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Effect of age and site quality on the wood properties of *Albizia richardiana* (Voigt) King and Prain

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Abstract

Albizia richardiana (Voigt) King & Prain is a promising light demanding fast growing species and planted as an ornamental tree in Bangladesh. Wood is light yellow colored, contain indistinguishable sapwood and heartwood. The present study abridges the results of an assessment designed at assessing the uses of A. richardiana as an alternative source of raw material for various purposes. The physical and mechanical properties were assessed and compared at two different ages of two ecologically difference and distinct districts namely Rajbari and Barisal in Bangladesh. The samples of Rajbari site exhibited the best results in both physical and mechanical properties compared to samples of Barisal sites in both cases of age and site quality. The results also revealed that samples of 12 years in both sites were superior.

Keywords: Wood quality, spatial variation, *Albizia richardiana*, Bangladesh.

Introduction

Albizia richardiana (Voigt) King & Prain is locally known as Raj koroi and Chambal, a well known avenue tree in Dhaka, the capital city of Bangladesh. The tree is signifying fast growing species that can be attained up to 30-40 meters high[1]. This exotic species play a vital role in country's coastal area[2]. Also, it is mostly available in different villages including the forest of Chattogram Hill Tracts[3]. Now a day, Raj koroi is commonly used as commercial purposes in this region. Furthermore, wood is used to make boats particularly in Barisal district along with cheap furniture and fuel wood in local markets[1]. The pulp yield was comparable to other hardwood species widely used in pulp and paper mills of Bangladesh[4].

The structure of wood is exaggerated in a number of ways by environmental factors including both below the ground (*e.g.* moisture, nutrients in the soil) and above the ground (*e.g.* light, temperature) factors[5]. The physical properties have significant contributions to wood durability and economic utilization[6]. Density is the prime single indicator of wood properties[7].

Both physical properties (PPs) and mechanical properties (MPs) are essential to better utilization of wood[8]. The properties are not same of a tree from top to the bottom. Tree age also affects wood properties[8,9]. By regarding performance and strength of wood, PPs are significantly considered in selecting wood for commercial purposes[6]. MPs of wood indicate the fitness and ability of wood to resist various types of applied or external forces. The properties vary with reference to the varying condition of growth, method of testing and preservation method of wood. Fundamental knowledge is limited on wood preservation chemistry, species and important design adjustment factors such as load duration, service use condition etc[10]. Consequently, it is very important to know about the effect of age and site quality on the properties of wood for its exact utilizations. The present study aimed at determine and compare the physical and mechanical properties in two different ages growing on different site conditions.

Materials and methods

Study area: The samples of Raj koroi, *A. richardiana* were collected from both Barisal and Rajbari districts. Location, soil type and other environmental characteristics of both region were given in the Table-1[11].

Table-1: Characteristics of the sites of sample collection[11].

Site Characteristics	Rajbari District	Barisal District
Annual Rainfall	2105 mm	1955 mm
Annual Temperature	38.5˚C-12.6˚C	35.1˚C -12.1˚C
Soil Type	Alluvial, raised from the Padma river and pH range from 7 to 8.5	Saline and pH values are neutral to slightly alkaline
Location	22°30´N and 90°30´ E	23°40´N and 89°32´ E

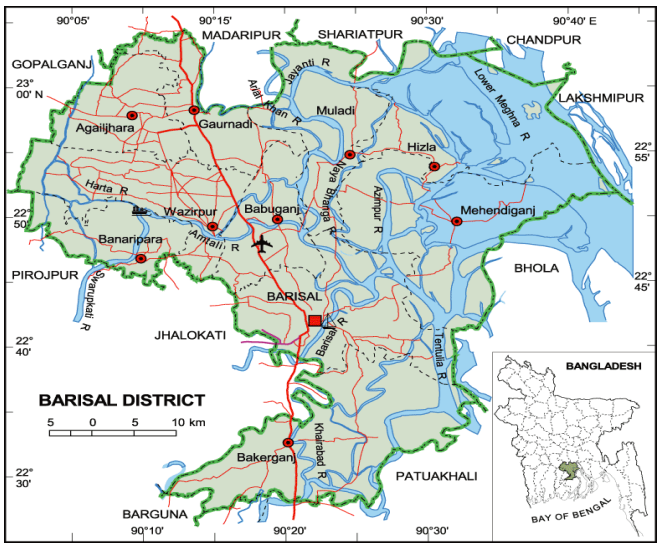

Figure-1: Map of Barisal district.

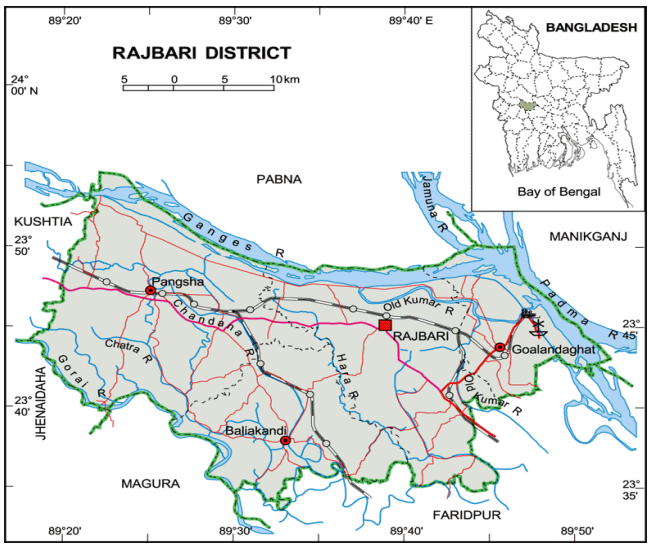

Figure-2: Map of Rajbari district.

Selection and collection of the test samples: Two trees of *A. richardiana* from each sites posed 7 years and another 12 years were selected. The sampled trees were fairly straight, free from defects. Knot, decay, dead streak, etc were excluded for getting clear specimen. By following Bhattacharjee and Sattar[12] all these position were marked and sawn into timber. The age, height and diameter of the sampled trees were given in the Table-2.

Samples were selected from three different planks of top, middle, and bottom of each tree. Three specimens were collected from each height. Consequently, nine samples were collected from three different heights and all together there were 36 samples from 4 trees. As the heartwood and sapwood were indistinguishable consideration made to collect samples near the pith part. Twelve samples were taken only from the middle portion for determination of mechanical properties because of longer sample length requirement. The sticks for air-dry tests were stacked in room temperature with adequate air supply and dried in the sun for 15 days. Density of the test samples was determined in air dry and oven dry condition. While mechanical properties were determined in air dry condition[6]. For determination of PPs and MPs the boles were converted into 2.5cm×5.5cm cross section and 1.5m long sticks. For ascertainment of moisture content, density and shrinkage test sticks were dressed to 5.08cm×5.08cm×2.54cm sizes[12]. The specimens for compression strength were in the form 2cm×4cm×8cm and 3cm×3cm×8cm for perpendicular and parallel to the grain respectively. The test sticks were dressed to 2.5cm×5.5cm×30cm strips for testing the static bending properties[12].

The laboratory tests for PPs were carried out in the Wood Technology Laboratory of Forestry and Wood Technology Discipline of Khulna University, Bangladesh. Length of radial, tangential and longitudinal surface was by measured using a slide caliper. Weight of each wood specimen was measured by electric balance, made in Korea by A&D Company Ltd., and the data were recorded. MPs were performed by using Hydraulic Universal Testing Machine, Model No.WE-100, made in Time Group Inc. in Mechanical Lab of Khulna University of Engineering and Technology, Khulna.

Statistical Analysis: PPs and MPs were examined using two-way analysis of variance (ANOVA) with replications and interaction to examine the effects of age and site quality. All the data were analyzed by using Microsoft Office Excel 2007, and analysis of variance was computed using SAS (Statistical Analysis System) software. Also, unpaired t -test was done to analyze the data.

Table-2: Characteristics of logs from sample tree of *A. richardiana.*

Age class	Age of the tree (years)	Rajbari District		Barisal District	
		Girth of the bole	Height of the bole	Girth of the bole	Height of the bole
Class A	7	77 cm	190 cm	82 cm	205 cm
Class B	12	117 cm	214 cm	126 cm	242 cm

Results and discussion

Physical Properties (PPs): The highest moisture content was observed 7 years of Barisal and the lowest in 12 year of Rajbari district (Table-3). Statistically significant variation of the moisture content (MC) values between 7 and 12 years tree of both districts (Table-4) were observed. The moisture content varies widely among species, even in an individual tree of a same species, and between sapwood and heartwood[13] as well. Also, MC of heartwood ranges from 33 to 98% and that of sapwood from 44 to 249%. However, within any species there is considerable variation depending upon the site, age and volume of the tree. The average green moisture content tends to decrease as the tree grows older[14].

No significant variation in radial, tangential and longitudinal of shrinkage values between the trees of both regions were detected in the present study (Table-4). Similar results were observed when comparison was made between the two sites. Between oven dry state and fiber saturation point, the aggregation of shrinkage is affected by the amount of moisture loss by wood when moisture content fluctuates[15]. Shrinkage is not uniform in all the direction; it is negligible in longitudinal direction, 1.5 to 2 times more in tangential direction than the radial direction[16]. Shrinkage of longitudinal surface is smaller than radial direction, radial shrinkage is smaller than tangential shrinkage and tangential shrinkage is smaller than volumetric shrinkage[17].

Statistically there was significant variation on air dry and oven dry density values between the trees of both the regions. No significant variation were founded the age class of same region and between the two regions (Table-4). Mohuiuddin and Das[18] stated that oven dry density of *A. richardiana* wood is 0.70 gm/cm³. The significant difference between the age classes reveals that the higher density was found in 12 years, *i.e*. trees of higher age containing more mature wood rather than juvenile wood. Again, the non-significant difference of densities between the regions may be the similar site qualities of the regions.

Mechanical Properties (MPs): Table-5 contains the effects of age and site on the mechanical properties of treated woods. The MOR and MOE values for both age classes Rajbari region is higher than that of Barisal region (Table-5). Statistically there was significant variation in MOR values between Rajbari and Barisal region with respect to age and no significant variation was observed in MOR values between Rajbari and Barisal region in terms of site quality (Table-6). Statistically there was no significant variation in MOE values between and within the age class of Rajbari and Barisal region. Similar results were observed when comparison was made between the two sites.

Table-3: Results of Physical Properties (PPs).

Properties		Rajbari District		Barisal District	
		7 years	12 Years	7 years	12 Years
Moisture content (%)		63.55±4.86	57.01±2.10	65.66±2.71	59.48±5.14
Density (g/cm³)	Air dry	0.59±0.02	0.61±0.02	0.58±0.01	0.60±0.01
	Oven dry	0.64±0.02	0.67±0.02	0.64±0.01	0.66±0.02
Shrinkage (%)	Tangential	4.81±0.52	4.73±0.36	4.85±0.30	4.77±0.27
	Radial	2.88±0.23	2.63±0.43	2.93±0.05	2.87±0.09
	Longitudinal	0.84±0.02	0.79±0.13	0.89±0.12	0.82±0.10
	Volumetric	8.53±1.98	8.15±1.97	8.66±1.98	8.15±1.97

(Note: Values after ± shows standard deviation and here, n=9 no. of replicates).

Table-4: Summery for ANOVA test of Physical Properties (PPs).

Source of Variation	MC (%)	Density (g/cm³)		Shrinkage (%)		
		Air Dry	Oven Dry	Radial	Tangential	Longitudinal
Age	*	*	*	ns	ns	ns
Site Quality	ns	ns	ns	ns	ns	ns

(Note*=Significant at 95% level of significance, ns=Not significant)

Table-5: Results of Mechanical Properties (MPs).

Properties	Rajbari District		Barisal District	
	7 Years	12 Years	Age A	12 Years
Modulus of rupture (MOR) (N/mm²)	35.98±0.82	40.80±1.96	35.33±1.44	39.98±2.22
Modulus of elasticity (MOE) (N/mm²)	5780.25±133.16	6875.15±158.58	5499.98±167.14	6647.60±250.18
Compression Parallel to the Grain (N/mm²)	42.87±1.55	47.78±1.25	41.99±1.11	46.45±1.10
Compression perpendicular to the Grain (N/mm²)	13.11±1.73	17.41±0.98	12.85±1.72	17.32±1.11

(Note: Values after ± shows standard deviation and here, n=9 no. of replicates).

Table-6: Summery for ANOVA test of Mechanical Properties (MPs).

Source of Variation	MOR	MOE	Compression Parallel to the Grain	Compression Perpendicular to the Grain
Age	*	ns	*	*
Site Quality	ns	ns	ns	ns

(Note*=Significant at 95% level of significance, ns=Not significant).

The compression strength parallel to the grain and perpendicular to the grain both values of Rajbari are higher than that of Barisal region (Table-5). Statistically there was significant variation in Compression strength parallel to the grain and Compression strength perpendicular to the grain values between Rajbari and Barisal with respect to age and no significant variation was observed in values between the regions in terms of site quality (Table-6).

The MOR and MOE increased with increasing density found in prior studies[14,19]. Lower moisture content enhanced MOR and MOE of wood[20,21]. Wood is low compression strength parallel to the grain but extremely high in compression strength Perpendicular to the grain[14].

The results which are not significantly different at 95% level of confidence indicate that these species will show similar strength properties regardless where they are planted not affected by the site. Sahri et al. reported that the age and the site have little or no effect on the major strength properties[22]. According to Panshin and De Zeeuw[17], the environmental factors such as mean temperature and mean annual rainfall have some effect on growth, and finally to the amount of wood properties produced by the tree[23.]

Conclusion

This preliminary work indicates that there is a great prospect to use A. richardianaas for structural purposes considering the mechanical properties. As it was an introductory and small scale experiment, further experiments would be recommended.

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