breast height (DBH) were evaluated, then the current annual increment (CAI) was calculated, as well as the mean annual increment (MAI) at 42 months. *Guazuma ulmifolia* showed higher growth in height and DBH compared to other species at both ages. The pruning resulted in a reduction of MAI in 0.15 cm. year-1 in DBH for every 25% of pruning intensity.

Keywords: Pruning, *Guazuma ulmifolia*, *Cordia trichotoma*, *Peltophorum dubium*, *Joannesia princeps*.

1. INTRODUCTION AND OBJECTIVES

In scenarios where the use of native species is part of the requirement for forestry implantation, such as the Legal Reserve in Brazil, the exploration of forestry products becomes a promising alternative to make reforestation projects economically viable (Brancalion et al., 2012). Despite this model appearing as an efficient strategy, the lack of knowledge about native species silviculture restrains its usage (Brancalion et al., 2015; Carneiro et al., 2017).

The absence of this detailed information prevails the interest in planting exotic species, especially those of the *Eucalyptus* and *Pinus* genera, due to the available silvicultural knowledge on these genera (Assis et al., 2013; Stuepp et al., 2018) and a consolidated market. This incentive to exotic species cultivation not only underestimates the market potential of native species but also limits their conservation, since many of these species are rare due to irrational exploitation, resulting in its local extinction in several regions (Mendonça et al., 2017).

According to Oliveira et al. (2021), many native species in favorable environmental conditions and if submitted to adequate silvicultural management present satisfactory potential for wood production in forest restoration plantations. Furthermore, the correct use of silvicultural treatments accelerates growth and reduces the cutting cycle (Sist et al., 2014).

Among the silvicultural treatments, pruning promotes wood free from knots with greater strength, durability, and beauty. The pruning management reduces and concentrates the incidence of knots in the wood and, therefore, results in higher added-value products (Oliveira et al., 2020). Pruning management is relevant, especially in the plantations where the species do not have natural pruning (Oliveira et al., 2012).

However, due to the reduction of the photosynthetically active area of the plant, pruning can compromise its growth in diameter and height (Fontan et al., 2011). Such effect was observed by Cezana et al. (2012) in hybrids of *Eucalyptus urophylla* x *Eucalyptus grandis*, noting the relationship between the increase in pruning intensity and the reduction in plant diameter and height growth. The pruning response may vary in different species and different crown architecture. Therefore, studies to define the influence of pruning intensity, especially in native species, are crucial.

In this context, the present study aimed to evaluate the silvicultural performance of four native species as a function of pruning intensity.

2. MATERIALS AND METHODS

The experimental area, located at Pirilampo Ranch on Ijaci - MG (21° 09' 26.60"S and 44° 56' 07.15"O), has Dark Red Latosol soil, an average altitude of 875 m and, Cwb climate, according to Koppen's classification. The average annual temperature is 19.4 ºC, varying between 15.8 ºC and 22.1 ºC for the months of July and February, respectively, and with total annual precipitation of 1530 mm (Alvares et al., 2013).

The experiment happened in a mixed-species even-aged stand, with a spacing of 3 x 1.5 m, implemented in 2018 to convert a crop field into a productive Legal Reserve (a mandatory native forest parcel). The soil preparation consisted of harrowing, a subsoiling with 40 cm depth, and base fertilization using 150 g of simple superphosphate per planting hole.

The treatments were four tree species (*Guazuma ulmifolia* Lam. (mutamba), *Cordia trichotoma* (Vell.) Arrab. (louro pardo), *Peltophorum dubium* (Speng.) (angico amarelo) and *Joannesia princeps* Vell. (cotieira)), and four pruning intensities (0, 25, 50, and 75%).

The pruning intensities were performed at 20 months and repeated at 32 months after planting, based on the proportion of individuals' total height (Table 1). At 18 months, the species had a mean height (H) and diameter at breast height (DBH) of 5.26 m; 2.43 cm for *G. ulmifolia*, 2.98 m; 1.06 cm for *C. trichotoma*, 3.82 m; 1.71 cm for *P. dubium*, and 3.91 m; 1.76 cm for *J. princeps*.

Table 1. Mean height before each pruning operation and height of pruning according to pruning intensities for each tree species at each pruning operation in Ijaci – MG.

	Guazuma ulmifolia		*Cordia trichotoma*		*Peltophorum dubium*		*Joannesia princeps*	
Pruning intensities	18 months	30 months	18 months	30 months	18 months	30 months	18 months	30 months
0%	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m	0.00 m
25%	1.32 m	1.96 m	0.75 m	1.48 m	0.96 m	1.68 m	0.98 m	1.73 m
50%	2.63 m	3.93 m	1.49 m	2.97 m	1.91 m	3.35 m	1.96 m	3.46 m
75%	3.95 m	5.89 m	2.24 m	4.45 m	2.87 m	5.03 m	2.93 m	5.18 m
Mean height	5.26 m	7.85 m	2.98 m	5.93 m	3.82 m	6.70 m	3.91 m	6.91 m

The experimental design was completely randomized, with ten replications and one plant per plot, in a factorial scheme 4 (tree species) x 4 (pruning intensities). The assessment of the trees' growth was after pruning at 30 and 42 months old. The height measurement was by a graduated ruler and the diameter at breast height with a measuring tape. The current annual increment (CAI) for H and DBH for each period (Equation 1) and the mean annual increment (MAI) for H and DBH at 42 months (Equation 2) were estimated.

$$\mathrm{CAI} = \mathrm{Y}_2 - \mathrm{Y}_1 \quad \text{(Equation 1)}$$

Where, = final H or DBH, and = initial H or DBH.

$$\mathrm{MAI} = \frac{\mathrm{Y}}{\mathrm{I}} \quad \text{(Equation 2)}$$

Where, = final H or DBH, and I = final age.

All the data were submitted to analysis of variance (ANOVA). To differentiate species was applied the Scott-Knott test ($p< 0.05$). For pruning, were performed regression analysis. All statistical analysis were supported by the SISVAR software (Ferreira, 2019).

3. RESULTS AND DISCUSSION

There was no significant interaction between species and pruning. The species showed a significant difference in all parameters analyzed, except for the current annual increase in height (CAI H) (Table 2). The pruning intensities had a significant effect on the CAI DBH, the DBH at 42 months, and the MAI DBH. The experimental variation coefficient ranged from 11.97% to 41.64%, with most parameters below 27% (Table 2).

There was a statistical difference, by the Scott-Knott test ($p<0.05$), regarding the growth of species in all analyzed parameters (Table 3). The species exhibited a distinct growth rate in DBH, with a clear distinction between their values. The differences between species did not change throughout the evaluations, highlighting, in descending order of DBH, the species *Guazuma ulmifolia*; *Joannesia princeps*; *Peltophorum dubium*, and *Cordia trichotoma* (Table 3).

Table 2. Summary of the analysis of variance for diameter at breast height (DBH), Height (H), current annual increment (ICA) at 30 and 42 months after planting and, mean annual increment (MAI), for different species and intensity of pruning, in Ijaci – MG.

FV	DF	Mean Square									
		30 months				42 months				MAI	
		DBH	H	CAI DBH	CAI H	DBH	H	CAI DBH	CAI H	DBH	H
Specie (S)	3	263*	24.40*	163.95*	1.25	508*	57.06*	43.15*	7.86*	56.50*	6.35*
Pruning (P)	3	6.59	0.73	7.59*	0.38	16.04*	1.01	3.16	0.42	1.78*	0.11
S x P	9	1.54	0.65	1.71	0.38	3.53	1.54	0.90	0.89	0.39	0.17
CV (%)		16.86	11.97	19.21	26.43	16.11	12.35	40.38	41.64	16.12	12.36
Mean		10.06	6.83	8.33	2.85	13.34	8.93	3.28	2.10	4.45	2.98

*: significant at the 5% probability level by the F test;

Table 3. Influence of pruning on the species *Guazuma ulmifolia*, *Joannesia princeps*, *Peltophorum dubium*, and *Cordia trichotoma* for the dendrometric variables DBH, H, CAI DBH, CAI H, and MAI of DBH and H, at 30 and 42 months.

Species	30 months			42 months				MAI	
	DBH (cm)	H (m)	CAI DBH (cm)	DBH (cm)	H (m)	CAI DBH (cm)	CAI H (m)	DBH (cm)	H (m)
Cordia trichotoma	7.20 d	5.93 c	6.15 d	9.17 d	7.38 c	1.97 c	1.45 b	3.06 d	2.46 c
Peltophorum dubium	9.31 c	6.70 b	7.59 c	12.29 c	8.92 b	2.99 b	2.22 a	4.10 c	2.97 b
Joannesia princeps	10.46 b	6.91 b	8.69 b	14.37 b	9.20 b	3.91 a	2.29 a	4.79 b	3.07 b
Guazuma ulmifolia	13.44 a	7.85 a	11.01 a	17.76 a	10.31 a	4.32 a	2.46 a	5.92 a	3.44 a

Means followed by the same letter in the column do not differ significantly by the Scott-Knott test ($p < 0.05$). DBH: diameter at breast height; H: tree height; CAI: current annual increment; MAI: mean annual increment.

The height growth patterns also occurred differently between species and maintained the same order as presented at DBH (Table 3). *Guazuma ulmifolia stands out with the tallest trees and Cordia trichotoma with the smallest growth in height*, *Joannesia princeps* and *Peltophorum dubium* had no statistical differences for height growth.

It is interesting to highlight the significant reduction in the CAI in DBH between the assessments at 30 and 42 months (Table 3), with a decrease of 60.76% for *Guazuma ulmifolia*, 55% for *Joannesia princeps*, 60.60% for *Peltophorum dubium*, and 67.96% for *Cordia trichotoma*. The current annual increment in height among species did not vary much (Table 3), with only *Cordia trichotoma showing statistically lower values than the other species.*

The mean annual increment followed the same pattern as the total values in DBH and H (Table 3), highlighting the species *Guazuma ulmifolia with a mean growth of 5.92* cm.year^{-1} and 3.44 m.year^{-1}, in DBH and H, respectively. The smallest annual increments were observed in *Cordia trichotoma*, with 3.06 cm and 2.46 m, in DBH and H, respectively. The pruning intensity effect was more expressive in the variables linked to DBH, with statistical differences being found for the CAI in DBH at 30 months, for DBH at 42 months, and the MAI in DBH (Table 2). The regressions showed a negative linear behavior for the variables CAI DBH at 30 months, DBH at 42 months, and MAI in DBH for increasing pruning intensity (Figure 1).

For each 25% increase in the pruning intensity, there was a decrease of 0.3 cm for the CAI DBH at 30 months, 0.47 cm for the DBH at 42 months, and one reduction of 0.15 cm.year^{-1} in the MAI DBH. The application of 75% pruning intensity resulted in a reduction in the MAI in DBH of 9.60% (0.45 cm.year^{-1}) in comparison to the treatment of 0% pruning intensity (Figure 1).

The different growth rates presented by the species are related to the successional groups and their correlation with evolutionary biology and ecology. Plants classified as pioneers play the primary role in colonization and formation of forest physiognomy in open areas. Pioneers species are well suited to environments with abundant light and space, with rapid growth as their main characteristics. Luminosity is the principal growth factor for pioneer species (Rigueira et al., 2012). The higher growth rate of *Guazuma ulmifolia* may be associated with the fact that it is classified as a pioneer species, as reported by Corrêa et al. (2014).

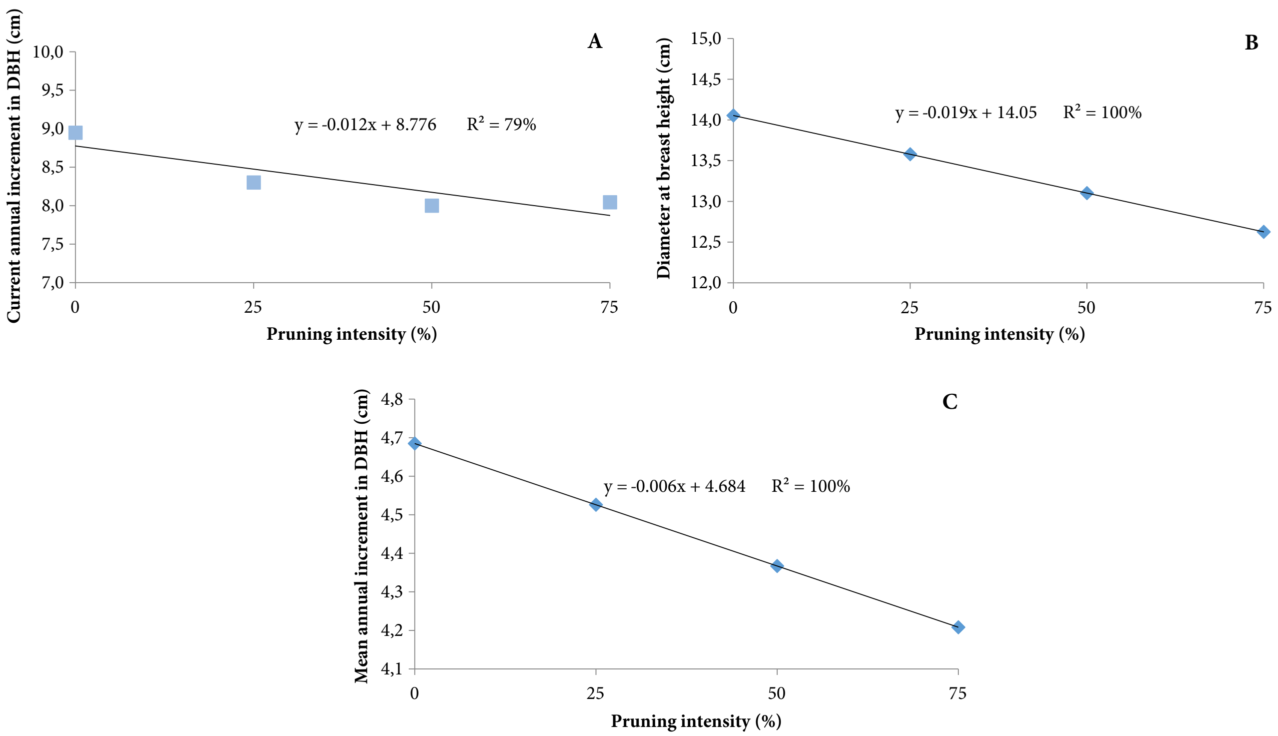

Figure 1. Influence of pruning intensity for the variables: Current annual increment in DBH at 30 months (A), diameter at breast height (DBH) at 42 months (B), and mean annual increment in DBH (C).

There is no consensus on the nomenclature of other successional groups. However, the prevalent idea is that non-pioneer species have slower growth rates. Silva et al. (2016) classify *Peltophorum dubium* and *Joannesia princeps* as initial secondary, a group with intermediate dependence on light for their growth (Callegaro et al., 2015). Both species showed a similar growth rate, not being statistically different in MAI for height. However, *Joannesia princeps* presented a distinguished mean annual increase in diameter, probably due to its greater crown density and, consequently, more production of photoassimilates. *Cordia trichotoma* is classified as a non-pioneer species by Corrêa et al. (2014), while Schneider et al. (2006) identified it as an initial secondary. However, the slower growth rate of the species when compared to the others is evident.

It is possible to notice that the pruning intensity affected, above all, the growth in diameter of the individuals, with a tendency towards smaller values with the increase in the pruning intensity. This phenomenon could be explained by the photosynthetic surface of the plant reduction by the pruning technique, which reduces the supply of carbohydrates and growth regulators produced in the crown (Pires et al., 2002).

However, the effect of pruning is not a consensus. In clones of *Tectona grandis*, Seta et al. (2021) found that pruning up to 66% of crown height did not negatively affect plant growth in diameter and height. In clones of *Populus* × *canadensis* the pruning affect diameter until the 10th year after plantation, where unpruned and pruned trees match (Danilović et al., 2022). This slow recovery is because the pruned plants invest first in the recovery of the crown and, later, they resume diameter growth (Machado et al., 2014). In *Pinus radiata*, Hevia et al. (2016) observed a reduction in mean diameter increment of 11.6% after one year of 29-37% of live crown removed. This reduction was similar to the found in this work, of 10.14%, for the 75% intensity pruning.

The regression showed a tendency to reduce the values linked to the diameter when increased crown removal intensity (Figure 1). Similar results were found by Bhargava & Rai (2019), in *Dalbergia sissoo*, where the growth values were inversely proportional to the pruning intensity. Pires et al. (2002) observed losses in the growth of *E. grandis* with pruning intensities above 50%. In general, the application of severe pruning can reduce the diameter and height growth (Hevia et al., 2016; Bhargava & Rai, 2019; Danilović et al., 2022) due to the crown reduction and, consequently, declining the photosynthetic area of the plant.

It was possible to note the effects of crown removal on the DBH growth for *G. ulmifolia*, *J. princeps*, *P. dubium*, and *C. trichotoma*. However, the more intense pruning (75%) resulted in a reduction of 0.45 cm.year^{-1} in DBH (9.60%), making the decision for the most drastic intervention in pruning a management strategy for the production of wood with higher added value.

Thus, the cost and complexity associated with pruning increase with the height to be pruned. and the quality of the final product is a function of the quantity of knot-free wood (Dobner Júnior, 2022). Therefore, deciding pruning intensity must be guided by the number of pruning operations and the final height to be pruned. Thus, more drastic interventions, such as 75%, would result in fewer pruning operations, but in a reduction in the growth in DBH, 9.60%, in this study. Less drastic interventions, such as 25%, would require additional pruning operations however, smaller growth reductions in DBH, 3.20% in this study.

The species *P. dubium* and *C. trichotoma* are of greater economic interest due to the better quality of the wood (Campos Filho & Sartorelli, 2015) and, therefore, the application of pruning to increase the quality of the final product is justified. The species *G. ulmifolia* and *J. princeps* have more appeal for energy production and can be used in agroforestry plantations (Campos Filho & Sartorelli, 2015). Within these systems, pruning is also intended to manage the entry of light between the lines, thus favoring the growth of intercropped agricultural species (Bohn Reckziegel et al., 2021).

Therefore, pruning must consider aspects such as the valuation of the final product and payment for the quality of the wood to justify its application since the use of the technique for species of lesser economic interest may not be economically viable.

4. CONCLUSIONS

1. There was no influence on the growth characteristics analyzed as a function of the interaction between the four species and the pruning intensity during the experimental period.
2. The species *Guazuma ulmifolia* showed the best growth in height and diameter, followed by the species J*oannesia princeps*, *Peltophorum dubium*, and *Cordia trichotoma*, respectively.
3. There was a linear reduction in diameter growth at breast height to pruning intensity, with a decrease of 0.15 cm.year^{-1} for every 25% pruning intensity.

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