BASIC DENSITY OF WOOD OF *PINUS CARIBAEA* GROWN IN ZANZIBAR, UNITED REPUBLIC OF TANZANIA

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KHIARI, S.K. & IDDI, S. 1991. Basic density of wood of *Pinus caribaea* grown in Zanzibar, United Republic of Tanzania. The basic density and its variation in 12-y-old *Pinus caribaea* grown in Masingini Forest Reserve, Zanzibar was investigated. Increment cores were extracted at breast height from 30 defect-free dominant and codominant trees. Basic density was calculated by dividing oven dry weight by saturated volume obtained by the water displacement method. The main results were: (i) Mean basic density for 12-y-old *P. caribaea* grown at Masingini Forest Reserve was 460 $kg\ m^{-3}$ with a standard deviation of 66 $kg\ m^{-3}$; (ii) Between tree basic density varied from a minimum of 345 $kg\ m^{-3}$ to a maximum of 637 $kg\ m^{-3}$; (iii) Generally, basic density increased from pith to bark. The increase from inner to middle core was slight while the increase from middle to outer core was sharp; (iv) Growth rate had no significant effect on tree basic density.

Key words: *Pinus caribaea* - basic density - core

Introduction

Pinus caribaea, commonly known as Carribean Pitch Pine is a native of the Carribean area, Cuba, British Honduras and Bahamas. As an exotic plantation species, *P. caribaea* is planted fairly widely in the south, east, west and central parts of Africa. The species has become the most important lowland fast growing timber species in tropical and subtropical countries (Lamb 1973). In Tanzania the species (Carribean Pitch Pine from Cuba) was introduced for planting on the coastal plains and shores of Lake Victoria in the 1950s (Bryce 1967). The first trial plots were established in the early 1950s. Large-scale planting started in the 1960s. To date the species is planted widely in Sao Hill, Rubare, Rubya, Ruvu, Buhindi and Zanzibar Islands. Planting of the species in Zanzibar started in 1976 at Masingini Forest Reserve. Currently there are about 280 *ha* under *P. caribaea* and planting continues. The species is planted for sawnwood. This calls for studies to be made to assess the quality of wood. Wood density is the single most important characteristic that can be used to predict wood quality since it has strong relationship with most wood properties. The objectives of this study were therefore:

(1) to determine the basic density of *P. caribaea* grown in Zanzibar;
(2) to determine the radial basic density variation within and between trees;
(3) to establish relationship between the rate of growth and basic density;
(4) to compare the results with other studies.

Materials and methods

Description of study area

Masingini Forest Reserve (longtd. 39°11' and 39°51'E, lat. 5°43' and 6°29'S) is located about 6 *km* northeast of Zanzibar Municipality. The area lies at an altitude of 80 to120 *m* above sea level. The terrain is rough and the soils are classified as reddish or greyish sand with 0 to 20 *cm* top layer of sand with humus which has a sandy loam underlayer. The area receives rainfall of 1,400 to 1,600 *mm* which falls in two seasons: short rainfalls in October to December and long rainy season in March to May.

Sample trees selection and core extraction

A total of 30 12-*y*-old trees free of any defects were selected from three compartments in the Masingini block for basic density determination. The block covers an area of 9.5 *ha*. The selected trees were dominant and codominant. Five trees were selected from compartment 02, 10 from compartment 05 and 15 trees from compartment 11. Compartment 02 has 1.7 *ha*, compartment 05, 3.1 *ha* and compartment 11, 4.7 *ha*.

After selecting the sample trees, their breast height diameters were measured and recorded. Cardinal directions were then marked at breast height of each tree to indicate direction of core extraction. Cores measuring 5 *mm* in diameter were extracted alternately from north, east, south and west of compass direction to minimise possible influence of compass direction on wood basic density. The cores were marked accordingly and sprayed with 95% alcohol to prevent fungal attack while awaiting further treatment.

Laboratory procedure

In the laboratory each core was cut at the pith with a sharp knife and its length measured with a ruler. It was then divided into three equal sections marked serially 1 to 3 from the pith to the bark. The section nearest the pith was designated inner core, the middle portion middle core and that nearest the bark outer core. The sections were next soaked in distilled water for at least 36 *h* to attain green volume. Green volumes of the sections were then measured by water displacement. After measuring the green volumes, the sections were dried in a oven at $103 \pm 2°C$ to constant weight. The oven dry sections were cooled in a desiccator over silica gel before their weights were recorded. Basic density was calculated as follows:-

$$\text{Basic density, } kg\ m^3 = \frac{\text{Section oven dry weight}}{\text{Section green volume}}$$

The basic wood density for the whole core was calculated as the mean of the three sections while the basic density for the compartments was calculated as the

arithmetic mean basic density of all trees sampled from the compartment. The basic density of all blocks was calculated as the mean basic density of all trees. The effect of growth on basic density was established using simple linear regression.

Results and discussion

Average basic density

Table 1 shows the average basic density and standard deviation (Sd) of *P. caribaea* for each compartment. The mean for all trees is also shown.

Table 1. Average basic density of *P. caribaea* ($kg\ m^{-3}$)

Compartment Number	Number of trees	Dbh (*cm*)	Section Number	Basic density		
				Section mean	Tree mean	Sd
05	10	29 - 40	1	386		
			2	425	450	64
			3	539		
02	5	28 - 39	1	394		
			2	434	455	68
			3	538		
11	15	20 - 36	1	422		
			2	427	467	70
			3	553		
Arithmetic mean for all trees					460	66
Coefficient of variation					14.3%	

The mean basic density of 460 $kg\ m^{-3}$ for all trees is within the range of 340 to 680 $kg\ m^{-3}$ reported by Chudnoff (1980) for the species. The age of the material studied by Chudnoff (1980) is, however, not indicated. It is known that generally in conifers density varies directly with age (Panshin *et al.* 1964).

Palmer *et al*. (1984) report a value of less than 388 $kg\ m^{-3}$ for 12-*y*-old *P. caribaea* grown at Rubya (altitude 1200 *m* a.s.l.) which is lower than the basic density of the species used in this study. This difference may be due to altitude. There is a tendency for the species to have higher density at lower altitude. Palmer and Ganguli (1982) for example found that *P. caribaea* had a basic density of 548 $kg\ m^{-3}$ at a site at sea level while two montane sites had basic density of 467 and 377 $kg\ m^{-3}$ respectively. Furthermore, Silinge and Iddi (1990) found that 19-*y*-old *P. caribaea* grown at Kondoa, Central Tanzania at an altitude of 1300 *m* had basic density of 403 $kg\ m^{-3}$. Lamb (1973) considers that *P. caribaea* with basic density of less than 400 $kg\ m^{-3}$ has low strength properties not suitable for constructional purposes. The basic density recorded in this study is above this minimum value and may therefore be suitable for constructional work. In addition, the wood is likely to have higher density than the recorded value at the expected rotational period of 20 to 25 *y*.

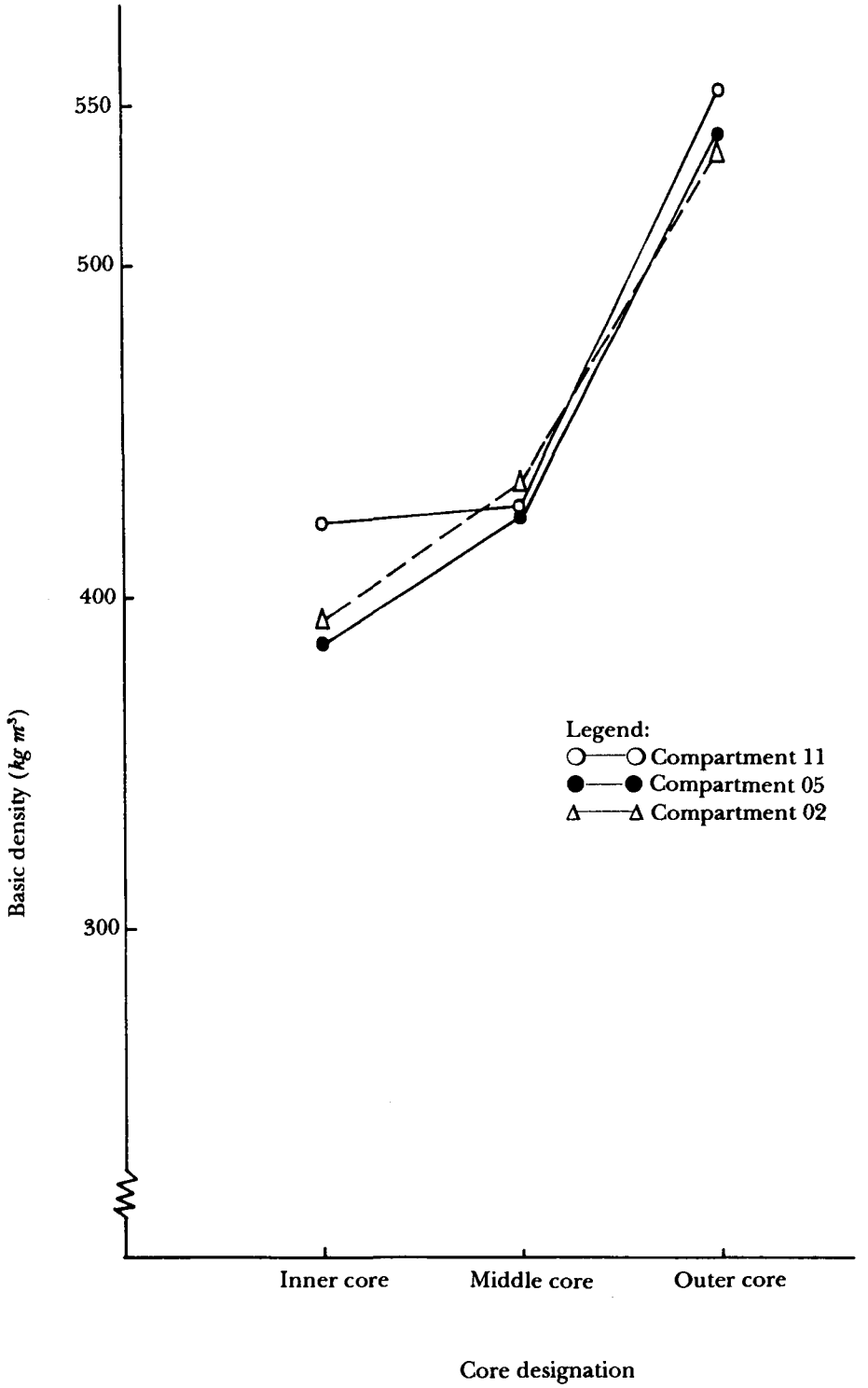

Figure 1. Radial variation in basic density of *P. caribaea*

Within tree basic density variation

Only the within tree radial variation of the basic density was studied. This variation is shown in Figure 1. The figure shows that basic density increased from pitch to bark. The general increase in density from pith to bark found in this study is in agreement with the general trend observed in many conifers (Lema *et al.* 1978, Ringo & Klem 1980). Results show that while the increase in basic density from inner to middle core was slight, that from middle to outer core was very sharp. A practical consequence of this is that *P. caribaea* grown in Zanzibar will have a large core of low density wood. This feature will mean that sawn wood from this area of the log will be of low strength and that it will be subject to severe defects, *e.g.* crooking, splitting, *et cetera* upon seasoning. The pattern of radial variation in basic density also implies that the species has to be grown on long rotations if the aim is to produce high density wood.

Between tree basic density variation

Between tree basic density variation showed a standard deviation of 66 $kg\ m^{-3}$ and a coefficient of variation of 14.3%. The minimum value was 345 $kg\ m^{-3}$ and the maximum value was 637 $kg\ m^{-3}$. The minimum value occurred in trees from compartment 05 while the maximum value occurred in compartment 11. Such large variation is expected in *P. caribaea.* Several authors such as Bryce (1967), Lamb (1973) and Plumptre (1984) report that the density of *P. caribaea* is quite variable. Plumptre (1984), for example, reports a coefficient of variation of 13.2% for material grown in Fiji. The main cause for this variation is probably genetic differences since all the three compartments studied are under the same climatic conditions.

The effect of growth rate on basic density

The following regression equation relating growth rate and basic density was obtained:

$$y = 552.14 - 2.99x$$
$$r = 0.2$$

where x = dbh (cm); y = the predicted basic density ($kg\ m^{-3}$).

This relationship was insignificant. Similar results have been reported for *P.patula* grown in Tanzania (Lema *et al.* 1978, Ringo & Klem 1980). This implies that neither dry matter production nor strength of the wood would be affected significantly by increased rate of growth.

Conclusions

The following are the main conclusions from the study:

- The mean basic density of 12-y-old *P.caribaea* grown in Zanzibar was 460 $kg\ m^{-3}$ with a standard deviation of 66 $kg\ m^{-3}$;

- Between tree basic density varied from a minimum of 345 $kg\ m^{-3}$ to a maximum of 637 $kg\ m^{-3}$;
- Basic density increased from pith to bark. The increase from inner to middle core was gradual while that from the middle to outer core was very sharp;
- Growth rate had no significant effect on basic density.

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