Appendix 7

Wood quality and yield in the genus *Leucaena*

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Introduction

For many farmers the principal product of interest from agroforestry trees, including *L. leucocephala*, is fodder for ruminant livestock. Accordingly, greater research effort has been directed towards improving leaf yield and quality than towards wood production. In spite of this, wood produced on farms is an increasingly important output from many trees. For example, in 1994 Asia was able to meet only 33% of its fuelwood requirement with serious shortfalls occuring in Myanmar, Malaysia, Indonesia, China , Cambodia and Bhutan (Anon, 1996). However, there has been little attempt to quantify wood quality and, to a lesser extent, productivity in most agroforestry tree species.

Leucaena leucocephala has certain key attributes which have enabled its rapid adoption in agroforestry systems throughout the tropics. Its fast growth, ability to produce high quality animal fodder and ease of propagation have encouraged development agencies and farmers to plant the species widely, and also stimulated research into improving its productivity. However, the narrow genetic base of *L. leucocephala* has highlighted problems of limited site adaptation and pest susceptibility, which has in turn contributed to the debate on selection criteria for agroforestry tree species (Pottinger et al., 1996).

Comprehensive exploration and seed collection programmes covering a trees' native range are expensive and time consuming, and few organisations are in the position to fund, or provide expertise to embark on this initial phase of a species introduction programme. This situation has meant that agroforestry tree evaluation programmes are frequently initiated with seed from only a small number of well known species, and then rapidly divert effort away from further evaluation and towards propagation of the top performing species. It is perhaps not surprising that this approach excludes many potentially useful closely-related species from entering evaluation programmes. The focus of improvement effort upon *L. leucocephala* illustrates the problems associated with such an approach perhaps better than with any other agroforestry tree species. While *L. leucocephala* has been promoted heavily throughout the tropics the remaining species within the genus *Leucaena*, which exhibit a diversity of growth and quality characteristics that is both valued and exploited by local farmers within their native ranges (Hughes, 1993), remain largely unknown.

Wood of *L. leucocephala* is described as being strong, light-weight and easy to work (National Research Council, 1984; Rao, 1984; Van Den Beldt and Brewbaker, 1985), and has been utilised for products ranging from fuelwood to higher value items such as furniture, flooring and carvings (Brewbaker[5], pers comm), in addition to pulp and industrial energy production (Pottinger and Hughes, 1995). Van den Beldt and Brewbaker (1985) reported that *L. leucocephala* produced wood of medium density. MacDicken and Brewbaker (1982) recorded a specific gravity (SG) of between 0.45 and 0.55, a value that compares favourably with other commonly grown fuelwood species such as *Gliricidia sepium* (0.5-0.6; Withington et al., 1987), *Albizia* spp. (0.45-0.59; Chundoff, 1984),

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Calliandra calothyrsus (0.51-0.78; National Academy of Sciences, 1980; Duguma[6], unpublished data) and *Prosopis juliflora*, considered one of the best fuelwood species (0.7; National Academy of Sciences, 1980).

The calorific value of *L. leucocephala* is comparable to other fast-growing non-resinous hardwoods (Pottinger and Hughes, 1995),and some interest has been shown in exploiting this attribute, in combination with its rapid growth rate. Only in the Philippines, however, have extensive dendrothermal energy schemes based on leucaena been developed, and these have met with mixed success (Brewbaker, 1987). Wood of *L. leucocephala* has excellent pulping qualities for the production of printing and writing paper (Brewbaker, 1987; National Research Council, 1984) but is unsuitable for heavy construction due to its low durability and susceptibility to termite attack (Bagwan, 1983).

Although it is unlikely that any of the hitherto poorly tested *Leucaena* species will match *L. leucocephala* in terms of its nutritive quality, the same cannot be said of wood quality or productivity. Within the native range of the genus, stretching from southern Texas, through Mexico and Central America to Peru, several Leucaena species are preferred to *L. leucocephala* for both construction and fuel (Hughes, 1993).

This paper reports on the wood quality of a range of species in the genus *Leucaena*.

Materials and methods

A sub-set of trials from LEUCNET was identified in order to investigate both the wood quality and wood productivity within the genus *Leucaena*. Although the vast majority of trials in LEUCNET have been established principally to investigate the production of animal fodder, and therefore harvested repeatedly on a relatively short cycle, a few were managed specifically to evaluate the wood production by either leaving trees altogether or thinning the trial periodically to allow the trees unimpeded growth. Three trials were selected for investigation of wood quality, based on the range of taxa included in the trial, and 11 for productivity using, principally, the criterion of availability of results for measurement of woody biomass (Table 1).

Table 1. LEUCNET trials used in the study

Trial location	Organisation managing trial	Study for which trial used
Redland Bay, Queensland, AUSTRALIA	Department of Agriculture, University of Queensland	Wood quality
La Soledad, Comayagua, HONDURAS	Forest Conservation & Tree Improvement Project (CONSEFORH)	Wood quality and productivity
Dahod, INDIA	Kribhco Indo-British Rainfed Farming Project	Wood productivity
Jhansi, Utta Pradesh, INDIA	National Research Centre for Agroforestry	“ ”
Makoka, MALAWI	International Centre for Research in Agroforestry (ICRAF)	“ ”
Lae, PAPUA NEW GUINEA	PNG University of Technology	“ ”
Markham Valley, PAPUA NEW GUINEA	Department of Agriculture & Livestock	“ ”
IRRI, Los Baños, PHILIPPINES	Forages for Smallholders Project	Wood quality and productivity
Tabora, TANZANIA	ICRAF	Wood productivity

[6]IRA/ICRAF Project, Yaounde, Cameroon

Trial location	Organisation managing trial	Study for which trial used
Chiang Mai, THAILAND	Faculty of Agriculture, University of Chiang Mai	“ ”
Chipata, ZAMBIA	ICRAF	“ ”
Dombashawa, ZIMBABWE	ICRAF	“ ”

Detailed assessments of wood quality are usually undertaken by submitting large, defect free samples of mature stem wood to a series of mainly destructive tests. Fortunately, timber properties of most value to farmers including compressive and tensile strength, and calorific value are related directly to density (Pension and De Zeeuw, 1980; Zobel, 1980) which can be measured relatively easily from small samples of wood.

For the wood quality evaluation sections of stem approximately 15cm in length were cut at 1.3m from the base of either two or three trees of each taxon in each of the two replications in the trial. The sections were air dried prior to despatch by air freight to OFI. Samples were de-barked, conditioned to 12% relative humidity, and the length, diameter and weight of each sample was measured.

Dry matter wood production was measured by individual trial managers and results sent to OFI. As the age of trials, trial composition, planting design, harvesting interval and harvesting method varied amongst experiments direct comparison between trials was not appropriate. Instead, the rank of each taxon in each trial was weighted according to the number of accessions in the experiment, and a mean score across trials calculated, thereby enabling assessment of performance across sites.

Results

Significant variation (P<0.001) was recorded in wood density between taxa at each of the three sites included in the study, and also between the mean densities recorded over the three sites. Significant correlation (P<0.001) was also evident in ranking between the three sites.

The taxon recording the highest figure for density over the three sites was *L. shannonii* (0.86 g/cm^3), followed by *L. collinsii* ssp. *zacapana* (0.84 g/cm^3) and *L. magnifica* (0.83 g/cm^3). The lowest densities were recorded by *L. multicapitula* (0.50 g/cm^3), *L. pulverulenta* (0.52 g/cm^3) and *L. leucocephala* (K156) (0.59 g/cm^3) (Figure 1).

The mean wood productivity assessment over 11 sites revealed the highest scores for *L. salvadorensis*, *L. leucocephala*, *L. macrophylla* ssp. *istmensis* and *L. collinsii* ssp. *zacapana* (Figure 2).

The correlation between wood productivity scores and mean wood density was not significant (*cc*=0.223). Two sites (Honduras and Philippines) provided the opportunity to compare ranking between wood productivity and density and both produced non significant correlations (cc=0.174 and -0.154 respectively).

Discussion

Comparison of values of wood density between studies are complicated by both the age of the sample (Gourlay et al, in press: Hossain et al, 1991; Sood, 1995) and the method of measurement. However, broad comparisons between experiments are possible. In this respect it is interesting to note the similarity in mean density recorded for *L. leucocephala* recorded in this study (0.61 g/cm^3), by Brewbaker (1987) (0.5-0.6 g/cm^3) and by Gourlay (unpublished data from samples supplied by Shelton[7]) (0.64 g/cm^3). Furthermore, the mean density figure for *L. leucocephala* recorded in this trial

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was below the average recorded for all species (0.7 g/cm³), reflecting the low regard for its wood when compared with other species in the genus in their native ranges (Hughes, 1993).

Given the wide variation in tree form within the genus and the comprehensive representation of that diversity in the three trials assessed for wood density it is not surprising that a highly significant variation in wood density was recorded between taxa. In addition, the strong overall correlation between sites was largely expected given the general high degree of genetic control of wood characteristics in angiosperms (Zobel and van Buijtenen, 1989). Of perhaps greater interest was the performance of the most promising taxa on each site. In this respect it is interesting to note that each of the taxa that comprised the overall top ten for wood density (Table 2) occurred in the top ten on each site except in four instances.

Table 2. The top ten ranking accessions for mean wood density of 34 Leucaena accessions across three sites.

Rank	Accession	Accession number	Density (g/cm^3)
1	*Leucaena shannonii*	26/84	0.86
2	*Leucaena collinsii* ssp. *zacapana*	57/88	0.84
3	*Leucaena magnifica*	19/84	0.83
4	*Leucaena shannonii*	53/87	0.82
5=	*Leucaena collinsii* ssp. *zacapana*	18/84	0.81
5=	*Leucaena collinsii* ssp. *collinsii*	45/88	0.81
5=	*Leucaena collinsii* ssp. *zacapana*	56/88	0.81
8	*Leucaena salvadorensis*	17/86	0.78
9	*Leucaena magnifica*	58/88	0.77
10	*Leucaena lanceolata* ssp. *sousae*	50/87	0.75

The assessment of mean wood productivity revealed the good growth rate of *L. leucocephala,* but when viewed in conjunction with wood density results suggested that this species should not be favoured for wood production. In fact, few taxa provided evidence of both high density and good wood production. However, the results have highlighted two species which appear promising in terms of their ability to grow well and produce wood of high density, when compared with commonly grown agroforestry species. It is interesting to note that these two species, *L. salvadorensis* and *L. collinsii* ssp. *zacapana* are already valued highly by farmers in Central America and Mexico for the volume and quality of their wood products (Hughes, 1993; Hellin & Hughes, 1993). (It is, nevertheless, important to note that several LEUCNET trials in southeast Asia not included in this study reported relatively poor growth of *L. collinsii* ssp. *zacapana*).

While this study has provided an indication of Leucaena species which appear promising for wood production, evaluation of wood productivity from a wider range of trials is required before firm conclusions can be drawn. Future assessment of field trials within LEUCNET will assist scientists, rural development agencies, and ultimately farmers, to make better informed choices with species selection for tree planting on farms if wood production is the principal output.

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Figure 1. Mean wood density of 34 Leucaena accessions grown at three sites

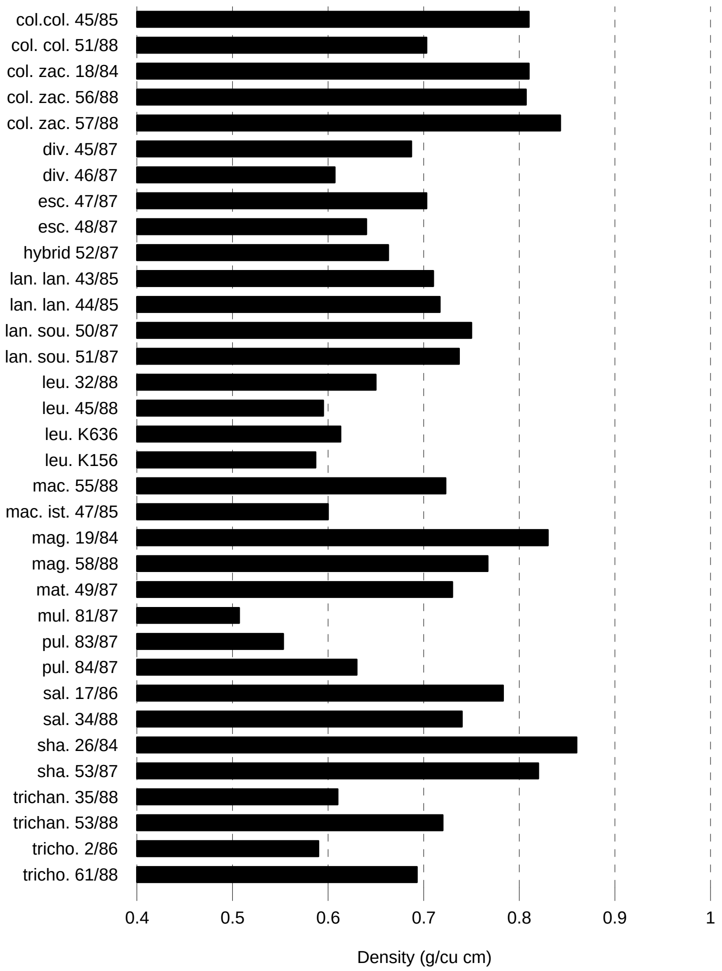

Figure 2. Mean wood production score of 34 Leucaena acccessions grown at 11 sites