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Assessment of Some Physical Properties of Pinus Caribeae (Morlet) in a Four Different Age Plantation in Oluwa Forest Reserve, Nigeria

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ABSTRACT

This study assessed of the effects of within tree variation on wood density, ring width and volumetric shrinkage of Pinus caribeae (Morlet) among four different plantation ages in Oluwa forest reserve. Five Pinus caribaea (Morlet) in three partitions were randomly selected from each of the four different ages (15, 16, 17 and 18) of the plantation and felled for the study. Wood samples were prepared from five height levels, 10%, 30%, 50%, 70% and 90% and also among the wood type; inner wood, middle wood and outer wood positions of the stem according to standard procedures. The result showed that the wood density ranged between 0.33g/cm3 and 0.56g/cm3. Among the plantation ages, a strong positive correlation was established between density, ring width and shrinkage properties including the relationship between ring width and volumetric shrinkage being positive. Thus, it may be possible to use density and grain orientation biometry to predict anisotropic shrinkage of the wood and its dimensional stability.

Keyword: *Physical properties, Pinus caribeaa (Morlet), Oluwa Forest Reserve, Nigeria*

1. INTRODUCTION

In the past, Pinus caribeae selection was based purely on the tree's vigor, stem quality, branch habit and crown features. Presently, interest in its improvement is not only centered on over-all form and growth rate but also on wood properties particularly density. Characterizations of the various wood properties of caribeae had been dealt with in a number of investigations (Scott, 1952; Wangaard et al., 1955; Shand, 1966; Hwghes, 1970; Burley et al., 1971; Lantican, 1972; Harris, 1973; Paraskevopoulou, 1973; de Villiers, 1974; Bower at al 1976; Banks, 1977). These studies suggest that there is a wide range of variability present in the wood properties of P. caribeae. Many researchers have also dealt with the identification and quantification of the different sources of variation in the wood properties of this species (Hughes, 1970; Andrew and Hughes, 1973; de Villiers, 1973; Barnes et al., 1977; Ong, 1978; Plumptre, 1978; Burley et al., 1979). There is a general agreement that, although site may be an important source of variation, the tree-to-tree differences in wood properties are considerable, and it is hoped that an appreciable proportion of these may be genetic in nature.

In pines, the negative genetic correlations obtained between specific gravity and diameter in some studies (Stonecypher et al., 1964; Zobel, 1966) is extremely discouraging. Nevertheless, there are also studies suggesting that there is independence between density and growth rate (Nicholls et al., 1964). For **P.** caribeae, negative correlations (phenotypic) have already been obtained between ring width and- density (Lantican, 1972; Ong, 1978) and it is feared that in the Oluwa Forest Reserve, the effects of age might have detrimental effects on its wood quality. Therefore, the objectives of the present study were to investigate the variation in wood density and wood shrinkage in the Pinus caribeae stem among four different age plantation and to examine the relationship between their wood density and shrinkage in Pinus caribeae.

2. MATERIALS AND METHOD

2.1 Study Area

Oluwa forest reserve is located at in Ondo State in the Western part of Nigeria on latitude 10˚37'N and longitude 9˚20'E with an area of 827 km^2 and falls within the tropical rainforest (Adekunle and Bakare, 2004). It is 50km east of Omo and 26km from Ore (Anifowose, 1989). The topography is undulating with a mean elevation of 90m above sea level, mean relative humidity of 80% and daily temperature of 25˚C. The vegetation of the study area is a mixed/moist semi-evergreen rainforest (Dauda et al., 2004).

2.2 Data Collection

The materials for the study were obtained from a Pinus caribeae (Morelet) plantation grown in Oluwa forest reserve (World Bank assisted project). The wood samples were collected from a 15 years, 16 years, 17 years and 18 years old plantation with an area of 25 ha. Each plantation was divided into a 5 partitions with an area of 5ha each. 5 trees from each partitions with good bole were randomly selected from 3 of the partitions in each of the partitions (P1, P2 and P3). The diameter at breast height (dbh), four cardinal points on the tree trunk with the aid of a meter tape and compass were recorded as described by TAPPI (1995) and Browning (1977) were observed in all the selected trees before they were felled.

Five (5) disc with a thickness of 50mm were obtained from the felled trees at 10%, 30%, 50%, 70% and 90% of their merchantable length. The discs were individually labeled and their surfaces coated with paraffin and stored separately in polythene bags. Each of the disc were subsequently debarked carefully and a strip of 50mm wide obtained after careful marking and rip-

sawing to the pith from the bark. Half of the strip was used for the wood properties investigated – wood density, shrinkage variations and ring width while the other halves were carefully preserved and stored for further study. From each of the sampling levels, the strips were partitioned radially into Inner wood (A) 1-5 rings, Middle wood (B) 6-10 rings and Outer wood (C) 11-18 rings respectively based on the number of rings counted from the pith to the bark and also carefully labeled after obtaining strips of 20mm x 20mm according to their wood type.

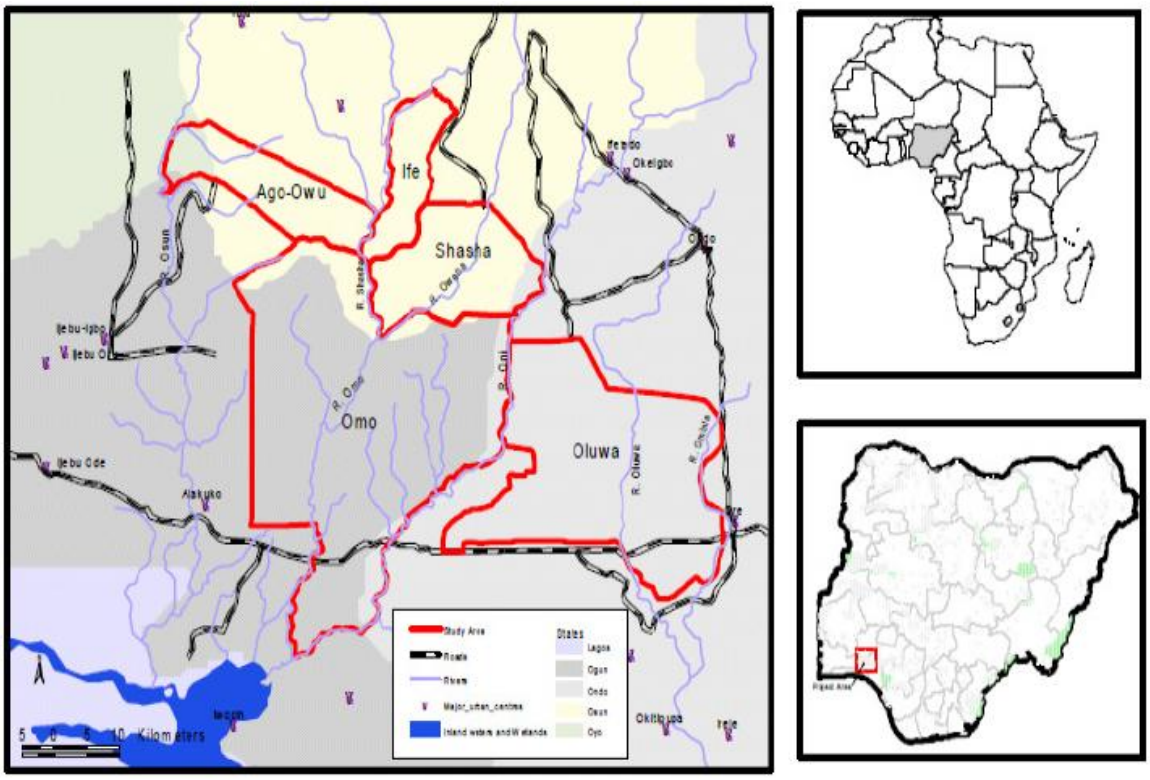

Fig 1: Map of study area showing location and major rivers in the area
Source: NCF, 2008

2.3 Wood density

The wood density was measured using the gravimetric method as prescribed by Smith (1954).

$$W_D = 1/((Ws - Wo / Wo) + 1 / 1.53) \text{ expressed in g/cm}^3 \quad (1)$$

Where W_D = wood density, Ws = saturated weight of specimen, Wo = Oven dry weight of specimen and 1/1.53 = reciprocal of the density of actual wood substance

2.4 Volumetric Shrinkage

The specimens of 20mm x 20mm x 20mm were properly aligned to show the radial and tangential planes and diligently coded for identification and measurement carried out with the aid of a vernier caliper during its wet condition. Specimens from each of the sampling height and partition were completely saturated with water by boiling and oven drying to a constant weight at 103˚C±2˚C for 48hrs as prescribed by Smith (1954) before measurement taken. Percentage shrinkage was determined for both the radial and tangential planes while the volumetric shrinkage was calculated from the sum of the tangential and radial shrinkage and expressed as a percentage of the original green dimension of the wood when dried to a constant weight (Chris, 2006; Onilu and Ogunsanya, 2000).

2.5 Ring Width

The ring width was determined according to the procedures used by Smulski (1996) and Onilude and Oluwadare (2000) by measuring the growth ring in the four cardinal positions by superimposing a double biconcave lens over a calibrated transparent ruler. The width was measured from the first formed early wood to the last formed latewood bands of each growth ring.

2.6 Statistical Analysis

The data obtained were analyzed using described statistics, analysis of variance (ANOVA), correlation and regression methods (Ezekiel and Fox, 1961; Snedecor and Cochran, 1997; Mc Donald, 2008).

3. RESULT AND DISCUSSION

3.1 Within-tree Density Variation

Density variation among the ages followed a pattern within the annual growth rings and along the radial and axial direction of the trees (Figure 1). The wood density decreased along the ages implying that increase in tree age resulted in a decrease in wood density. Within-tree density at the outer wood was higher among all the ages (16, 17 and 18) with 0.51g/cm^3, 0.50g/cm^3 and 0.40g/cm^3 respectively except for the15 year

plantation which had its highest within-tree density of 0.56 at its inner wood. The middle wood of the 16 and 17 year plantation had the least density while 15 and 18 year plantations had their least density at the outer and inner wood with 0.46g/cm^3 and 0.33g/cm^3 respectively.

Analysis of variance from pooled data from the four plantations on wood density showed that the regression of variation in density due to partition where positive (Figure 2).

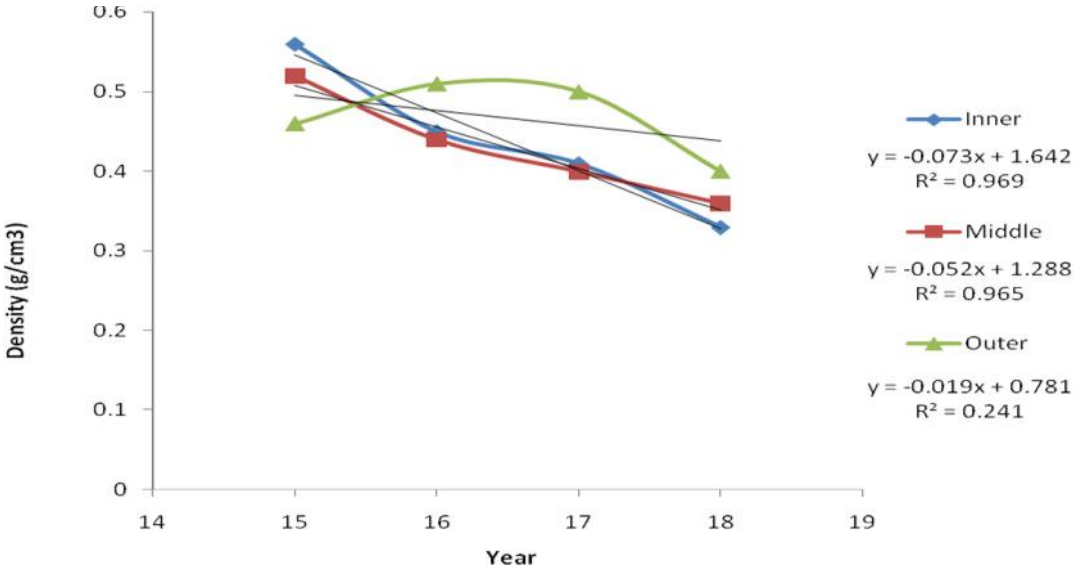

Fig 2: Within Tree density variation among plantation ages

3.2 Ring Width Variation in Plantation Ages

The result of ring width variation among the wood type shows that the ring width increased from the outer wood to the inner wood in all the plantation ages (Figure 2) except in the 15 year old plantation which decreased from the outer wood to the inner wood . The highest mean value of 2.3% was obtained at the inner wood of the 16 year plantation. The 15 year plantation had the highest ring width along the middle and outer wood among the plantations. The regression for all the wood types and the plantation age showed a positive value indicating that the wood types and age had a significant effect on the ring width variation (Figure 3).

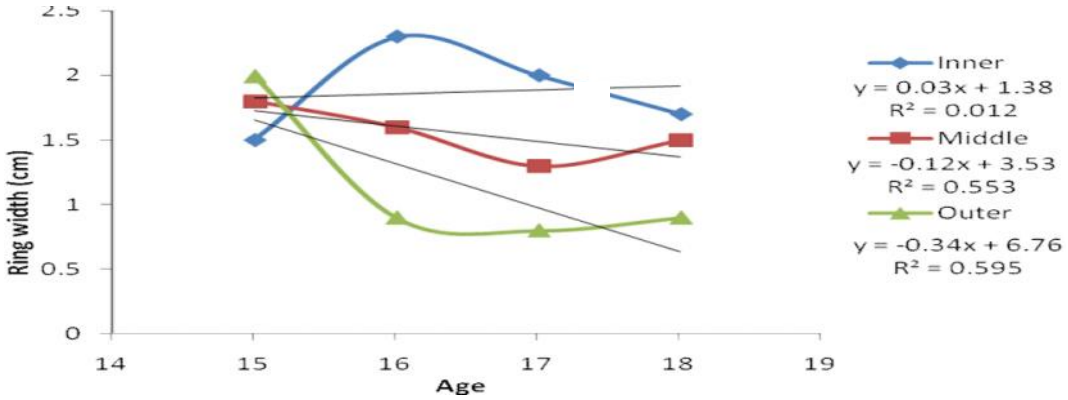

Fig 3: Ring width variation among plantation

3.3 Effect of Wood Type on Volumetric Shrinkage

The variation in volumetric shrinkage among the different wood types shows that the variation increased with increased in age of Pinus caribeae (Figure 3). Outer wood in 16, 17 and 18 year plantation had the highest mean shrinkage value of 10.6cm^3, 11.6cm^3 and 12.4 cm^3 respectively. In the 16 year old plantation, the Inner wood had the highest mean shrinkage value (10.3%) and outer wood had the least mean shrinkage value of 9.6%. The regression of volumetric shrinkage against wood types also showed a positive correlation and they were very high for each of the Partitions (Figure 4).

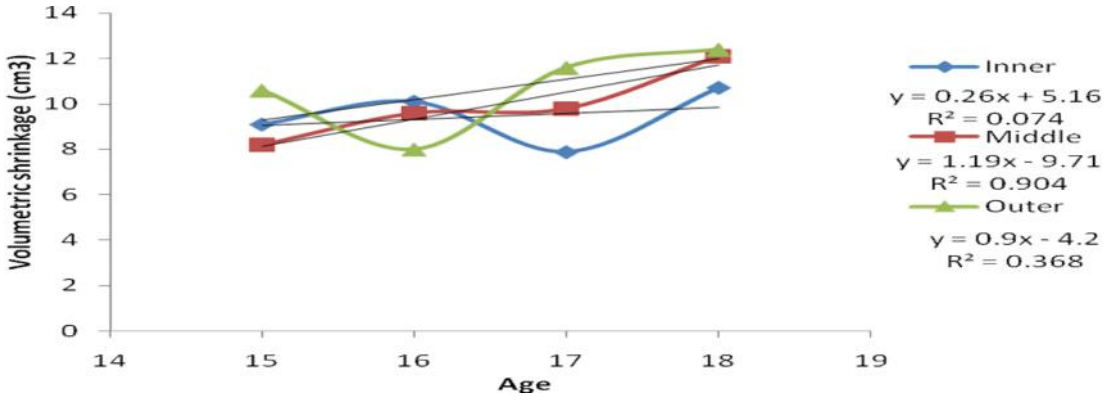

Fig 4: Volumetric shrinkage variation among plantation ages

3.4 Effect of Length on Volumetric Shrinkage of Trees among the Partitions

The result obtained shows that in the 18 years plantation, the mean volumetric shrinkage value was highest at 70% of merchantable height (11.5cm^3), while 15 and 16 years plantation had their highest mean at 30% of merchantable height with 10.1cm^3 and 10.2cm^3 respectively. The 17 years plantation had its highest mean at 90% of merchantable height with 10.4cm^3 (Figure 5). The regression model for all the plantation ages gave a positive correlation of the volumetric shrinkage with percentage level of merchantable height. However, the mean volumetric shrinkage among the plantations ranged between 8.0cm^3 and 11.5cm^3 with the highest regression value of 26% obtained in the 17 year plantation.

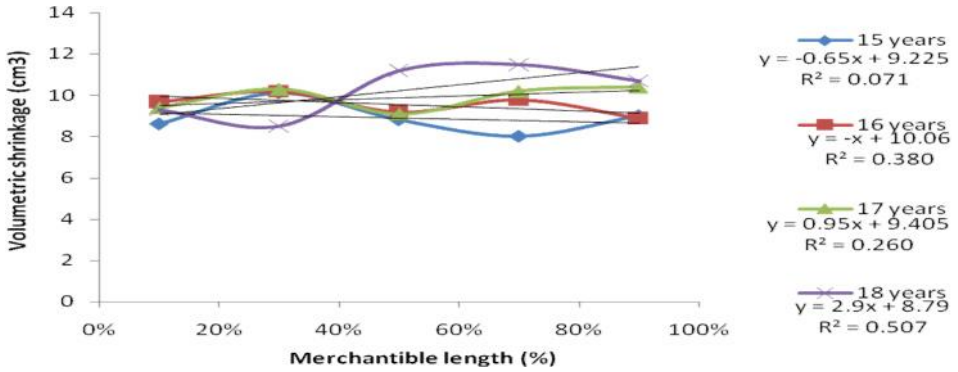

Fig 5: Volumetric shrinkage variation along merchantable length

3.5 Ring Width Variation and Wood Density

The result in Figure 5 shows the relationship between growth rate (ring width) and wood density among the four plantations. The ring width variation and wood density decreased with increase in age among the plantations. Moreover, when the samples were pooled, the coefficient of variation was 96% when the ring width and wood density was regressed against the plantation age.

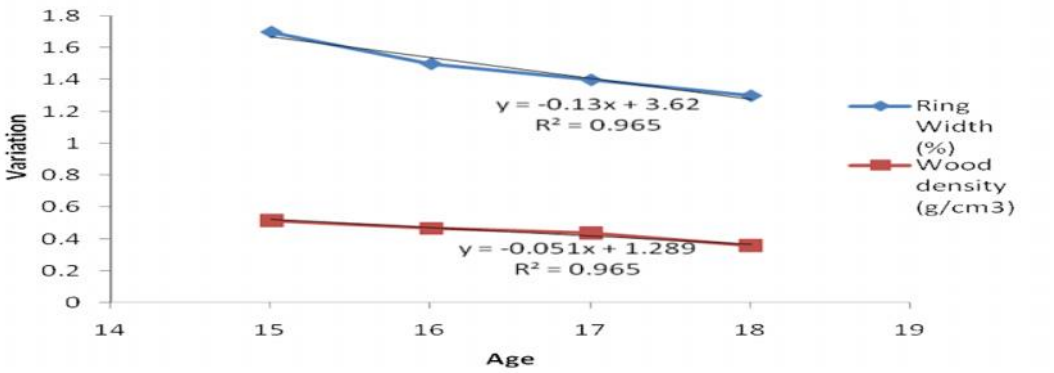

Fig 5: Ring Width and Wood density variation among the plantation ages

4. DISCUSSION

Some researchers have reported that wood density increases with age or distance from the pith (Boyce and Kaiser 1961; Farmer and Wilcox 1968; Bonneman 1980). This is supported by the fact that juvenile wood is usually known to be of lower density than mature wood (Dadswell 1958; Zobel and Buijtenen 1989). However, from the result obtained, wood density decreased with decrease in ring width as the plantation ages. This relationship does not follow a pattern described by Akachukwu (1982) and Udoakpan (2012). The higher density of Pinus caribeae in the 15 year old plantation declining toward the 18 year old plantation could be attributed to the presence of heartwood and extraneous materials resulting in the higher density values of the 15 year old plantation at the earlier growth rate or ring width. However, differences in growth rate have been reported to cause differences in wood density variation patterns in the axial direction of the tree (Larson, 1963; Jourex et al., 2001).

Changes in wood shrinkage with cambium age are related to radial inter-tree variation in wood density, which often displays an inverse pattern of changes (Johnson, 1942; Okkonen et al., 1972; Yanchuk et al., 1984). Increase in volumetric shrinkage was more on the 30% level than any other levels with values ranging between 4.3% and 5.5%. These values were in accordance with the observation of Udoakpan (2012), Chris (2006) and Martins (1984) with the range of 5.0% - 18%. The positive correlations between the between basic wood density, ring width and volumetric shrinkage in Pinus caribeae were in accordance with the observation of Koubaa and Smith (1959) with P. euramericana hybrid clones. Furthermore, the decreasing pattern of ring width as the plantation ages in the study implies that the sample trees of Pinus caribeae experienced fast response in their early growth years that resulted in the production of wider growth rings. Thus, as the trees mature with age, the rate of growth gradually decreases culminating in smaller growth rings development. It is evident from the study that variations in the growth rate had considerable and direct effect on the cell length development.

5. CONCLUSON

The wood of Pinus caribeae is heavy. With-in tree, wood density decreased from the base to the top and from sapwood to heartwood. The range of density values obtained in this study fall within the range of 0.45 – 0.65g/cm3 Moreover, the wood ring width had a characteristic variation among the partitions. A strong positive correlation was established between density and shrinkage properties and the relationship between ring width and anisotropic shrinkage was also positive. Thus, it may be possible to use density and grain orientation biometry to predict anisotropic shrinkage of the wood. Volumetric shrinkage increased from the base to the top and from heartwood to the sapwood. The range of values of volumetric shrinkage along the height and radial position shows that the woods are dimensionally stable and although not suitable for pulp and paper making, but for the production of veneer, plywood, and saw wood..

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