IPEF, n.39, p.49-52, ago.1988

Eucalyptus/Leucaena MIXTURE EXPERIMENT - WOOD PROPERTIES

R.M. DE JESUS
N.C. ROSSMANN
Florestas Rio Doce S.A., Depto. de Florestas Tropicais
29900 - Linhares - ES

J.S. BROUARD
North Carolina State University, School of Forest Resources
Raleigh, N.C. - U.S.A

ABSTRACT - Wood properties of **Eucalyptus urophylla** Blake and two varieties of **Leucaena leucocephalla** (Lam) de Wit, [Brewbaker's vars K8 and K72], were analyzed at the wood laboratory of the Companhia Vale do Rio Doce forest reserve of Linhares in Espírito Santo, Brazil. The material was collected from a species mixture experiment which was clear felled at age 7 years. As the two major end uses for wood in the region are pulp and charcoal, the wood properties were analyzed in two groups: 1. Physical and chemical properties of the wood: proportion of bark, moisture content, basic density, hollocellulose, extractives, lignin and ash content. 2. Conversion yields and properties of charcoal: % charcoal yield on a dry wood basis, volatiles, fixed carbon and ash content. In general there were no significant differences in wood properties between pure stands and mixture-grown trees of a given species or variety. Although the two **Leucaena** varieties were indistinguishable in most traits, significant differences were observed between **Eucalyptus** and **Leucaena** wood **Eucalyptus** wood had lower basic density than that of **Leucaena** (E = 540 vs L= 620 Kg/m^3) and had a higher moisture content (E = 52% vs L = 41%). **Eucalyptus** wood had lower ash (E = 0.1% vs L = 0.55%) and extractives (E = 3.3% vs L = 5.5%) but higher lignin content (E = 26% vs L= 22.5%) than **Leucaena** wood. There were no significant differences in holocellulose content (all approx. 70%). The percentage conversion to charcoal was higher in Eucalyptus wood (E = 35;8% vs L = 34.7%) on a dry weight basis. The analysis of dry charcoal revealed no significant differences in content of volatiles (18% for both spp) or fixed carbon (81%) but Eucalyptus charcoal had 1/3 of the ash content of **Leucaena** charcoal (E = 0.5% vs L= 1.5%).

RESUMO - As propriedades da madeira de **Eucalyptus urophylla** Blake - duas variedades de **Leucaena leucocephalla** (Lam.) de Wit, [Brewbaker vars. K8 e K72], foram analisadas no Laboratório de Carboquímica Florestal da Reserva Florestal da Companhia Vale do Rio Doce em Linhares, Espírito Santo - Brasil. O material foi amostrado em um consórcio entre estas espécies e que foi cortado aos 7 anos de idade. Como as principais finalidades da madeira na região são celulose e carvão, as propriedades da madeira foram analisadas em dois frutos: 1. Propriedades físico-químicas da madeira: percentagem de casca, teor de umidade, densidade básica, holocelulose, extrativos, lignina e teor de cinzas. 2. Rendimentos e propriedades do carvão: percentagem de produção de carvão com base na madeira seca, óleos voláteis, carbono fixo e conteúdo de cinzas. Em geral não houve diferença significativa nas propriedades da madeira entre árvores crescendo em plantio puro e em consórcio para uma dada espécie ou variedade: Embora as duas variedades de **Leucaena** sejam indiferenciáveis em muitos tratamentos, diferenças significativas foram observadas entre a madeira de **Eucalyptus** e **Leucaena.** A madeira de **Eucalyptus** teve menor densidade básica que a de **Leucaena** (E = 540 Kg/m^3 e L= 620 Kg/m^3) e teve maior teor de umidade (E = 52% e L= 1%). Teve ainda menos cinzas (E = 0,10% e L= 0,55%) e extrativos (E = 3,3% e L= 5,5%), porém maior teor de lignina (E = 26% e L= 22,5%) que a madeira de **Leucaena**. Não houve diferença significativa no teor de holocelulose (todos com aproximadamente 70%). A percentagem de conversão em carvão foi maior na madeira de **Eucalyptus** (E = 35,8% e L= 34,7%) sobre um peso seco básico. A análise de carvão seco demonstrou não haver diferenças significativas em teor de voláteis (18% para ambas as espécies) ou carbono fixo (81%), mas o carvão de **Eucalyptus** teve 1/3 do conteúdo de cinzas do carvão de **Leucaena** (E = 0,5% e L= 1,5%).

INTRODUCTION

An experiment to compare the performance of pure species blocks and mixtures of **Eucalyptus urophylla** Blake and **Leucaena leucocephalla** (Lam.) de Wit (vars K8 & K72) was clearfelled at the age of 7 years. The growth and yield performance are reported in a companion paper (JESUS et alii, 1988). Wood samples were taken from breast-height disks, cut into wedges and processed in the Companhia Vale do Rio Doce (CVRD) forest reserve wood laboratory near Linhares in Espirito Santo, Brazil.

MATERIALS AND METHODS

The experiment consisted of five treatments: **Eucalyptus** in pure stand, **Leucaena** varieties K8 and K72 in pure stand, and the two possible Eucalyptus-Leucaena mixtures. There were three replications of these five treatments in a randomized complete block design with 64-tree plots. The mixture treatments consisted of alternating rows of **Eucalyptus** and **Leucaena**. The wood properties described here were determined on the four central trees in each plot and block. The central eight trees (four of each species) were sampled in the mixture treatments. This gave a total of 36 sampled trees for **Eucalyptus** and 24 trees for each of the **Leucaena** varieties.

Percentage of bark in the stem wood was measured on these 84 trees in the following manner. The trees were cross-cut at 1 m intervals to a top diameter of 7 cm over bark. Diameters were measured at the cut ends both inside and outside bark. The volumes (with and without bark) were calculated for each section using Smalian's formula and summed to obtain total tree volume.

The remaining wood properties were determined on sample disks 2 to 4 cm thick taken, from breast height in the sample trees. The disks were cut into 300 segments for determination of moisture content, chemical properties of the wood, basic density, charcoal conversion rate and chemical properties of the resulting charcoal. Standard laboratory techniques were applied in the determination of the chemical and physical properties of the wood and charcoal.

Data from the above measurements were subjected to analyses of variance where total variance was partitioned into effects due to blocks and species or treatments; Treatments (pure stand versus mixtures) did not affect wood properties and thus only models separating variation into that caused by blocks and species were retained. Separation of means techniques were applied to the averages by species and variety for each trait. The Waller-Duncan k-ratio t test was selected for mean separation (STEEL & TORRIE, 1980).

RESULTS AND DISCUSSION

I. Wood properties

1. Proportion of Bark

Eucalyptus had almost twice the bark volume of **Leucaena** despite the fact that the **Leucaena** were multi-stemmed and smaller in diameter. Differences in bark volume are attributable to bark thickness. The relatively high proportion of bark in **E. urophylla** is surprising, given that results elsewhere with hybrid eucalypts report only 10-12% bark for 4-year old material (DELWAULLE, 1985).

TABLE 1

Species	Sample Size (N)	Mean* %
Eucalyptus	36	20.2 a
Leucaena K8	24	12.1 b
Leucaena K72	24	11.7 b

*Means followed by the same letter are not significantly different:

2. Moisture Content

The moisture content of "green" stem wood was calculated after "wet" and "oven-dry" weighing of samples taken from the four central trees in each plot. The higher moisture content of **Eucalyptus** wood is a reflection of the well known inverse relationship between wood basic density and moisture content,

TABLE 2

Species	N	Mean (%)
Eucalyptus	36	49.5 a
Leucaena K8	24	38.8 b
Leucaena K72	24	7.5 c

3. Basic Density

Wood basic density is defined as the ratio of oven dry weight to saturated volume. It is one of the most important properties of wood since it gives an indication of wood strength as well as pulp and energy yield. Specific gravity is a related pure measure of density and multiplication of specific gravity by 1000 Kg/m^3 gives basic density in metric units. A specific gravity of 0.54 was reported for 6- to 8-year old (**Leucaena** bole wood by the NATIONAL ACADEMY OF SCIENCES (1984). However, BAWAGAN (1982) states that specific gravity tends to increase with age and reports a value of 0.63 for 6-year old **Leucaena** wood in the Philippines. For **Eucalyptus**, DELWAULLE (1985) discusses the systematic increase of basic density from pith to bark, from the base to the top of the stem with increasing age and available growing space. Similar patterns of variation in basic density for eucalypts have been found in CVRD plantation-grown trees (BROUARD, personal communication).

TABLE 3

WOOD BASIC DENSITY - [X 10^{-3} kg/m^3]

Species	N	Mean
Leucaena K8	24	0.63 a
Leucaena K72	24	0.62 a
Eucalyptus	36	0.54 b

The relative proportions of these four chemical constituents of the wood are important determinants of cellulose yield and conversion efficiency in the pulping process. In general high holocellulose content is considered desirable, whereas extractives and lignin interfere with the pulping process or produce lower quality pulp. Mean values are presented below for these four wood properties. It should be noted that there were no significant differences in percentage of holocellulose, while **Eucalyptus** was clearly distinct from **Leucaena** in the other three properties. There were no significant differences between the two varieties of **Leucaena**. These proportions were measured on pooled samples from the wood disks taken from the 84 sample trees used throughout this study. Holocellulose, lignin and ash yields are similar to those reported for **Leucaena** by BAWAGAN (1982).

TABLE 4

SPECIES	EXTRACTIVE (%)	HOLOCELLULOSE (%)	LIGNIN (%)	ASH (%)
Leucaena K8	5.6 a	68.0 a	22.4 a	0.6 a
Leucaena K72	5.0 a	70.6 a	22.7 a	0.5 a
Eucalyptus	3.2 b	71.7 a	25.9 a	0.1 b

Note: The percentages do not add up to 100% because different sub-samples were used for each determination.

II Charcoal yield and properties

1 Percent Charcoal yield

The charcoal yield was defined as the proportion of a given weight of oven-dry converted to charcoal after kilning in a small-scale laboratory kiln. In general, dense wood produces dense charcoal (BRITO & BARRICHELO, 1980). It should be noted however that despite its higher basic density, **Leucaena** wood has a slightly lower conversion rate than **Eucalyptus** wood. This is because the charcoal yield was determined on a gravimetric and not on a volumetric basis.

TABLE 5

Species	N	Mean
Eucalyptus	36	35.8 a
Leucaena K8	24	34.8 b
Leucaena K72	24	34.6 b

2 Charcoal Analyses

Just as the chemical properties of the wood affect pulp yield and quality, so in charcoal the relative proportions of fixed carbon, volatiles and ash affect its usefulness as a source of energy or as a reducing agent. Composite charcoal samples were subjected to detailed determinations of percentage of volatiles, fixed carbon and ash **Leucaena** charcoal fixed carbon and volatile content are similar to those reported by BAWAGAN 91982). Here charcoal from **Leucaena** and **Eucalyptus** differ only in ash content.

TABLE 6

SPECIES	VOLATILES (%)	FIXED CARBON (%)	ASH (%)
Leucaena K8	16.4 a	82.0 a	1.6 a
Leucaena K72	18.8 a	79.8 a	1.4 a
Eucalyptus	19.5 a	80.0 a	0.5 b

CONCLUSIONS

For a given species or variety, wood properties were unaffected whether the individuals grew in pure stand or species mixtures. Except for wood moisture content, there were no significant differences between the wood of the two **Leucaena** varieties. **Eucalyptus** wood was less dense and had higher moisture content than **Leucaena** wood Holocellulose contents were similar in **Eucalyptus** and **Leucaena**, but **Leucaena** had lower lignin content and higher extractives and ash levels. **Eucalyptus** wood yielded slightly more charcoal on a dry weight basis and the resulting charcoal was similar to **Leucaena** charcoal except in ash content.

REFERENCES

BAWAGAN, P.V. Research on Leucaena wood at the Forest Products Research and Development Institute, Philippines. In: LEUCAENA RESEARCH IN THE ASIA-PACIFIC REGION WORKSHOP, Singapore, 1982. **Proceedings**. P.119-22.

BRITO, J.O. & BARRICHELO, L.E.G. Correlações entre características físicas e químicas da madeira e a produção do carvão: 2-densidade da madeira x densidade do carvão. **IPEF**, Piracicaba, (20): 121-6, 1980.

DELWAULLE, J.C. Production papetière de peuplements clonaux d'**Eucalyptus** au Congo. **Bois et forêts des tropiques**, Nogent-sur-Marne (208): 43-8, 1985.

JESUS, R.M. de et alii. **Eucalyptus/Leucaena** mixture experiment: 1 - growth and yield. **IPEF**, Piracicaba (39), 1988 (this volume).

NATIONAL ACADEMY OF SCIENCES. **Leucaena**: promising forage and tree crop for the tropics. 2.ed. Washington, 1984.

STEEL, R.G.D. & TORRIE, J.H. **Principles and procedures of statistics**: a biometrical approach. 2.ed. New York, McGraw-Hill, 1980.