Research Journal of Agriculture and Forestry Sciences ______________________________ ISSN 2320-6063
Vol. **1(6),** 12-15, July **(2013)** *Res. J. Agriculture and Forestry Sci.*

Dimensional Relations and Physical Properties of Wood of *Acacia saligna*, an Invasive Tree species growing in Botswana

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Available online at: www.isca.in
Received 21st June 2013, revised 30th June 2013, accepted 6th July 2013

Abstract

A study was carried out to evaluate wood physical properties of Acacia saligna, an invasive alien species that has naturalized in Botswana. Wood samples were collected from three different trees at three different heights to study the properties. The trees showed relative change in diameter, density, moisture content and bark thickness. This study revealed that there was a significant change in diameter, bark thickness, proportion of the heartwood and no significant differences in wood basic density at different heights. The density of wood was average at 637 kg m^{-3}. Moisture content was highest in samples collected from the top end of the stem with no significant differences between the base and the mid-height. The average moisture content of wood was 45.1%. The results showed a strong relationship between tree diameter (r^2 = 0.9964) and bark thickness (r^2 = 0.9974) at three different heights in the tree stem.

Keywords: *Acacia saligna*, basic density, wood and Botswana,

Introduction

Acacia saligna (Labill.) H.L. or the Port Jackson willow is very adaptable and fast growing evergreen shrub or tree native to Western Australia[1]. It is a dense with several stems, thorn less and spreading shrub or with a single stem, growing to a height of about 9 meters. The bark of this tree is smooth and grey to red-brown in small branches and dark grey and fissured in older trees[2]. *Acacia saligna* wood possesses sappy wood, light and it is not popular for firewood. Wood of this species has been used to make particle board and the wood is also used as fuel, charcoal, for making stakes for vines and agricultural implements[3].

Acacia saligna has naturalized to parts of Botswana and is found growing along the Kolobeng River and near hills in the south-eastern part of Botswana. The species is classified as an invasive species in South Africa and Botswana[4]. In Australia and many countries around the world, it is used extensively for soil stabilization, animal fodder[1,5], and also for fuel and timber[1].

The use of wood is influenced by the physical properties of the timber such as colour, moisture and density. The wood colour is determined by deposition of phenolics and tannins and discoloration caused by several factors including pests and diseases. Colour of *Acacia saligna* wood is influenced by phenolic compounds, saponins, alkaloids and lectins[6]. Colour variations may be found between sapwood and heartwood in some trees. Colour adds to the visual properties of wood.

Moisture influences the workability, strength of wood and its ability to resist attack by diseases and pests[7]. Wood with low moisture content is known to resist pests and diseases and possess excellent strength properties. An acceptable moisture level for wood in use is 10 to 15% moisture content. Information on the moisture content of wood of *Acacia saligna* is lacking in Botswana.

Density is an important physical property of wood. Wood with high densities is known to possess superior mechanical properties[7]. The physical and mechanical properties of timber are also influenced by inherent and environmental conditions within the microsite[8]. In tests carried out in Western Australia on wood of *Acacia saligna*, the basic wood density was reported at 470−730 kg/m^3[3, 9].

Tree diameters, bark thickness, heartwood proportion and their relationship to tree height are well documented[8,10-12]. These are affected by inherent factors, conditions of plantation and silvicultural treatments carried out in a forest[8]. Form taper is relationship is a factor that affects efficiency of extracting timber from roundwood. Stems with high form factors tend to have high efficiency in yielding timber boards. In Botswana *Acacia saligna* trees are harvested and the timber is used for making excellent furniture. However information on physical properties of wood of this tree species growing under Botswana environment is lacking. The objective of this study was therefore to investigate physical properties and other factors in this tree species.

Material and Methods

Study area: Three sample trees were selected at random along the Kolobeng River (24° 39′23″S, 25° 41′55″E), located 25 km west of Gaborone, the capital City of Botswana.. The samples were collected from trees growing at is approximately 230m above sea level. The soils where trees were harvested are sandy to clay loam. The area has an annual rainfall ranging from 300-400mm per annum.

Selection of sample trees and sample selection: Trees with relatively straight stems were randomly selected for sampling as these are commonly harvested for timber. Diameter, bark thickness, heartwood were measure at the base, just below the canopy and mid-way between the two points. Diameter and heartwood were measured using flexible arm caliper, while bark thickness was measured using the Swedish bark gauge. Bark thickness was measured from two opposite sites and the average was used.

Sample discs were collected from the base, at mid-height and at the top, just below the canopy. Samples discs were approximately 2 cm in thickness. After felling the tree, wood discs about 2 cm in thickness were cut using the chain saw. Three disc samples were collected from the base for each tree, three disc samples at mid-height for each tree and three disc samples at the top for each tree to assess some physical properties.

Laboratory studies: Wood discs were taken to the soil science laboratory at Botswana College of Agriculture (BCA), Sebele to determine wood density, moisture and colour BCA is located at the latitude 24° 33'S, longitude 25° 54'E longitude and elevation of 994m above sea level.

Determination of physical properties: Diameter and bark thickness: Diameter and bark thickness were measured at the base of the tree, at the mid-height point and below the tree canopy. A caliper with a flexible arm was used to measure tree diameters. Where the stem was deemed irregular, the diameter was measured two times in two opposite directions and the mean diameter calculated and used. The thickness of the tree bark was measured using a Swedish bark gauge. Two bark measurements were taken and the average calculated and used.

Moisture content: The fresh weight of the wood was measured in the field immediately after the wood discs were cut from the tree stem using an electronic balance AFW – 120K with an accuracy of 0.1 kilograms. The wood samples were air-dried in the laboratory until constant weight was achieved and recorded. Subsequently, wood samples were oven dried at 103 ± 2°C for 24 hours. The final moisture content was determined using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{(wet weight-dry weight)}}{\text{(dry weight)}} \times 100 \qquad (1)$$

Wood density: Dimensions and weight measurements were used to determine the dry weight density and moisture content of the wood. Density was calculated using the formula below:

$$\rho = (\text{mass (kg)})/(\text{volume } (m^{-3})) \qquad (2)$$

where ρ is wood density.

Heartwood proportion: The proportion of the heartwood was evaluated at different heights in the tree stem. The heartwood and total diameter were measured using a digital caliber. The diameter of the heartwood was compared with the total diameter of the stem at each point of measurement and multiplied by 100% to compute heartwood proportion.

Data analysis: Data were checked for normality and transformed when required and then subjected to analysis of variance (ANOVA). A single factor ANOVA set at a significance of P=0.05 was used to compare physical properties in wood. Regression was used to estimate the relationship between moisture, bark thickness, heartwood proportion at three different positions along the tree stem and the relation between DBH and total height of the tree. All data were analysed to compare means. Differences in diameters were indicated using standard errors of means.

Results and Discussion

Diameter and bark thickness: There were significant differences in diameter between the different stem heights (figure 1). A taper factor of 0.45 was calculated for this species in this study. High values above 0.6 have been reported in pine species[12]. The change in diameter from the base to the top is typical in hardwood trees. There are significant differences in bark diameter at the three different heights (P =0.006, figure 2). The change in bark thickness at different stem heights for other tree species has been reported elsewhere[11,13].

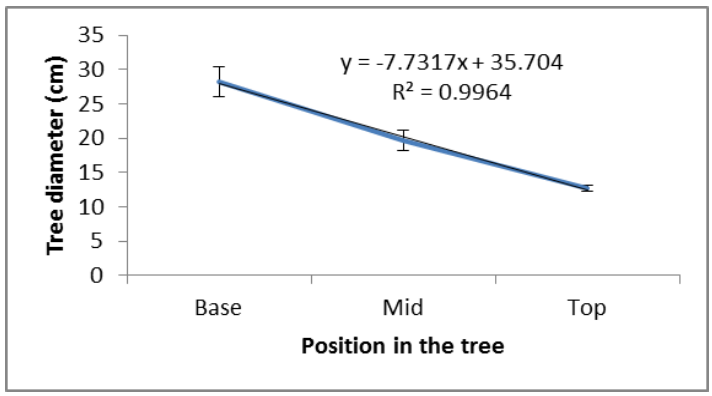

Figure-1
Average diameter of *Acacia saligna* wood at different heights

Proportion of heartwood: The tree base and the mid-height showed a similar ratio of the heartwood. Samples picked from the top were significantly smaller with average heartwood of more than 50%. Heartwood proportion from 15 to 90% in plantations of *Tectona grandis* in West Africa have been reported[10]. Relatively lower heartwood proportions have been reported in Australian acacias species[14]. These differences in heartwood proportions could probably be due to differences in inherent nature of the wood and differences in site conditions and competition between individual trees within a forest stand[10].

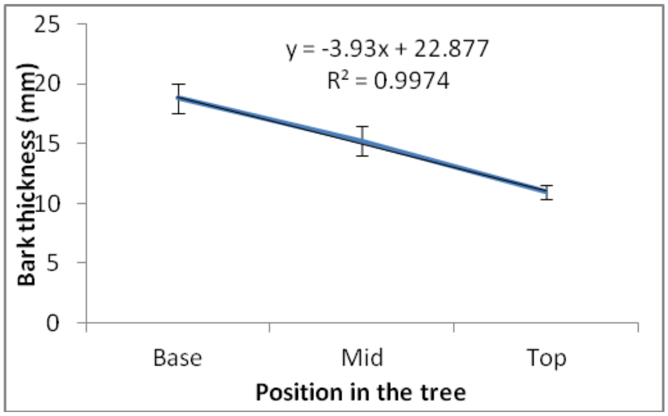

Figure-2
Bark thickness at different positions in the stem

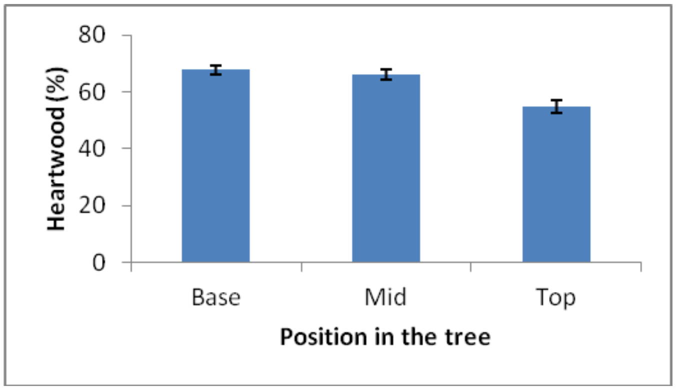

Figure-3
Proportion of heartwood in tree stem

Wood density: Average wood density was calculated at 634.7 kg m^{-3}. Figure 5 shows density of wood samples from three different heights. Wood density displayed no significant differences between the three different sample heights ($P>0.5$). A basic wood density range of 470−730 kg m^{-3} has been reported in *Acacia saligna*[9]. A wide range of wood density values of acacia species from different areas of the world have been reported[14,16].

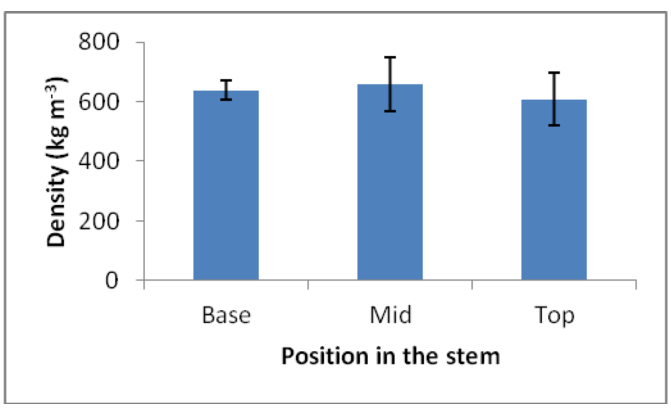

Figure-4
Basic wood density in *Acacia saligna* at different positions in the stem

Wood moisture: The wood moisture contents at different tree heights are shown in figure 5. Overall, the average moisture content was 45%. There were significant differences in moisture content with a high moisture content found in samples obtained from the top end of the stem. The highest moisture content was found in the upper part of the stem. Similar variations in moisture content have been reported in other studies[16], and this may be attributed to the high proportion of sapwood in the wood close to the tree canopy. The results are similar to reports of other studies conducted elsewhere which recorded wood moisture content of between 35 and 50%[10]. Moisture content at the base and the mid-section of the tree stem was similar. Moisture at the top section of the stem was significantly high compared with the middle and base of the tree stem.

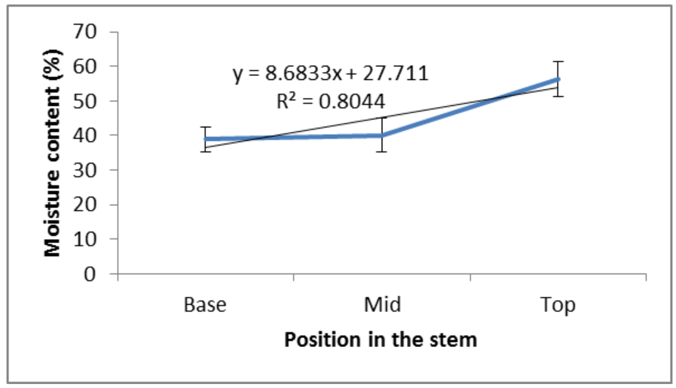

Figure-5
Moisture content in wood at different positions in the stem

Conclusion

Acacia saligna possess good physical properties. The density is average, relatively light, making it a good timber for making furniture and for construction. The large proportion of the heartwood means the there is a large proportion of strong wood that is available for various uses such as household furniture. It is recommended the mechanical tests be carried out on wood of this species to place it into an appropriate strength class.

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