Scientia
Forestalis

Influence of spacing on some physical properties of *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke)

Influência do espaçamento sobre algumas propriedades físicas da madeira de *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke)

Luiz Eduardo de Lima Melo[1], Cláudia de Jesus Silva[2], Thiago de Paula Protásio[3], Paulo Fernando Trugilho[4], Iedo Souza Santos[1] e Cláudia Viana Urbinati[1]

Resumo

Em virtude principalmente de seu rápido crescimento a espécie *Schizolobium parahyba* var. *amazonicum* (paricá) têm se destacado em plantios comerciais na região Norte do Brasil. Entretanto, a escolha do espaçamento ideal, no qual se obtenha uma maior proporção de madeira e melhor qualidade é uma questão a ser considerada nas pesquisas de manejo florestal do paricá. O objetivo do trabalho foi verificar a influência do espaçamento na densidade básica, contrações lineares – radiais e tangenciais, contração volumétrica e fator anisotrópico da madeira de paricá, aos 9 anos de idade, bem como a variação no sentido medula-casca destas propriedades. Utilizou-se delineamento experimental inteiramente casualizado disposto em esquema fatorial 2 x 4 (2 espaçamentos e 4 posições radiais) e 5 repetições nos espaçamentos de 4 x 4m e 8 x 4m, totalizando 10 árvores amostradas, obtidas no município de Garrafão do Norte/PA. De cada árvore foram retirados discos de 8 cm de espessura a 1,30 do nível do solo. De cada disco foram obtidas amostras em quatro posições no sentido medula-casca: a 0% (próximo à medula), a 33 e 66% do raio, e a 100% (na periferia do fuste). Os resultados indicaram que o espaçamento entre árvores não influenciou significativamente as propriedades físicas. Observou-se também aumento da densidade básica e contração tangencial no sentido medula-casca, sendo o contrário observado para a contração radial. Não foram observadas diferenças significativas para a contração volumétrica e o fator anisotrópico em função da posição radial.

Palavras-chave: Paricá, densidade básica, retratibilidade, espaçamento inicial.

Abstract

Schizolobium parahyba var. *amazonicum*, which is known in Brazil as paricá, has been highlighted in commercial plantations in Northern Brazil, mainly due to its fast growth. However, the choice of the ideal spacing, in which a higher proportion of good quality wood is obtained, constitutes an issue to be considered in research on paricá forest management. The objective of this study was to verify the influence of spacing on basic density, tangential and radial shrinkage, volumetric shrinkage and anisotropic factor of 9-year-old paricá wood, as well as variation of such properties from pith to bark. An entirely randomized design was used, arranged in a 2 x 4 factorial scheme (2 spacings and 4 radial positions) and 5 replications in 4 x 4m and 8 x 4m spacings, with a total of 10 sample trees obtained in the municipality of Garrafão do Norte/PA. In each tree were obtained 8-cm thick disks were obtained at 1.3m from ground level. The radial position from pith to bark was divided into four parts: at 0% (near the pith), at 33 and 66% along the radius, and at 100% (near the bark). The results indicated that spacing among trees had no significant effects on physical properties. Basic density and tangential shrinkage showed an increasing trend from pith to bark, while the reverse trend was observed for radial shrinkage. Significant differences were not observed for volumetric shrinkage and anisotropic factor as a function of radial positions.

Keywords: Paricá, basic density, shrinkage, spacing.

[1]UEPA - Universidade do Estado do Pará. Departamento de Tecnologia e Recursos Naturais. Caixa Postal 479 - 66095-100, Belém, PA. E-mail: luizmelo@uepa.br; iedosantos@gmail.com; urbinatiuepa@gmail.com.

[2]Graduação em Tecnologia Agroindustrial ênfase em Madeira. UEPA - Universidade do Estado do Pará. Departamento de Tecnologia da Madeira. Caixa Postal 479, CEP: 66095-100, Belém, PA – Brasil. E-mail: claudia_jsilva@yahoo.com.br

[3]UFG - Universidade Federal de Goiás. Regional Jataí – Câmpus Jatobá - 75801615 - Jataí, GO – Brasil. E-mail: depaulaprotasio@gmail.com

[4]UFLA - Universidade Federal de Lavras. 37200-00, Lavras, MG - Brasil. E-mail: trugilho@dcf.ufla.br

INTRODUCTION

The source of raw material for the forest-based industry in Southern and Southeastern Brazil is established with the reforestation of *Eucalyptus* and *Pinus* species, mainly for the production of charcoal, cellulose and board (ABRAF, 2011). However, in the Northern region, where some of these activities are still under development or do not exist, plywood industries are predominant, and they use *Schizolobium parahyba* var. *amazonicum* wood. *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke), or Barneby tree, is known as paricá in Brazil.

Paricá is indicated for commercial plantations and reforestation of degraded areas because of its good performance and fast growth, in homogeneous plantations, as well as agroforestry systems. It can reach from 15 to 40 meters in height and 50 to 100 centimeters in diameter at breast height; in commercial plantations at 6 years of age trees have an approximate height of 18 m at a diameter of approximately 12 cm (SOUZA et al., 2003). Paricá wood may be used in the production of lining, matchsticks and canoe manufacture, and is considered promising for obtaining cellulose and paper, mainly because of the easy whitening and excellent resistance obtained with the white paper (LE COINTE, 1947; PEREIRA et al., 1982; RIZZINI, 1971).

However, despite the wide range of use, planted paricá forests have been basically destined to industries which produce laminates, and more recently mixed with other species for the production of MDF (Medium Density Fiberboard), which shows the scarcity of information about the quality of the wood produced in forest plantations.

It is important to know the influence of silvicultural practices on wood properties of this species, because paricá plantation programs are still in their initial stages. It is also necessary to understand internal variations as preliminary and indispensable parameters for technological evaluation of wood, and, consequently, provide a better quality for the raw material.

In this context, research has shown that any change in plantation spacing may significantly influence the properties of the produced wood and, when this practice is linked to the growth rate characteristics of trees, they may be useful for deciding when and how much wood must be cut in order to obtain the necessary quantity and ideal quality (FUJIMOTO; KOGA, 2009; LIMA et al., 2009).

Therefore, the objective of this study was to evaluate the effect of plantation spacing on some physical properties of *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke): basic density, radial and tangential shrinkage, volumetric shrinkage and anisotropic factor, as well as variations of the mentioned attributes from pith to bark.

MATERIAL AND METHODS

The material was obtained from a 9 year-old plantation, located in the municipality of Garrafão do Norte, in the state of Pará (01° 55′45″ S and 47° 03′24″ W). The soil of the area is medium texture yellow latosol. The average annual rainfall and temperature are 2,800 mm and 26°C, respectively. The driest period is September to December, and the rainy period from January to May (PACHECO et al., 2011).

In order to obtain an approximate average diameter of trees within the 4 x 4 m and 8 x 4 m spacing, 25 randomly selected individuals were measured at 1.30 m from ground level of in each spacing. Then, five trees were collected within the spacing of 4 x 4 m and 8 x 4 m, for a total of ten individuals sampled. The mean diameter values were 23.49 cm for the 4 x 4 m spacing and of 25.40 cm for the 8 x 4 m spacing.

In each tree were obtained 8-cm thick disks at 1.3 m from ground level were obtained from each tree. Four positions were taken from pith to bark in the discs: near the pith, at 0%, at 33 and 66% along the radius, at 100% near the bark. Four replications were obtained at each position, with a total of 160 specimens analyzed.

Samples were then water-saturated by a vacuum pump for about 6 hours. They were then weighed in a semi-analytical scale, with a sensitivity of 0.01 g; the linear dimensions (radial and tangential) were measured with a 0.01mm digital caliper. The volume was determined by the hydrostatic balance method. Afterwards, the specimens were oven dried at 103±2 °C for measurements of anhydrous weight, dimensions and volume.

The basic density, shrinkage in radial and tangential directions and volumetric shrinkage were determined according to the assay proceedings specified by NBR 7190/97 of ABNT (ABNT, 1997). The nominal dimensions of the specimens were 2 cm x 2 cm x 3 cm, flawless and perfectly oriented.

From the data obtained, calculations were made for the physical properties of basic density (ρ_{bas}), linear shrinkage – radial direction (ε_r) and tangential direction (ε_t) and volumetric shrinkage (ε_v), according to Equations 1, 2 and 3, respectively. The anisotropic factor was obtained by dividing the tangential contraction by the radial contraction of each specimen evaluated, that is, the value obtained is dimensionless.

$$\rho_{bas} = \frac{m_s}{V_{green}} \quad (1)$$

$$\varepsilon_{(r,t)} = \left(\frac{L_{sat} - L_{dry}}{L_{sat}}\right) \times 100 \quad (2)$$

$$\varepsilon_{(v)} = \frac{V_{sat} - V_{dry}}{V_{sat}} \times 100 \quad (3)$$

In which:

ρ_{bas} is the basic density (g cm^{-3}); m_s is the anhydrous mass (g); v_{green} is the green volume (cm^3); v_{dry} is the anhydrous volume (cm^3); L_{sat} is the saturated dimension (cm); L_{dry} is the anhydrous dimension (cm); $\varepsilon_{(r,t)}$ are the linear shrinkage (%); $\varepsilon_{(v)}$ is the volumetric shrinkage (%).

Two-way ANOVA was used for the detection of statistically significant differences by a double 2 x 4 factorial scheme, in other words, two plantation spacings and four radial positions of samplings and 5 repetitions. A test of variance homogeneity (Bartlett test, at 5% significance) was performed preliminarily for all the wood characteristics. Deviations were not observed in relation to this presupposition of ANOVA. In the subsequent step, if main effects were significant, physical attributes would be plotted against radial position. Simple linear regressions were run to test the relationship between physical properties as dependent variables and radial position as an independent variable.

RESULTS AND DISCUSSION

The results showed the effect of spacing, and the interaction between spacing and radial sampling position were not significant at 5% by the F test for all physical attributes (Table 1). A non--significant interaction means that the investigated effects (spacing + radial position) in this study are not interdependent, which shows that the variation pattern of certain properties along the radius is the same for all treatments.

The effect of variation from pith to bark was significant for basic density and shrinkage in tangential and radial directions (Table 1). Significant effects of initial spacing were not observed on the evaluated physical attributes of *S. parahyba* wood at 9 years of age.

The average basic density value in this study (Table 2) is comparable with Paula (1980), Rojas and Martina (1996) and Vidaurre et al. (2012). They reported that the basic density of paricá wood ranges from light to moderately heavy, that is, from 0.26 g cm^{-3} to 0.62 g cm^{-3}. Radial, tangential and volumetric shrinkage (Table 2) were lower than what has been already reported by others (IBDF, 1983).

Table 2. Mean values of physical properties in different spacings.
Tabela 2. Valores médios das propriedades físicas nos diferentes espaçamentos.

Spacing	Contractions (%)			T/R	ρ_{bas} (g cm^{-3})
	ε_v	ε_t	ε_r		
4 m x 4 m	8.01 (1.71)	5.11 (0.95)	2.98 (0.58)	1.84 (0.67)	0,33 (0.07)
8 m x 4 m	8.32 (1.37)	5.48 (1.16)	3.13 (0.86)	1.99 (0.72)	0,34 (0.07)
General mean	8.17 (1.53)	5.29 (1.06)	3.05 (0.73)	1.92 (0.69)	0.33 (0.07)

Values in parenthesis represent the standard deviation. ε_v: volumetric shrinkage (%); ε_t: tangential shrinkage (%); ε_r: radial shrinkage (%); T/R: anisotropic coefficient; ρ_{bas} basic density (g cm-^{3}); CEV (%): coefficient of experimental variation.

Table 1. Summary of the variance analysis on physical properties of paricá wood related to spacing and variation from pith to bark.
Tabela 1. Resumo das análises de variância efetuadas para as propriedades físicas do paricá em relação ao espaçamento e a variação da medula para casca.

Cause of variation	DF	Mean square				
		Contractions (%)			T/R	ρ_{bas} (g cm^{-3})
		ε_v	ε_t	ε_r		
Spacing (S)	1	0.479^{ns}	1.346^{ns}	0.204^{ns}	0.229^{ns}	0.002^{ns}
Radial position (R)	3	2.688^{ns}	4.424 **	1.540 **	0.344^{ns}	0.055 **
S x R	3	0.642^{ns}	0.552^{ns}	0.235^{ns}	0.344^{ns}	0.001^{ns}
Error	32	2.523	0.866	0.479	0.501	0.001
CEV (%)	-	19.45	17.58	22.67	36.96	8.72

** Significant at 5% by the F Test; n.s: not significant at 5% by the F Test; DF: degrees of freedom; ε_v: volumetric shrinkage (%); ε_t: tangential shrinkage (%); ε_r: radial shrinkage (%); T/R: anisotropic coefficient; ρ_{bas} basic density (g/cm^3); CEV (%): coefficient of experimental variation.

Zobel and Buijtenen (1989) state that spacing has a little influence on the properties of hardwoods.

Brasil and Ferreira (1971) reported that there was no significant variation of wood basic density in *Eucalyptus* species planted in 3 m x 1.5 m and 3 m x 2 m spacings.

In the present study, trees were cut from seedling plantations; therefore, important genetic variations may exist between individuals. Malan (1988), in a similar study, reported that the effects of genetic factors on wood properties were more pronounced than environmental ones. Lima et al. (2009) did not observe significant influence of spacing on basic density and volumetric shrinkage of *Tectona grandis* wood at 31 years of age but apparent density increased in wide spacing.

Roque and Ledezma (2003) also expressed a significant increase of basic density, followed by reduction in radial, tangential and volumetric shrinkage in wide spacing.

Dense plantations may produce a higher volume of wood per hectare (Fishwick, 1976; Schneider, 1993). This means that, according to the result of the present study, initial spacing can be reduced from 4 m x 8 m to 4 m x 4 m without negative effects on the basic density and shrinkage behavior of paricá wood at 9 years of age for the production of a higher volume of wood.

Lopes et al. (2011) evaluated the wood of *Eucalyptus dunnii*, at 18 years of age intended for use in the furniture industry, and observed values of physical properties considerably higher than those found for *Schizolobium parahyba* var. *amazonicum* wood.

The authors observed an average shrinkage of 21.28%, average tangential contraction of 14.08% and average radial contraction of 5.91%. Thus, the higher dimensional stability of paricá wood becomes evident, allowing, therefore, its use in the furniture industry.

However, it is important to consider that the wood from *Eucalyptus dunnii* has a higher basic density (0.61 g cm^{-3}), when ??compared to the wood from *Schizolobium parahyba* var. *amazonicum* (0.33 g cm^{-3}), and this factor certainly influenced the results of the physical properties evaluated.

Radial trends of physical properties are shown in figures 1, 2 and 3. A strong adjustment to the simple linear model for basic density (R^2 = 0.99) and tangential contraction (R^2 = 0.96) was observed. For volumetric contraction and anisotropic factor, no significant statistical variation was observed for the radial sampling position.

However, for radial contraction, the quadratic linear model presented a better adjustment (R^2 = 0.94). Obtaining the first derivative of this quadratic function and equating the result to zero, it is possible to obtain the inflexion point of 69.78% which, in this case, is a minimum point, because the second derivative informs that the function is positive.

Analyzing angular coefficients of the obtained regressions (Figures 1 and 2), it was observed that for each 1% increase in the radial sampling position (from pith to bark), there was an increase of about 0.0017 g.cm^{-3} and 0.015% in basic density and in tangential contraction of the wood, respectively.

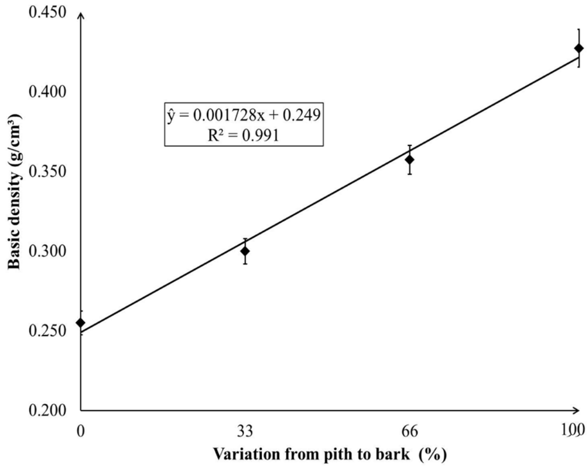

Figure 1. Functional relationship between basic density and variation from pith to bark in the log of *S. parahyba* var. *amazonicum* at 9 years of age. 0% is near the pith and 100% is near the bark.

Figura 1. Relação funcional entre a densidade básica e a posição radial na tora de *S. parahyba* var. *amazonicum* aos nove anos de idade.

It is necessary to highlight that linear and volumetric contractions presented higher variations than basic density within the radial sampling positions.

The results found for the radial variation of basic density and tangential contraction are in accordance with Oliveira and Silva (2003), who verified increases in this property from pith to bark of *Eucalyptus saligna* wood. Lopes et al. (2011) verified a tendency towards an increase in tangential contraction values of *Eucalytpus grandis*, *Eucalyptus dunnii* and *Eucalyptus urophylla* wood in the same direction.

Oliveira et al. (2010) statistically observed an increasing pattern of shrinkage variations (linear and volumetric), from pith to bark for

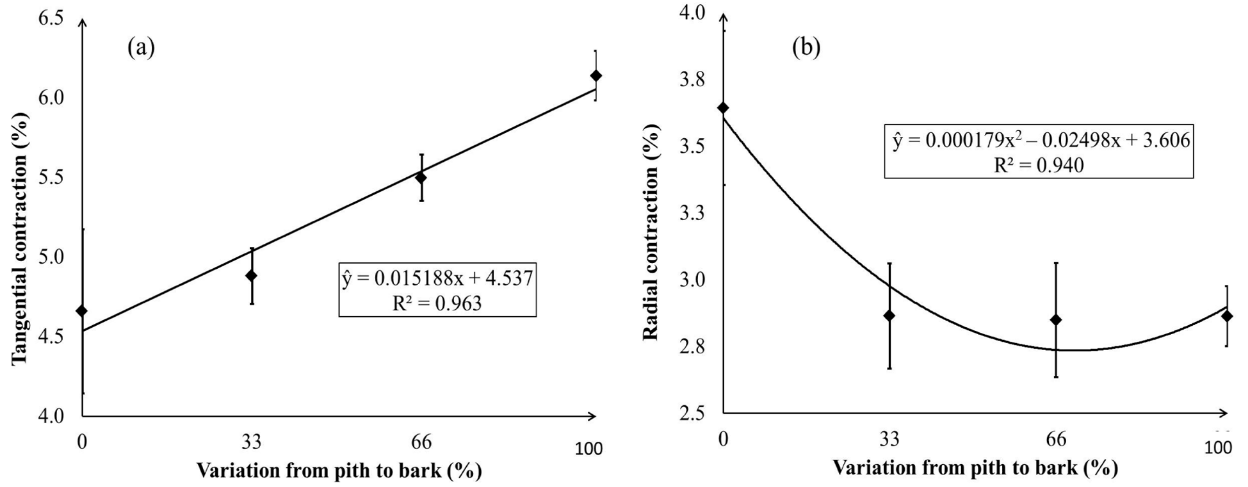

Figure 2. Functional relationship between the evaluated physical properties and variation from pith to bark in a log of *S. parahyba* var. *amazonicum* at 9 years of age. (a) Tangential contraction. (b) Radial contraction. 0% is near the pith and 100% is near the bark.

Figura 2. Relação funcional entre as propriedades físicas avaliadas com a posição radial na tora de *S. parahyba* var. *amazonicum* aos nove anos de idade. (a) contração tangencial. (b) contração radial.

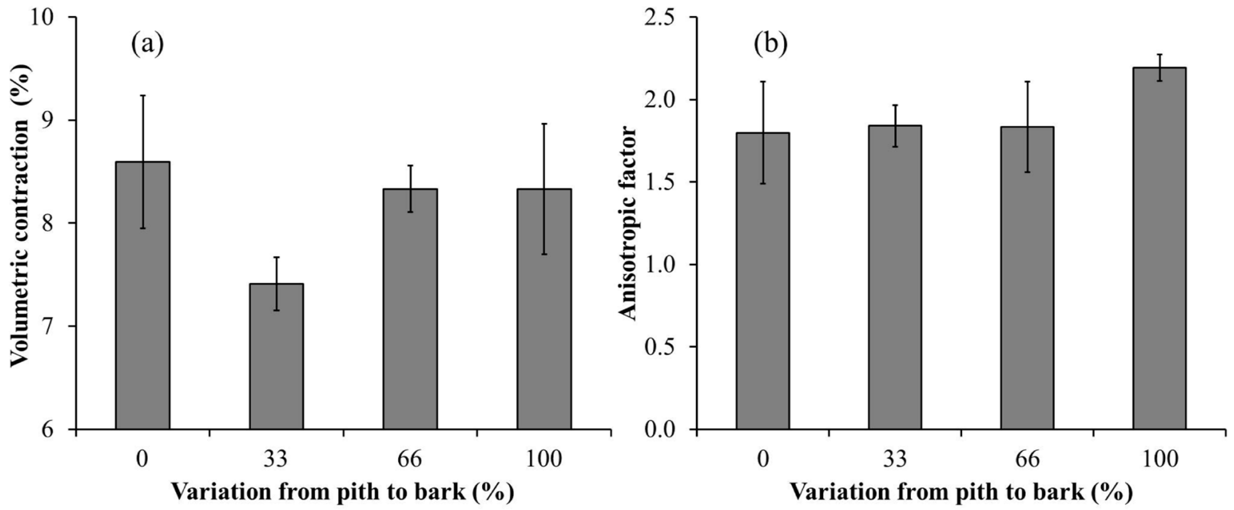

Figure 3. Relationship between physical properties and variation from pith to bark in the log of *S. parahyba* var. *amazonicum* at 9 years of age. (a) Volumetric contraction. (b) Anisotropic factor. 0% is near the pith and 100% is near the bark.

Figura 3. Relação entre as propriedades físicas e a posição radial na tora de *S. parahyba* var. *amazonicum* aos nove anos de idade. (a) contração volumétrica. (b) fator anisotrópico.

the wood species: *Corymbia citriodora*, *Eucalyptus cloeziana* and *Eucalyptus urophylla*. This result is in part similar to that observed for *Schizolobium parahyba* var. *amazonicum* (paricá) wood.

The increase in wood density value from pith to bark is the result of the formation of juvenile wood during the first years of plant growth and a tendency towards wood homogenization as it reaches maturity (BALLARIN; PALMA, 2003; SERPA et al., 2003). In relation to the increase in tangential contraction from pith to bark, Oliveira and Silva (2003) explain that this behavior is due to the reduction in the microfibrillar angle, increase in cellulose content and increase in fiber length in the same direction.

The increase in basic density from pith to bark was recently described by Settle et al. (2012) for *Endospermum medullosum*, Longui et al. (2011) for *Pittosporum undulatum*, Ishiguri et al. (2011) for *Pericopsis mooniana*, Lima et al. (2011) for *Balfourodendron riedelianum*, Santos et al. (2011) for *Astronium graveolens*, Hein and Brancheriau (2011) and Evangelista et al. (2010) for *Eucalyptus urophylla* and Gonçalves et al. (2009) for *Eucalyptus urophylla* x *Eucalyptus grandis* clonal hybrid.

Parolin (2002) also observed increases in the density from pith to bark for several species from Central Amazonia, many of them pioneer species, such as *S. parahyba* var. *amazonicum* (CARVALHO, 2007). For Wiemann and Williamson (1988) the increase in density from pith to bark may be related to the successional groups, especially pronounced in tree pioneer species, because the colonizing habit of the species requires a fast growth in height. This results in the formation of a weak shaft and lighter wood in the beginning of the tree development, and when it reaches the necessary height to absorb light well, mechanical reinforcement of the wood occurs with the increase in apparent density.

Wiemann and Williamson (1989) mention extreme variations in density, from 100 to 300% from pith to bark, in the tropical pioneer species *Hampea appendiculata*, *Heliocarpus appendiculatus* and *Ochroma pyramidale*. They explain that this behavior is possibly due to the intense competition for light among the most demanding species.

CONCLUSIONS

It was observed that the plantation spacing and radial sampling position factors in *paricá* wood are independent from the physical properties evaluated, because the interaction among them was not significant.

The physical properties studied in paricá wood were not significantly influenced by the analyzed spacing.

Basic density and tangential contraction increased significantly from pith to bark. Radial contraction decreased from pith to bark.

In relation to volumetric contraction and anisotropic factor, significant differences were not observed with the radial sampling position.

ANKOWLEDGMENTS

The authors thank Universidade do Estado do Pará for supporting the development of this work and FAPEMIG, CNPq and Capes for financial support.

REFERENCES

ABRAF – Associação Brasileira de Produtores de Florestas Plantadas. **Anuário estatístico da ABRAF 2011: ano base 2010**. Brasília: ABRAF, 2011. 130 p.

ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 7190**: projeto de estruturas de madeira. Rio de Janeiro, 1997. 107 p.

BALLARIN, A. W.; PALMA, H. A. L. Propriedades de resistência de madeira juvenil e adulta de *Pinus taeda* L. **Revista Árvore**, Viçosa, v. 27, n. 3, p. 371-380, 2003.

BRASIL, M. A. M.; FERREIRA, M. Variação da densidade básica da madeira de *Eucalyptus alba*, *E. saligna* e *E. grandis* aos 5 anos de idade, em função do espaçamento. **IPEF**, Piracicaba, n. 2/3, p. 129-149, 1971.

CARVALHO, P. E. R. **Paricá,** *Schizolobium amazonicum*. Colombo: Embrapa Florestas, 2007. 8 p. (Embrapa Florestas. Circular técnica, 142).

EVANGELISTA, W. V.; SILVA, J. C.; DELLA LUCIA, R. M.; LOBO, L. M.; SOUZA, M. O. A. **Ciência da Madeira**, Pelotas, v. 1, n. 2, p. 01-19, 2010.

FISHWICK, R. W. Estudos de espaçamentos e desbastes em plantações brasileiras. **Brasil Florestal**, Brasília, v. 7, n. 26, p. 13-23, 1976.

FUJIMOTO, T.; KOGA, S. An application of mixed-effects model to evaluate the effects of initial spacing on radial variation in wood density in Japanese larch (*Larix kaempferi*). **Journal of Wood Science**, New York, v. 56, n. 1, p. 7-14, 2009.

GONÇALVES, F. G.; OLIVEIRA, J. T. S.; DELLA LUCIA, R. M.; NAPPO, M. E.; SARTÓRIO, R. C. Densidade básica e variação dimensional de um híbrido clonal de *Eucalyptus urophylla* x *Eucalyptus grandis.* **Revista Árvore**, Viçosa, v. 33, n. 2, p. 277-288, 2009.

HEIN, P. R. G.; BRANCHERIAU, L. Radial variation of microfibril angle and wood density and their relationships in 14-year-old *Eucalyptus urophylla* S.T. Blake wood. **Bioresources,** Raleigh, v. 6, n. 3, p. 3352-3362, 2011.

IBDF - INSTITUTO BRASILEIRO DE DESENVOLVIMENTO FLORESTAL. **Potencial madeireiro do Grande Carajás.** Brasília: IBDF/LPF, 1983. 134 p.

ISHIGURI, F.; WAHYUDI, I.; TAKEUCHI, M.; TAKASHIMA, Y.; LIZUKA, K.; YOKOTA, S.; YOSHIZAWA, N. Wood properties of *Pericopsis mooniana* grown in a plantation in Indonesia. **Journal of Wood Science**, New York, v. 57, n. 3, p. 241-246, 2011.

LE COINTE, P. **Árvores e plantas úteis:** indígenas e aclimatadas. São Paulo: Nacional, 1947. 390 p.. (Série Brasiliana, 251).

LIMA, I. L.; MASTELIN, S. M.; LONGUI, E. L.; FREITAS, M. L. M.; ROMEIRO, D.; ZANATTO, A. C. S.; FLORSHEIM, S. M. B. Densidade básica e dimensões celulares da madeira de *Balfourodendron riedelianum* em função da procedência e posição radial. **Revista do Instituto Florestal**, São Paulo, v. 23, n. 2, p. 217-230, 2011.

LIMA, I. L.; FLORSHEIM, S. M. B.; LONGUI, E. L. Influência do espaçamento em algumas propriedades físicas madeira de *Tectona grandis* Linn. **Cerne**, Lavras, v. 15, n. 2, p. 244-250, 2009.

LONGUI, E. L.; ROMEIRO, D.; SILVA, M. T.; RIBEIRO, A.; GOUVEIA, T. C.; LIMA, I.L.de.; FLORSHEIM, S.M.B. Caracterização do lenho e variação radial de *Pittosporum undulatum* Vent. (pau-incenso). **Hoehnea**, São Paulo, v. 38, n. 1, p. 37-50, 2011.

LOPES, C. S. D.; NOLASCO, A. M.; TOMAZELLO FILHO, M.; DIAS, C. T. S.; PANSINI, A. Estudo da massa específica básica e da variação dimensional da madeira de três espécies de eucalipto para a indústria moveleira. **Ciência Florestal,** Santa Maria, v. 21, n. 2, p. 315-322, 2011.

MALAN, F. S. Wood density variation in four trees of South African grown *Eucalyptus grandis* (Hill ex Maiden). **South African Forestry Journal**, Pretoria, v. 144, p. 36-42, 1988.

OLIVEIRA, J. T. S.; SILVA, J. C. Variação radial da retratibilidade e densidade básica da madeira de *Eucalyptus saligna* Sm. **Revista Árvore**, Viçosa, v. 27, n. 3, p. 381-385, 2003.

OLIVEIRA, J. T. S.; TOMAZELLO FILHO, M.; FIEDLER, N. C. Avaliação da retratibilidade da madeira de sete espécies de *Eucalyptus*. **Revista Árvore**, Viçosa, v. 34, n. 5, p. 929-936, 2010.

PACHECO, J. J.; PALHETA, M. V. O.; COSTA JUNIOR, R. N. F.; COSTA, S. V.; TOSTES, W. S. **Estatística municipal do município de Garrafão do Norte**. Garrafão do Norte: Instituto de desenvolvimento econômico, social e ambiental do Pará, 2011. 44 p. Disponível em: < http://iah.iec.pa.gov.br/iah/fulltext/georeferenciamento/garrafdonorte.pdf >. Acesso em: 01 mar. 2014.

PAROLIN, P. Radial gradients in wood specific gravity in trees of Central Amazonian floodplains. **Iawa Journal**, Leiden, v. 23, n. 4, p. 449-457, 2002.

PAULA, J. E. Madeiras que produzem álcool, coque e carvão. Autalidades do **Conselho Nacional de Petróleo,** Rio de Janeiro, n. 72, p. 31-45, 1980.

PEREIRA, A. P.; MELO, C. F. M.; ALVES, S. M. O paricá (*Schizolobium amazonicum*), características gerais da espécie e suas possibilidades de aproveitamento na indústria de celulose e papel. **Revista do Instituto Florestal**, São Paulo, v. 16, n. 2, p. 1340-1344, 1982.

RIZZINI, C. T. **Árvores e madeiras úteis do Brasil**: manual de dendrologia brasileira. Rio de Janeiro: E. Blucher, 1971. 190 p..

ROJAS, M. R.; MARTINA, A. M. S. **Manual de Identificación de Especies Forestales de la Subregión Andina**. Lima: Instituto Nacional de Investigación Agraria (INIA). Organización Internacional de las Maderas Tropicales, 1996. 489 p.

ROQUE, R. M.; LEDEZMA, V. A. Efecto del espaciamiento em plantación sobre las propiedades físicas de madera de teca a lo largo del fuste. **Madera y Bosques**, Heredia, v. 9, n. 2, p. 15-27, 2003.

SANTOS, C. M.; LIMA, I. L.; LONGUI, E. L.; ROMEIRO, D.; ZANATTO, A. C. S.; MORAIS, E.; ZANATA, M.; FLORSHEIM, S. M. B. A densidade básica e características anatômicas variam radialmente na madeira de *Astronium graveolens* Jacq. (Anacardiaceae). **Revista do Instituto Florestal**, São Paulo, v. 23 n. 2, p. 191-201, 2011.

SCHNEIDER, P. R. **Introdução ao manejo florestal**. Santa Maria: UFSM/CEPEF-FATEC, 1993. 348 p.

SERPA, P. N.; VITAL, B. R.; DELLA LUCIA, R. M.; PIMENTA, A. S. Avaliação de algumas propriedades da madeira de *Eucalyptus grandis*, *Eucalyptus saligna* e *Pinus elliottii*. **Revista Árvore**, Viçosa, v. 27, n. 5, p. 723-733, 2003.

SETTLE, D. J.; PAGE, T.; BUSH, D. ; DORAN, J. ; SETHY, M.; VIJI, I. Basic density, diameter and radial variation of vanuatu whitewood (*Endospermum medullosum*): potential for breeding in a low density, tropical hardwood. **International Forestry Review**, Craven Arms, v. 14, n. 4, p. 463-475, 2012.

SOUZA, C. R.; ROSSI, L. M. B.; AZEVEDO, C. P.; VIEIRA, A. H. **Paricá: *Schizolobium parahyba var. amazonicum* (Huber ex Ducke) Barneby**. Manaus: Embrapa Florestas, 2003. 12 p. (Embrapa Manaus. Circular técnica, 18).

VIDAURRE, G. B.; CARNEIRO, A. C. O.; VITAL, B. R.; SANTOS, R. C.; VALLE, M. L. A. Propriedades energéticas da madeira e do carvão de paricá (*Schizolobium amazonicum*). **Revista Árvore**, Viçosa, v. 36, n. 2, p. 365-371, 2012.

WIEMANN, M. C.; WILLIAMSON, G. B. Radial gradients in the specific-gravity of wood in some tropical and temperate trees. **Forest Science**, Washington, v. 35, n. 1, p.197-210, 1989.

WIEMANN, M. C.; WILLIAMSON, G. B. Extreme radial changes in wood specific-gravity in some tropical pioneers. **Wood and Fiber Science**, Michigan, v. 20, n. 3, p.344-349, 1988.

ZOBEL, B. J.; BUIJTENEN, J. P. **Wood variation**: its causes and control. Berlin: Springer-Verlag, 1989. 361 p.

Recebido em 05/11/2013
Aceito para publicação em 25/06/2014