Comparison of wood basic density and basal area of 5-year-old *Acacia crassicarpa, A. julifera, A. leptocarpa, Leucaena pallida* and *Senna siamea* in rotational woodlots trials in western Tabora, Tanzania

Raphael Luhende
Tabora Miombo Woodland Research Centre
P.O. Box 1960 Tabora, Tanzania
Email: rluhende2003@yahoo.co.uk
Tel: +255 026 4540 Fax: +255 026 4906

Gerson Nyadzi
Tumbi Agricultural Research and Development Institute
P.O. Box 306 Tabora Tanzania
Fax: 255 26 260 4907
Email: gnyadzi@hotmail.com

Rodgers E. Malimbwi
Sokoine University of Agriculture
Department of Forest Mensuration and Management
Morogoro, Tanzania
Tel: +255 2604648
Email: malimbwi@suanet.ac.tz

Introduction

The term rotational woodlot connotes a technology which involves growing trees, normally N-fixing, with crops for 2-3 years until the trees out-compete the crops. The woodlot may then be used as a source of fuelwood, building poles or fodder. Soil fertility is also restored during this time until the farmers can cut the trees and start growing crops between the stumps, 4 to 5 years later. The technology was designed to mimic the traditional practice of shifting cultivation by introducing trees into the crop and shrub land with shortened fallow. The cropping and fallow phases take place concurrently. This allows the farmers to crop for an extended period without returning the land to bush fallow. The technology is flexible in the sense that it allows the farmers to adopt both the cropping phase and trees to suit individual needs which diversifies production base, enhances trees and crops productivity and allows a sustainable cropping system (Ramadhani *et al*. 2002).

This technology is being promoted by the World Agroforestry Centre (ICRAF) in collaboration with farmers, Tanzania Forestry Research Institute (TAFORI), and the Agricultural Research and Development Institute (ARDI) Tumbi. The main objective is the provision of fuelwood for tobacco curing and other domestic uses to rural farmers and improvement of soil fertility in the tobacco-cereal land use system of Tabora, Tanzania. It reduces pressure on the 'miombo' woodlands. Despite the potential of this technology, there are few studies on wood basic density and basal area on trees currently used in rotational woodlots. Wood density is highly affected by woodlot manipulation through silvicultural and cultural practices. This study reports comparison of wood basic density and basal area of 5-year-old N-fixing trees of *Acacia crassicarpa, A. julifera, A. leptocarpa, Leucaena pallida* and *Senna siamea* grown in rotational woodlots both on-station and in farmers fields.

Materials and Methods

Study site

Data were collected from both on-station and from farmers' fields. The sites used were: Kipera (1180 m asl), Manoleo/Itonjanda (1250 m asl), Magiri/Sido (1240 m asl), Isikizya (1250 m asl) and ARDI-Tumbi (1160 m asl). Soils in the study area are ferric acrisols or Oxic Haplustalfs. They are are acidic, low in organic carbon, nitrogen, phosphorus and cation exchange capacity. Trials on farmers' fields were farmers managed trials. Farmers were chosen based on their willingness to offer land for the trial and ability to establish and conduct all operations in the trials.

Experimental design

A Complete Randomized Block Design replicated seven times (three times on-station and four times on-farm) where each five plots on-station and each farmer on-farm represented a replicate. Plot size was 16 m x 20 m (on-station) and had 20 trees. Plot size was 16 m x 16 m, (on-farm) and each plot had 16 trees. Plot spacing was 2 m.

Data collection and analysis

Wood samples were selected from small, middle and large diameter sizes. A total of 84 trees were sampled, 36 trees (on - station) and 48 trees (on - farm trial) 3 trees for each species for wood density studies. This is because the method is time consuming and destructive. Sampled wood disks of 2 cm thickness from each main stem were crosscut at 30%; 60% and 90% of the stem length. They were then soaked in distilled water for one week to ensure full cell saturation. The green volume of each disk sample was measured by water displacement method. The disks were then oven dried at 103±2°C and cooled over silica gel before determining oven dry weight.

Wood basic density was calculated based on oven dry weight and green volume as follows:

$$\textit{Basic density} = \frac{\textit{Oven dry weight of disk sample}}{\textit{Green volume of disk sample}}$$

Basal area studies were done to all surviving trees in a plot by measuring tree diameter at breast height (DBH). Mean basal area per hectare was determined in each plot by using the following formula:

$$G = (\Sigma g_i) / a$$

Where $g_i = (\pi d_i^2) / 4$,
a and d_i are plot area (ha) and Diameter at breast height (DBH) of the i^{th} stem in the plot respec tively
G = Mean basal area
g = basal area per tree
$\pi = 3.1428$

ANOVA was conducted using SAS statistical program. Significant difference means were separated at $p< 0.001$ according to Zar (1984). An ordinal ranking scheme was used to separate overall best species.

Results and Discussion

Basic density of trees grown in rotational woodlots

Focusing on basic density for trees grown on-station trial, *Acacia leptocarpa* and *A. julifera* produced higher basic densities while *S. siamea* and *L. pallida* had relatively lower basic density. Differences in basic density between the species were notable for trees grown on-station whereas for trees grown in farmers' fields differences were not significant (Tables 1 and

2). The basic densities obtained in this study were comparable to those of *A. mangium* and *A. auriculiformis* of 0.570 g cm^{-3} and 0.617 g cm^{-3} respectively at the age of six years in Zanzibar (Ali *et al*. 1997). The results demonstrate that these species are highly suitable for fuel wood.

Table 1. Mean diameter, height, and basic densities of trees grown on-station in rotational woodlots.

Species	DBH (cm)	Height (m)	Basic density (g cm^{-3})	Basal area (m^2 ha^{-1})	Overall rank
A. crassicarpa	15.7a*	10.4 a	0.560 bc	3.54 a	1.25
A. julifera	9.9 b	6.6 b	0.627 ab	2.12 ab	2.00
A. leptocarpa	7.6 bc	6.7 b	0.693 a	1.06 bc	2.25
S. siamea	7.4 bc	5.9 b	0.507 c	2.32 ab	2.50
L. pallida	5.16 c	5.6 b	0.550 bc	0.63 c	3.00

*Mean values in the same column with same following letters do not differ significantly ($P > 0.001$).

Table 2. Mean diameter, height, and basic densities of trees grown on-farm in rotational woodlots.

Species	DBH (cm)	Height (m)	Basic density (g cm^{-3})	Basal area (m^2 ha^{-1})	Overall rank
A. crassicarpa	15.3a	9.4 a	0.584 a	4.67 a	0.25
A. julifera	8.1 b	6.6 b	0.622 a	3.97 a	1.50
A. leptocarpa	7.8 b	6.9 b	0.647 a	1.98 a	1.50
S. siamea	7.0 b	5.9 bc	0.540 a	4.36 a	1.75
L. pallida	4.0 b	4.6 c	0.444 a	1.18 a	2.00

* Mean values in the same column with same following letters do not differ significantly ($P > 0.001$)

Mean basal area for trees grown in rotational woodlots

Differences in basal area were outstanding for trees grown on-station. Trees on farmers' fields trial were uniform in basal area production. *Acacia crassicarpa* and *A. julifera* had the highest basal area respectively in both trials followed by *S. siamea* (Tables 1 and 2).

Mean diameter and height growth for trees grown in rotational woodlots

Differences in diameter between the species are important for trees grown on-station compared to those from farmers' fields. *Acacia crassicarpa* was the tallest species and *L. pallida* the shortest. Other species exhibited uniformity in height growth in both trials which suggest little contribution to basal area in both sites.

Conclusion

The higher basic density of wood for nitrogen fixing trees grown in rotational woodlots in Tabora suggests suitability of these species for fuelwood purposes. The trees can be good source of fuel for curing tobacco in the tobacco cereal land use system. It is recommended that long-term observation studies on wood basic density be done in rotational woodlots in order to understand the effects of different management. It is also noted that among the species tested *A. crassicarpa* has the greatest wood yield.

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Productivity of *Acacia mangium* in Kerala State, India

C. Buvaneswaran* and *M. George
Forest Productivity & Agroforestry Division
Institute of Forest Genetics and Tree Breeding,
Indian Council of Forestry Research & Education
P. B. No.:1061, Forest Campus, Coimbatore - 641 002
Tamil Nadu. India
E-mail: cbuvanes@ifgtb.res.in

Introduction

Acacia mangium Willd. was introduced into India in 1980s and farmers started planting the species on farm fields in the early 1990s, particularly in the State of Kerala (Dhamodaran and Chacko 1999). Fast growth and expectations on higher economic return in short rotation have made this acacia popular for growing on farmlands of Kerala. It is planted both as a sole crop in the form of block plantation as well as introduced as a component in homesteads. This paper describes its performance and productivity under different planting conditions on farm fields in various agro-climatic zones of Kerala.

Materials and Methods

The study was conducted in the state of Kerala. Altitude varies from sea level in the coastal plain to 2694 m at Anamudi. Mean annual rainfall varies from 2000 to 3200mm in most of the areas. The soils are either shallow-medium depth, loamy, red and lateritic or deep coastal alluvials. Kerala is divided into eight agro-climatic zones and *A. mangium* is grown mainly in three zones *viz*. Northern, Southern and High Altitude zones both in homesteads and in plantations.

Most of the *A. mangium* plantations on farmlands are 6-10 years old. Spacing is between 2.5 x 2.5 and 3 x 3m in block plantations and varies widely in homesteads.

Results and Discussion

The growth of *Acacia mangium* on farmlands is shown in Table 1.

Table 1. Mean growth performance of *Acacia mangium* at different ages in Kerala.

Age (years)	Girth (cm)	Height (m)
4	46.0	12.0
5	57.7	12.0
6	61.1	13.0
7	63.0	13.0
8	81.2	15.0

The mean annual increment (MAI) in terms of girth at breast height was calculated for three zones in Kerala. Plantations in the High Altitude zone had the highest MAI (9.6 cm) compared to 8.0 cm and 9.3 cm in the Southern and Northern zones respectively.

This study confirms that growth performance of *A. mangium* varies greatly with site conditions. The productivity of *A. mangium* was 35-45 m^3 ha^{-1} yr^{-1} in humid zones, particularly in the Southern zone, and from 20-25 m^3 ha^{-1} yr^{-1} in subhumid