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Wood density and fiber dimensions of *Gmelina arborea* in fast growth trees in Costa Rica: relation to the growth rate

R. Moya Roque[1]* and M. Tomazello Fo[2]

[1] *Escuela de Ingeniería Forestal. Instituto Tecnológico de Costa Rica. Apdo. 159-7050. Cartago. Costa Rica*

[2] *Departamento de Ciências Florestais. ESALQ/Universidade de São Paulo. Avda. Pádua Dias, 11. Caixa Postal 09. CEP 13418-900. Piracicaba (São Paulo). Brasil*

Abstract

A short rotation system was possible in the *Gmelina arborea* plantations due to silvicultural techniques that increased their growth rate. The objective of this research was to determine growth rate effects measured in tree diameter on wood density parameters (mean, minimum, maximum and intra-ring variation) and in fiber dimensions (wall thickness, fiber width, lumen diameter and fiber length) of trees from fast growth plantations. Thirty mature trees were sampled from thirty different fast-growth plantations with a wide growth rate in Costa Rica. A disc was cut from each tree at DBH. The wood density parameters and fiber dimensions were determined in each growth ring.

Some wood density parameters and fiber dimensions were related with growth rate. The minimum and mean density, cell wall thickness, fiber width and lumen diameter decreased with increase in growth rate. Intra-ring wood density variation increased with growth rate but the weak correlation was established. Maximum wood density was not found correlation with growth rate. A pronounced decrease was presented in minimum and mean density from 0 to 20 mm/year and after to 45 mm/year. A pronounced decrease and increase with increase in growth rate were presented in the fiber length and intra-ring wood density, respectively. Lumen diameter and fiber width presented few variations, until 40 mm/year; however, they showed decrease after this growth rate value.

Key words: silvicultural practices, X-ray densitometry, wood density variation, fast-growth conditions.

Resumen

Densidad y dimensiones de la fibra de *Gmelina arborea* en árboles de rápido crecimiento en Costa Rica: relación con el rango de de crecimiento

La *Gmelina arborea* es utilizada en plantaciones debido a que las practicas silviculturales producen altas tasas de crecimiento del árbol. El presente trabajo tiene el objetivo de establecer los efectos de la tasa de crecimiento en los parámetros de densidad de la madera (media, máxima, mínima y la variación intra-anillo) y las dimensiones de la fibra (largo, ancho, diámetro del lumen y espesor de pared) en árboles de plantaciones de rápido crecimiento. Fueron seleccionadas treinta árboles de treinta 30 plantaciones diferentes próximas al turno de rotación con una amplia tasa de crecimiento. Un disco a la altura del pecho fue cortado en cada uno de los árboles. Los parámetros de densidad y dimensiones de las fibras fueron determinadas en cada anillo de crecimiento.

Algunos de los parámetros de la densidad y las dimensiones de la fibra fueron correlacionados con la tasa de crecimiento. La densidad mínima y el promedio, espesor de pared celular y diámetro del lumen diminuyen con el incremento de la tasa de crecimiento. La variación intra-anillo incremento, pero una débil correlación fue encontrada. La densidad máxima no presentó correlación. Una gran disminución de la densidad mínima y la densidad media fue encontrada cuando la tasa de crecimiento se encuentra entre 0 y 20 mm/año o superior a 45 mm/año. Un pronunciado decrecimiento e incremento con el incremento de la tasa de crecimiento fue encontrado en la longitud de la fibra y la variación intra-anillo, respectivamente. El diámetro del lumen y ancho de la fibra presentaron pocas variaciones cuando la tasa de crecimiento es menor a 40 mm/año, sin embargo, estos mostraron un decrecimiento luego del mencionado valor.

Palabras clave: manejo slvicultural, densitometría de rayos X, variación de la densidad, rápido crecimiento.

* Corresponding author: rmoya@itcr.ac.cr
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Introduction

Gmelina arborea (melina) was introduced in large tropical areas due to the well known silvicultural techniques and wood quality produced by fast growth trees that were managed in short rotation systems (Dvorak, 2004). This species is considered a useful multi-purpose species and its wood is used as raw material for cellulose (Foelkel *et al*., 1978), firewood (Lugo *et al*., 1988), polewood (Moya, 2004a), particleboard (Chew and Ong, 1989), veneer (Sicad, 1987) and structural uses (González *et al*., 2004). In Costa Rica, approximately 65 thousand hectares of melina have been planted in different ecological locations under a wide variety of management regimes (Moya, 2004a).

Wood density and fiber dimensions are related to many structural, physical and chemical properties in wood. It affects many wood-product manufacturing, like pulping process, behavior in the drying process and resistance to cutting and machining (Hughes and Alburquerque-Sardinha, 1975). Variations in wood density and fiber dimensions are also present in the tree, in the radial and longitudinal direction and within the annual rings (Zobel and Van Buijtenen ,1989). The variation may be due to genetic, physiological or silvicultural treatments (Muller-Landau, 2004).

On the other hand, intra-ring wood density variation in trees is present due to differences in dimension, structure and distribution of woody cells (Zobel and Van Buijtenen, 1989). This variation is produced because of the differences in tracheid formation of early and latewood in softwood species (Decoux *et al*., 2004). In contrast with the hardwoods, the variation depends on the amount or proportion of different cell types and spatial arrangements (Guilley *et al*., 2003). It is important to know the magnitude and the pattern of intra-ring wood density variation in order to determine the degree of wood uniformity (Akachuku, 1985). For example, a lack of uniformity in physical and chemical properties of wood is one of the major problems that wood industry faces (Olson and Arganbrigtht, 1977). Densitometry profiles from x-rayed samples have been used to determine intra-ring wood density variation (Schinker *et al*., 2003). Also, different terminology has been used like: homogeneity, uniformity, heterogeneity or intra-ring wood density variation. Several statistic parameters also were created for its determination (Walker and Dodd, 1988; Liu and Tang, 1991).

Although studies have shown the variability of wood density (within and between) and fiber dimensions in *Gmelina arborea* (Pearson and Brown, 1932; Hughes and Esan, 1969; Zeeuw and Gray, 1972; Ogbonnaya, 1976; Akachuku and Burley, 1979; Tang and Seng, 1982; Akachuku, 1985; Ohbayashi and Shiokura, 1989; Alipon, 1991; Moya, 2004b), few have presented the effects of different growth rate on fiber dimension, wood density and its variability within the annual ring. The purpose of this study is to investigate the relationships between growth rate and above mentioned characteristics in trees from different fast-growth plantations in Costa Rica. The understanding of these relations is essential to silvicultural practices and wood quality predictions.

Material and Methods

— **Sampled areas**: The study was carried out on 30 mature *Gmelina arborea* trees obtained from plantations in the northwest and the northern part of Costa Rica (Fig. 1). Mean annual precipitation is 3,000-5,000 mm with temperature of 20-25°C, a moderate drought period of 3 months (January-March) with rainfall decreasing from 450 to 70 mm/month in the north. In the northwest, the mean annual precipitation is 1,500-2,000 mm, with temperatures of 25-28°C with a severe drought between January and March and rainfall of almost 0 mm/month.

— **Plots and trees selection**: Thirty mature melina trees were selected with a wide growth rate, from 17.9 to 42.2 mm/year and 9-12 years of age (Table 1). Within each plantation a plot (400 m^2) was located and positioned geographically by GPS. Also, the diameter at breast height (DBH), total and crown height of all trees within the plots were measured. A tree with an average DBH (Table 1), straight trunk, normal branching, and no disease or pest symptoms was selected in each trial.

— **Wood samples**: Each sampled tree was marked facing north and a stem section (3 cm thickness) was cut at DBH. A slice, 1 cm width and 2 cm thick, was cut across the diameter (Fig. 2). For density determination, samples (1 ± 0.045 mm; mean $\pm$ SD) were cut using a twin-blade saw. At the bottom north position each growth ring was separated for to measurement of their fiber dimensions (Fig. 2).

— **X-ray radiographs**: The thin laths at 12% moisture content (MC) were x-rayed using a Hewlett Pakard Faxitron (Model 43805 N) previously adjusted (time: 5 minutes; energy: 16 Kv; intensity: 3 mA). The films (Kodak, Diagnostic Film X-Omat XK1, 24×18 cm) were developed using normal procedures (Amaral and

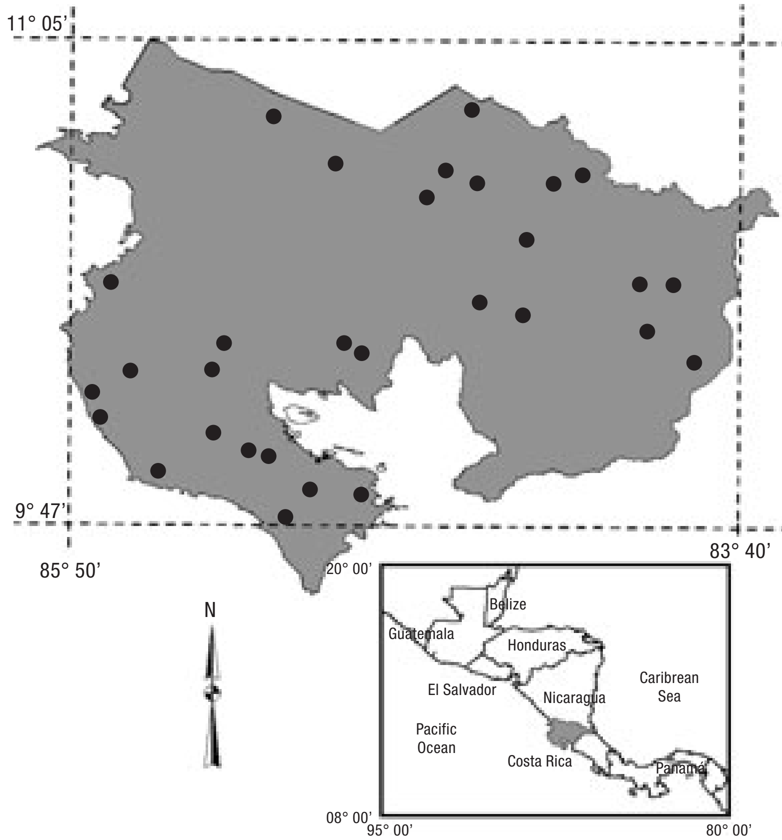

Figure 1. Location of sampled plantations in northern part of Costa Rica and Central America zone.

Tomazello, 1998). The radiographs of *Gmelina arborea* wood samples were scanned in a 256 gray scale with 1,000 dpi resolution. X-ray micro-density measurements (x-ray densitometry) were measured on this digital image by CERD software (Mothe *et al*., 1998).

— **Growth rate**: The X-ray densitometry provided a continuous recording of wood density (12% at moisture content) across the wood sample (Hughes and Alburquerque-Sardinha, 1975). The width of each growth ring was the distance of the earlywood-latewood and latewood-earlywood boundaries in all the densitometry graphs (Akachuku, 1985). Width values in the north and south parts of the thin laths were added to calculate growth rate in the tree diameter.

— **Wood density and intra-ring wood density variation**: The lowest and highest density values in each growth ring were established as minimum and maximum density, respectively.

Walker and Dood's method (1988) for densitometry profiles was used in the determination of the mean wood density and intra-ring wood density variation. The density parameters (mean, minimum, maximum and intra-ring variation) in each growth ring were averaged between the north and south parts of the stem.

— **Fiber dimensions**: Each growth ring sampled was cut at the beginning part (like earlywood in temperate species) and macerated using Franklin's method (Ruzin, 1999). The maceration of each annual ring was replicated three times on a glass slide and stained with safranin. An LC color camera was used on an optical microscope and then connected to a computer. A magnification X250 for length and X1000 for fiber width and lumen diameter was used. Twenty fibers were measured for fiber dimensions using the Image Analysis System for wood (SAIM) developed by Anatomy and Tree-ring Laboratory of São Paulo University, Brazil (Ribeiro *et al*., 2005).

— **Data analysis**: The relation between fiber dimensions and wood density parameters with growth rate was analyzed using Pearson's correlation matrix. A scatter plot was then graphed between growth rate and age of the tree and wood characteristics with growth rate. The different statistical model regressions (lineal, quadratic or cubic) were tested to analyze the fiber

Table 1. Description of plantation sampled

Sampled plantation	Density of plantation (n ha^{-1})	Diameter at breast height (cm)	Average growth rate (mm year^{-1})	Total height (m)	Crown height (m)	Age (years)
1	159	38.0	42.2	15.5	11.0	9
2	300	31.5	39.4	22.0	11.0	8
3	191	33.2	33.2	18.5	11.2	10
4	223	32.0	4.00	23.5	14.5	8
5	127	30.7	34.1	18.0	13.0	9
6	659	25.0	31.3	19.0	6.0	8
7	477	28.5	35.6	22.5	14.0	8
8	350	25.2	31.5	21.4	14.0	8
9	446	30.0	37.5	23.2	16.0	8
10	505	28.3	28.3	24.0	18.0	10
11	732	24.0	26.7	21.8	15.0	9
12	1032	21.5	26.9	21.5	17.5	8
13	764	21.0	19.1	19.1	11.6	11
14	891	24.1	24.1	15.0	12.0	10
15	1,496	24.3	20.3	20.0	13.8	12
16	318	31.9	31.9	20.8	11.0	10
17	350	29.8	27.1	19.5	12.5	11
18	223	32.5	27.1	24.7	13.5	12
19	344	30.5	30.5	24.0	11.0	10
20	250	33.2	27.7	27.1	17.1	12
21	509	19.7	17.9	19.5	13.2	11
22	477	22.5	25.0	23.3	13.4	9
23	477	23.4	23.4	17.8	13.5	10
24	605	23.5	26.1	18.5	7.7	9
25	509	23.9	29.9	22.1	15.1	8
26	827	20.5	20.5	18.7	13.0	10
27	732	18.8	20.9	19.0	9.5	9
28	836	20.5	20.5	22.1	14.2	10
29	796	20.7	20.7	18.3	9.1	10
30	1,025	20.2	22.4	22.0	13.0	9

dimensions variation and wood density parameters (dependent variables) with growth rate (independent variable) to determine X-ray densitometry in the north parts of the tree. The best allometric model was determined by p-valor and the highest values of determination coefficient (R^2). It was necessarily applied to transform some variables (Table 2) to solve the normality model problem. SAS statistical program (SAS Institute, 1997) was used to evaluate the meaning of the model regression.

Results and Discussion

Growth rate and its relation to tree age

The mean growth rate in the tree diameter was 22.15 mm for the first twelve years for different climatic and management conditions in Costa Rica. The range variation was between 1.14 and 69.94 mm/year and the coefficient variation was approximately 65%, which is considered very high. However, this result can be attributed to the sample variation of the area or the different management conditions of the plantations sampled, which presented an average growth rate from 17.9 to 42.2 mm/year (Table 1). The melina results agreed with Zobel and Van Buijtenen's (1989) theory that studied growth rate in temperate and tropical species, establishing that tropical plantation species under fast-growth conditions show a superior growth rate, especially in young trees. These results can be varied by 10 to 50 mm for some species.

Growth rate was related tree age, that was expected in many wood species growing in tropical conditions, like *Eucalyptus* sp (Wilkins and Horne, 1991) and *Tectona grandis* (Varghese *et al.*, 2000) or tropical species growing in Costa Rican conditions (Bermejo

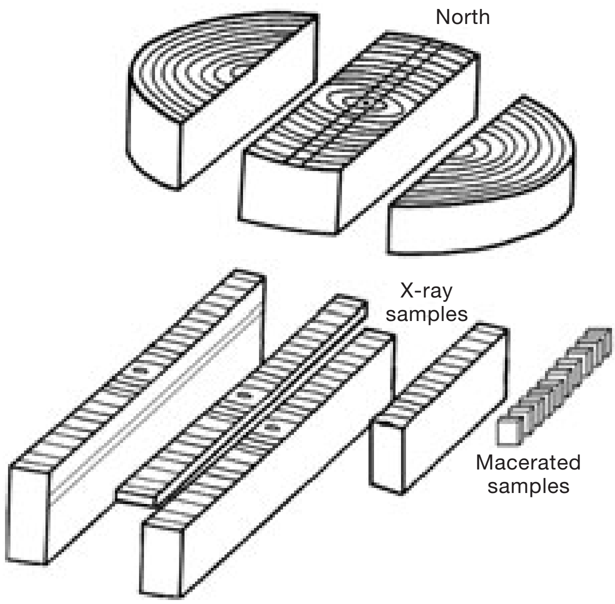

Figure 2. X-ray and macerated sample from a stem section of *Gmelia arborea* trees.

and Canellas, 2001). The highest growth rate was presented in the first years; afterward growth rate began to decline rapidly with aging of the tree. The estimated regression model demonstrated that the decrease was quadratic. The correlation coefficient between both growth rate and tree age was 0.769 or the coefficient determination was 0.591 (Table 3) when we established regression analyses (Fig. 3). Debell *et al*. (2004) and Yanz and Hazenberg (1994) established that the fast decrease in the growth rate was due to the increasing competitions in tree age when the plantation condition was presented, like the results obtained in *Gmelina arborea* trees from the fast-growth conditions in Costa Rica.

Table 2. Pearson's matrix correlation between growth rate and fiber dimensions and wood densities parameters (N = 556)

Wood characteristics	Parameter	Coefficient correlation with growth rate
Wood density	Mean	–0.47**
	Minimum	–0.32**
	Maximum	-0.02^{NS}
	Variation	0.16**
Fiber dimensions	Cell wall thickness	–0.58**
	Length	–0.61**
	Width	–0.43**
	Lumen diameter	–0.11**

** Statistically significant at 99% level. NS:not significant statistically.

Table 3. Model regression estimated between wood characteristic of melina and growth rate in *Gmelina arborea* trees in Costa Rica

Correlated variables	Model regression	Transformed type	Intercept (A)	B	C	D	RMSE	CV	P valor of model	R^2
Growth rate with tree age	Quadratic	SQRT	7.055**	–0637**	0.0212**		0.967	21.69	<0.0001**	0.591
Wall thickness with GR	Quadratic	LOG_{10}	0.671**	–0.004**	3.2×10^{-5}**	—	0.050	8.39	<0.0001**	0.393
Fiber length with GR	Lineal	not	1.463**	–0.008**	—	—	0.166	12.89	<0.0001**	0.387
Fiber width with GR	Quadratic	LOG_{10}	1.500**	$-8.2\times10^{-5\ NS}$	-1.2×10^{-5}**	—	0.028	1.891	<0.0001**	0.223
Lumen diameter with GR	Quadratic	Not	22.05	0.078**	–0.001**	—	2.003	8.84	<0.0001**	0.071
Minimum wood density with GR	Cubic	Not	537.5**	–11.51**	0.319**	–0.003**	57.54	13.50	<0.0001**	0.230
Mean wood density with GR	Cubic	LOG_{10}	2.824**	–0.011**	0.0003**	-3.0×10^{-5}**	0.042	1.54	<0.0001**	0.322
Maximum wood density with GR	Cubic	Not	726.10**	–7.75**	0.267*	–0.003*	67.91	10.18	$<0.0054^{NS}$	0.045
Variation of wood density with GR	Lineal	SQRT	2.893**	0.011**	—	—	0.478	15.16	<0.0001**	0.093

* Statistically significant at 95% level. Tree age in years. LOG_{10}: logarith transformation. Not: variable not transformed. CV: coefficient variation. Lineal regression: A + B*X. Cubic model: A + B*X + C*$(X)^2$ + D*$(X)^3$. ** Statically6 significant at 99% level. GR: growth rate of tree diameter in mm/year. NS: not significant statistically. SQRT: square root transformation. RMSE: root medium sum error. R^2: coefficient of determination. Quadratic model: A + B*X + C*$(X)^2$.

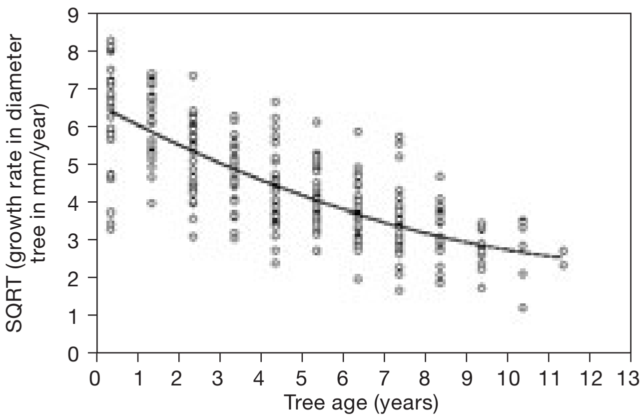

Figure 3. Relationship between growth rate in diameter tree and tree age in fast-growth plantations of *Gmelina arborea*.

Relation between growth rate and wood density

Correlation analyses of relations between growth rate and wood density parameters indicated significant relationships, except for maximum density. For minimum and mean wood density negative correlation was found (Table 2). Cubic relation was found when regression analyses were applied for minimum and mean wood density with growth rate (Table 3). There was a gradual decline in growth rate from 0 to 20 mm/year in tree diameter (Fig. 4) in those density parameters (Fig. 4A, 4D). Whereas the relation between these density variables and growth rates in range from the 20 to 55 mm/year became non-significant, afterwards, mean and minimum wood density decreased gradually with increase in growth rate. Although some wood density parameters (mean and minimum) were statistically significant with growth rate, however a weak correlation ($R^2 < 0.322$) was found.

Several researches have studied the effect of growth rate on mean wood density and contrasting results were found. Different provenances tested in the northern parts of Brazil at 14 and 17 months (Woessner, 1983) with a growth rate of 24 to 34 mm demonstrated similar results as trees growing in Costa Rican conditions. Trees with lower diameters showed higher basic wood density values; however, these differences were attributed to different provenances of the seed (Woessner, 1983). Moreover, there were important variations between trees sampled in Brazil and trees sampled in Costa Rica. Young trees in Brazil had a maximum growth rate of 34 mm/year. 10-12 year-old melina sampled trees of fast growth plantations in Costa Rica showed a growth rate of 17.9 and 42.2 mm/year in diameter (Table 1). Meanwhile15-year-old trees from Japan (Ohbayashi and Shiokura, 1989), 11-21 year-old trees from Sabah

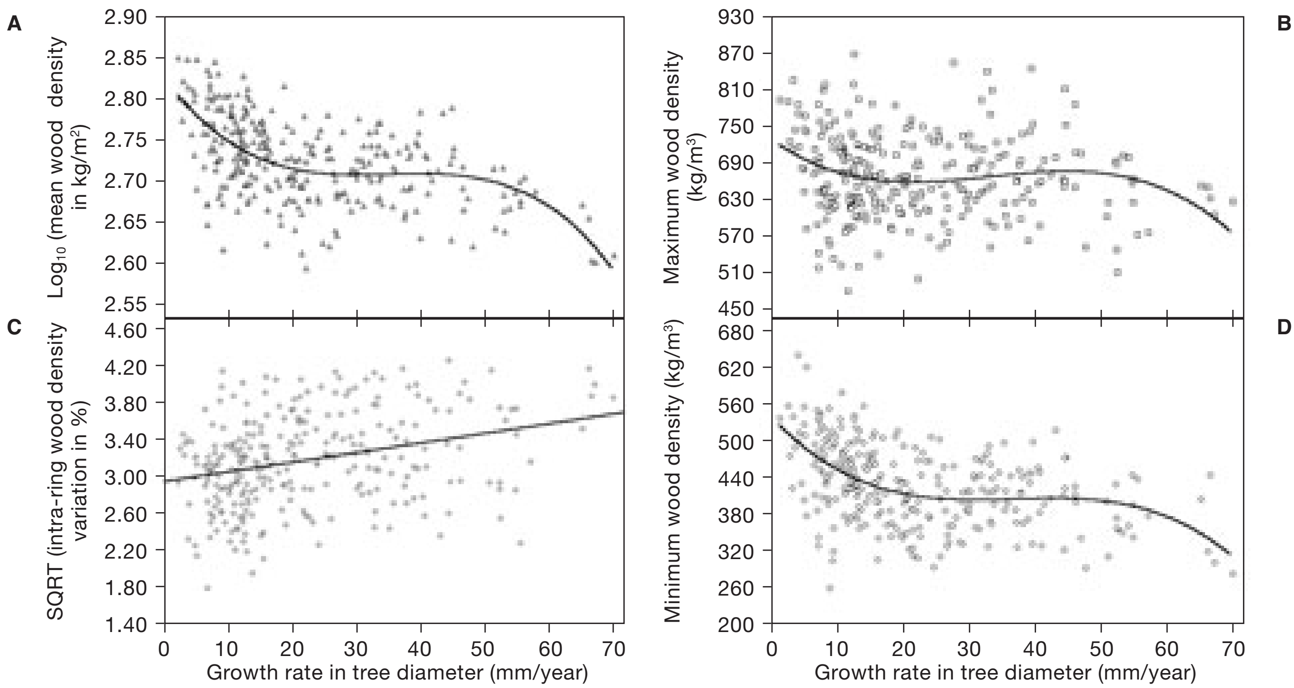

Figure 4. Relationship between mean wood density (A), maximum wood density (B), intra-ring wood density variation (C) and minimum wood density (D) with growth rate in the diameter tree in fast-growth plantations of *Gmelina arborea*.

Island (Tang and Seng, 1982) and 9-year-old trees from Nigeria (Akachuku and Burley, 1979) contrasted with the results found in Costa Rican 9-12 years old trees. The wood density was not affected by growth rate in these countries.

With these results, it was clearly shown that there was not a unanimous result of the effect of growth rate in wood density in *Gmelina arborea* trees. This problem was stated in Zobel and Van Buijtenen's textbook (1989). They established that the different behavior wood density in relation to growth rate are produced by differences in the ring porous present in several hardwood species. For example, changes in wood density are generally influenced by growth rate in ring porous woods, but diffuse porous species are quite independent from growth rate. Besides, research has also found different ring porous patterns in *Gmelina arborea* trees that are due to different growing conditions (Chowdhury, 1947). Thus, the sampled trees used in Costa Rica, Nigeria and Sabah Island, Japan could have presented different growing conditions, resulting in contradictory results.

Research on maximum and minimum wood density in *Gmelina arborea* trees, and for tropical species in general; have been limited because of the multiple growing conditions that possibly affect the final results of wood formation (Fichtles *et al*., 2003). Maximum and minimum wood density variations in 7-year-old melina plantations in Nigeria (Akachuku, 1985) were studied. The results confirmed our study about mature melina trees growing in Costa Rica. However, this research demonstrated that the proportions of wood with low and high wood density were affected by tree age, annual ring width and rainfall variations.

The intra-ring wood density presented positive correlation with growth rate (Table 2). Regression analysis showed that these density parameters increased linearly with growth rate (Fig. 4C) and was significant statistically. However, the coefficient determination (R^2) was very low, only 0.093 (Table 3). Low R^2 indicated that growth rate is not good parameters in intra-ring wood density prediction.

Parker *et al*. (1978) found a relationship, in a temperate hardwood species (*Alnus rubra*), between intra-ring wood density and ring growth width. We also found this relation; however, it was weak in *Gmelina arborea* (low coefficient correlation). They concluded that the presence of large voids in the vessels presented in the transverse sections did not establish the real relation of growth rate and wood density within the annual rings. Vessel distribution results in melina wood may have been influenced by the low coefficient determination.

The results with temperate softwood species disagree with our results: wood density variations in annual rings were generally reduced to increasing the growth rate. For example, Walker and Dodd (1988) found that wide growth rings produced a reduction in the fluctuations in the density variation in *Pinus radiata* clones and it is related to the formation of transitional cells between early and latewood. Recently, Ivkovic and Rozenberg (2004) found high correlations between intra-ring wood density variation and growth rate in P*seudotsuga menziesii*, *Pinus pinaster* and *Picea abies* clones.

Relation between growth rate and fiber dimensions

The correlation analysis showed negative relation between growth rate and fiber dimensions (Table 2). The cell wall thickness, lumen diameter and fiber width presented a quadratic relation, and fiber length presented a linear relation (Table 3) when regression analyses were applied. These analyses showed low determination coefficient, especially for lumen diameter. Zobel and Van Buijtenen (1989) established that cell dimensions in many wood species decreased because of rapid growth in trees. This is caused by an increase of cell division rate in the cambium. However, differing studies in hardwood species such as in eucalypt species disagreed with these findings (Wilkes and Abbott, 1983).

As shown in figure 5A, fiber length was significantly reduced when growth rate increased, for example 8 μm for a 1 mm/year in growth rate increment. The lumen diameter (Fig. 5B) and fiber width (Fig. 5D) were less variable except when growth rate of 50 mm/year, where these dimensions showed some pronounced reduction. Meanwhile, cell wall thickness (Fig. 5C) gave a clear decrease of 30 mm/year. Afterward, these fiber dimensions were stable when growth rate increased. Large sample variations or different management conditions of the plantation (Table 1) could be reason for the weak correlation between fiber dimensions and growth rate ($R^2 < 0.393$).

Decrease in fiber dimensions and growth rate were found also in Japan (Ohbayashi and Shiokura, 1989). Fiber with less length and a small diameter was found in small diameter trees. However, trees from Nigerian disagreed with these results (Hughes and Esan 1969):

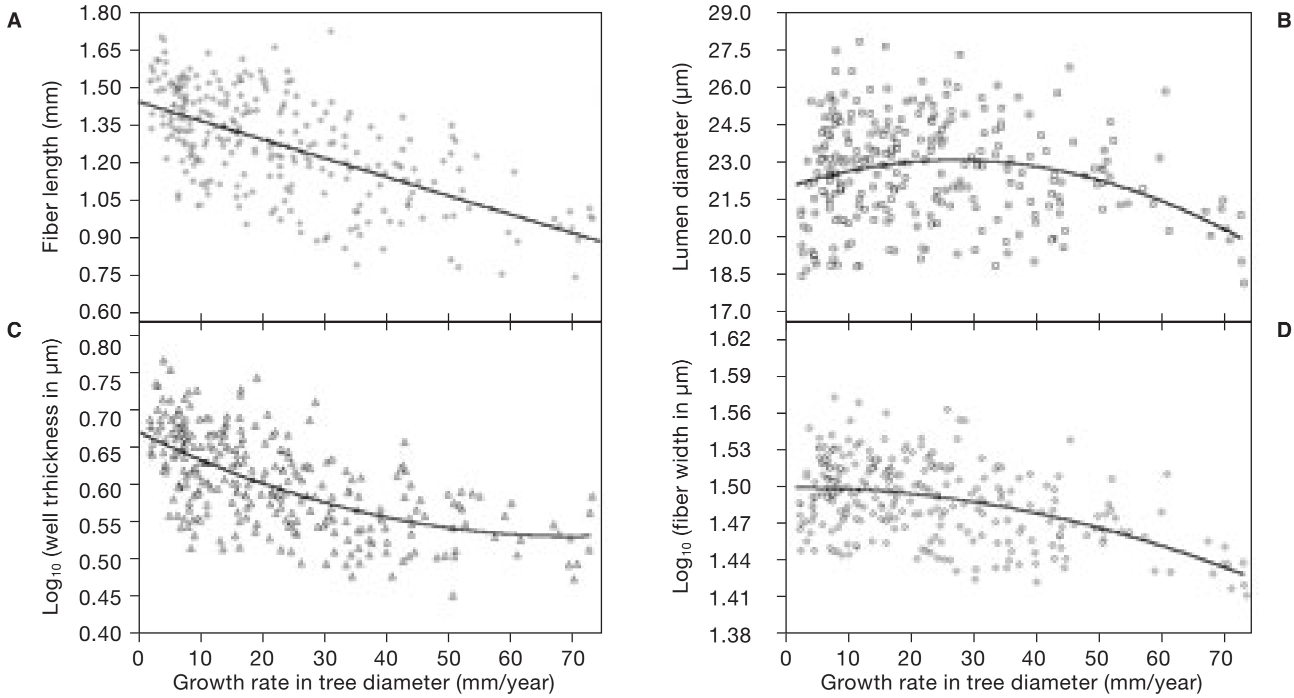

Figure 5. Relationship between fiber length (A), lumen diameter (B), cell wall thickness (C) and fiber width (D) with growth rate in diameter tree in fast-growth plantations of *Gmelina arborea*.

fiber length slightly longest in trees with fast growth rate. With others trees growing in Nigeria (Akachuku and Burley, 1979) it were found that fiber length and other anatomical features (fiber, vessel and parenchyma proportion) were not correlated with growth rate.

Different methods have been used to measure the effects of growth rate. The growth ring width or annual ring width and diameter at breast height (DBH) were frequently used. Serious errors in evaluating the relation between growth rate and wood properties can be present when tree diameter is included (Zobel and Van Buijtenen, 1989). The differences found among trees growing in Costa Rica, Japan and Nigeria conditions can be affected by the different methods used to measure growth rate. The results presented in melina wood from Nigerian and Japan were correlated to fiber dimensions using the tree diameter, but not with different growth rates present in trees like the ones that were determined in melina trees from different areas in Costa Rica.

In several studies, growth ring width was used to measure growth rate values to determine fiber dimensions in hard or softwood species. For example, in *Alnus rubra* (Lei *et al*., 1997), a negative relation was found in cell wall thickness and growth rate. However, other fiber dimensions disagreed with the melina results. The results in these cases were a negative correlation between fiber length and growth rate yet no relation in the fiber width. The negative correlation between fiber length and growth rate found in *Quercus petraea* (Heliríska-Raczkowka and Fabisiak, 1991) agreed with the results obtained with melina.

Silvicultural implications

Large changes in cell wall thickness (Fig. 5C), mean density (Fig. 4A) and minimum density (Fig. 4B) are presented when growth rate is maintained from 0 to 20 mm/year; however, transversal fiber sections (fiber width and lumen diameter) are slightly affected in these rates. When the growth rate is increased from 20-40 mm/year, wood density (mean, minimum and maximum) and some fiber dimension (cell wall thickness, lumen diameter and fiber width) values are slightly affected. But when growth rate is increased to 40 mm/year among fiber dimensions and different parameters, density is largely affected.

Silvicultural practices such as the usage of spacing and thinning help to control growth rate in the tree (Gartner, 2005). This can help control wood density and fiber dimensions in *Gmelina arborea* trees. Another important aspect is that the highest growth rate values are presented during early years (Fig. 3); therefore, decisions regarding plantation management must consider this during this period.

As was discussed wood properties are affected by differing growth rates. If growth rate of the tree is a key consideration for it's final use, then the gain or loss should be considered. If a large growth rate is required in melina plantation, then its wood is characterized by its low-density values, short cell with thin walls, and low transversals dimensions and the highest wood density variation.

Conclusions

Variations of in some wood density parameters and fiber dimensions are presented with modifications in tree diameter growth rates. The followings conclusions were obtained:

1. Growth rate in tree diameters was related to age. Highest growth rate was presented in the first years; afterward, growth rate began to decline rapidly with age. The estimated regression model demonstrated that the decrease was quadratic and 0.591 in correlation coefficient.
2. The minimum and mean wood density decreased significantly with growth rate according correlation analysis. Regression analyses showed that there was a gradual decline from 0 to 20 mm/year in tree diameter. In contrast to a 20 to 55 mm/year dimension slightly affected, to a higher growth rate of 45 mm/year that was largely affected. However low determination coefficient was found.
3. The maximum wood density was no found any relationships with growth rate. In meantime, intra-ring wood density presented positive correlation with growth rate; however, the coefficient determination was very low, indicating that growth rate is not good parameters in intra-ring wood density prediction.
4. The fiber dimensions decreased significantly with increasing of the growth rate, but low determination coefficient found limits these correlations. Lumen diameter and fiber width presented few variations, 40 mm/year in growth rate of tree diameter. However, these dimensions showed a clear decrease in tree diameter growth rate after 50 mm/year. The cell wall thickness presented a pronounced decrease of 30 mm/year. Afterward, these fiber dimensions were stable when growth rate increased. Fiber length presented a pronounced decrease with increase in growth rate.
5. Silvicultural practices can help control growth rate of melina trees and its effects on wood processing and usage due to the anatomical characteristics and wood density.

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