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Natural Decay Resistance of *Acacia auriculiformis* Cunn. ex. Benth and *Dalbergia sissoo* Roxb

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Abstract

Natural decay resistance of two fast growing timber species, *Acacia auriculiformis* Cunn. ex. Benth. and *Dalbergia sissoo* Roxb. grown in Bangladesh was evaluated by adopting an accelerated decay test method. The wood specimens were exposed to a white rot fungus, *Schizophyllum communie* for 12 weeks. The natural decay resistance was determined by the weight loss percentage of the tested wood specimens. The weight losses were found 2.0% and 4.37% in heartwood, and 22.19% and 13.61% in sapwood of *A. auriculiformis* and *D. sissoo*, respectively. In both the species, the weight loss was significantly higher in sapwood than heartwood. This means that heartwood was more resistant than sapwood. The weight loss significantly increased from bottom to top. Significant variation has been observed in weight loss between *A. auriculiformis* and *D. sissoo* both in heartwood and sapwood. The wood of *A. auriculiformis* and *D. sissoo* were classified as naturally durable following the standard classification of natural durability.

Key words: Decay resistance, *Acacia auriculiformis, Dalbergia sissoo, Schizophyllum communie*, Accelerated decay test

Introduction

The determination of biological durability of wood is an issue requiring sufficient reliability regarding end-use related prediction of performance (Van Acker *et al.* 2003). By natural durability is meant the inherent ability of timber to resist decay and other destructive agencies (FAO, 1986). For using wood out of doors such as decking, fencing and garden furniture, natural durability is one of important characteristics of wood. Because of the increasing population, expansion of agricultural land and rapid industrialization, the forest wealth is fast depleting. Thus, it has become imperative to make use of the fast-growing species. But most of fast growing species are considered to be not durable against microorganisms, because fast growing species have lower density than slow-growing species. Selection of a timber species for a specific use, therefore, plays an important role in achieving its most economic utilization (Latif *et al.* 1978). If the fast-growing species are not naturally durable, they need preservative treatment with chemicals to improve the service life.

Akashmoni (*Acacia auriculiformis* Cunn. ex. Benth.), family: Leguminosae, sub family: Mimosoideae, is a fast-growing medium sized tree native to coastal lowlands of Northern Australia, Papua New Guinea and few islands in Eastern Indonesia (Alam *et al.*, 1991). In Bangladesh, it is an exotic, mostly planted as roadside and/or avenue tree along the side of high ways, rail way tracks and parks (Das and Alam, 2001). It is widely planted as agro-forestry species in throughout Bangladesh. It has been included in the plantation program as a fast-growing species and to rehabilitate the denuded hills (Alam *et al.,* 1991). The timber of *A. auriculiformis* is moderately heavy, strong and stable (density ranges 610 to 700 kg/m^3). It is suitable for furniture, door, window and other constructional purposes. Transmission pole and post can also be made from round timber (Sattar *et al.,* 1999). Again, Sissoo (*Dalbergia sissoo* Roxb.), family: Leguminosae, sub family: Papilionoideae is also a fast-growing species with a spreading crown. It occurs throughout the Indian sub-continent and appears on hillsides, on new embankments, on grasslands and wherever the soil is exposed in Bangladesh (Zabala, 1990). The wood of D. sissoo is heavy, moderately strong and very stable with graceful colour (density ranges 650 to 740 kg/m^3). The timber is suitable for door, window, beam, floor and such other purposes. It is also used for cart and wheel and general utility (Sattar *et al.,* 1999).

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The considerable decline of natural forest promotes afforestation with fast-growing tree species such as *A. auriculiformis* and *D. sissoo* in Bangladesh. However, wood qualities and utilization of the fast growing species are not considered substantially so far, as fast growing species has been generally introduced as the purpose for quick recovery of vegetation or just greening. Comprehensive understanding of wood properties of fast growing species is of importance to utilize them effectively. A few researches concerning natural durability of wood have been reported in Bangladesh. Latif *et al*. (1989) tested natural durability of 28 timber species of Bangladesh. Akther *et al.* (1992) tested 10 common village tree species in Bangladesh. Both the study were conducted followed by stack yard test or accelerated field test method, but no research concerning wood decay resistance against fungi has been reported.

Information on the resistance to insect and decay fungi is important to evaluate the utilization potential of any species, besides knowing the anatomical, physical and mechanical properties. Since service life can be based on natural durability classes, it is evident that these are identified differently for uses in or out of ground contact for softwoods and hardwoods. This study was undertaken to determine the decay resistance in two fast-growing timber species, *A. auriculiformis* and *D. sissoo* grown in Bangladesh in the laboratory condition and classify these species into the grade of natural durability.

Materials and Methods

Two representative trees from each selected species, i.e., *Accacia auriculiformis* and *Dalbergia sissoo,* of 9 to 12 years old were harvested from Khulna University Campus. The diameter and height of the felled logs ranges 21.3 to 30.8 cm and 11.7 to 12.5 m for *A. auriculiformis*; and 20.7 to 26.5 cm and 13.7 to 14.6 m for D. sissoo. After felling each of the trees were cut into three equal parts, i.e., top, middle and bottom. Wood samples were prepared from both sapwood and heartwood of the top, middle and bottom parts for testing of natural decay resistance. From each of the tree species, 36 specimens of small wooden blocks were collected, containing 18 specimens from sapwood and 18 specimens from heartwood. The dimensions of wood blocks for the tests were 15 mm x 10 mm x 5 mm.

The test blocks were exposed to a white rot fungus *Schizophyllum commune* Fr. (FWT KU: WM - 011)* which is commonly called "Split Gill" and were used as the bioassay organisms in decay test. In general, it occurs on standing trees of both hard and softwoods, common logs, stumps and on timbers in ground contact. Colonization of this fungus is rapid in tropical climates (Eaton and Hale, 1993). Various test fungi including white rot and brown rot are used for testing natural decay resistance of wood. In the present study, white rot fungus is used because, for hardwoods brown rot fungi did hardly yield any information (Van Acker *et al.,* 2003). This is consistent with the fact that in nature, hardwoods are more susceptible to white rot decay fungi and more resistant to brown rot decay fungi than softwood (Green and Highley, 1997).

The decay test was conducted according to ASTM Standard D 2017-81 (ASTM, 1989) for accelerated laboratory test, with few modifications, such as, agar block method which is based on a malt extract agar supported by the European Standard EN 350-1 (Anon, 1994) and use of *S. commune* as the test fungi. The fungal cultures were grown and maintained on a 2% malt agar (MA) nutrient medium containing 20 g malt, 20 g agar powder and 1 L water. The medium was prepared and sterilized at 1.05 kg/cm^2 and 121^{o}C for 20 min. Petridishes were poured, allowed to cool and inoculated with test fungi. The petridishes were incubated at 25±2^{o}C temperature and 65±5% relative humidity. Fungal mycelium growth was continued until sufficiently vigorous for 5 days. Fungal inoculums cut 15 mm was aseptically transferred to the sterilized jar containing 2% MA medium and further incubated until the mycelium growth on the surface of the medium spread and was distributed evenly and became slightly thick at the desired temperature and relative humidity for 6 days.

The test blocks were made from clear heartwood and sapwood and were free from knots, stain, decay, insect holes or other deformity or defects. The samples were dried in oven at 103±2^{o}C to obtain constant weight. The test specimens were then steam sterilized and aseptically transferred into jar with a cross sectional face centered in contact with the fungal mycelium. Each jar contained one replicate specimen. These jars were incubated at 25±2^{o}C temperature and 65±5% relative humidity. After 12 weeks, the specimens were removed from the culture jar carefully so that it was not contaminated. Then samples were whipped carefully and dried in oven at 103±2^{o}C to obtain constant weight. Decay was measured as a percentage of loss of wood substances

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according to the following equation (Amusant *et al.*, 2005):

Loss of weight in wood (%) = $[(M_o-M)/M_o] \times 100$

Where, M_o = Oven dry weight of wood prior to the decay test, M = Oven dry weight of wood after the decay test.

Data from the accelerated decay test were analyzed for determining the performance of natural decay resistance using analysis of variance (ANOVA) and unpaired t-test.

Results and Discussion

Deterioration of wood could be indicated by its weight loss due to fungal attack. It is considered that percentage losses in mass are a better indicator of loss of strength, which is the real indicator for performance in service (Van Acker *et al.,* 2003). In general, factors that influence wood resistance include growing site, growth rate, age of the trees, portion of wood (heartwood and sapwood), extractive content in wood and environment of the wood being exposed to (Suprapti, 2010).

The weight loss in *Acacia auriculiformis* ranges from 1.88 to 2.10% in heartwood and 19.0 to 25.8% in sapwood. On the other hand, in *Dalbergia sissoo* the weight loss ranges from 3.83 to 4.89% in heartwood and 11.0 to 15.9% in sapwood (Table I). In both the species the weight loss percentage was higher in sapwood (22.2% in *A. auriculiformis* and 13.6% in *D. sissoo*) than heartwood (2.0% in *A. auriculiformis* and 4.37% in *D. sissoo*) (Fig. 1). The differences in weight loss were statistically significant between the heartwood and sapwood for both the species (Table II).

The difference of the weight loss between heartwood and sapwood can occur due to various reasons. According to Panshin and De Zeeuw (1984), the presence of reserve food in the parenchyma cells of sapwood may increase its susceptibility to decay. The main reason of natural durability of heartwood of some species are the presences of toxic substances in the heartwood. It was reported that (Anon 1999) the decay resistance of heartwood is greatly affected by difference in the preservative qualities of the wood extractives, the attacking fungus, and the conditions of exposure. Akhter *et al.* (1992) stated that the natural durability of timber largely depends on the extent of heartwood formation with accumulation of extractable chemicals. These chemicals impart natural durability to the heartwood against decay and vary in quality in different timber species resulting in variability in natural durability. Das and Wallin (1978) described that, in heartwood of some hardwoods, vessels are blocked by enlarging adjacent parenchymatus cell membrane called tylosis. As a result of tylosis, air and liquid cannot pass easily through wood. In addition, the permeability of heartwood is decreased due to deposition and hardening of some extractives, e.g., gums, resins, tannins etc. (Wilkinson, 1979). Impermeability of timber is the secondary cause for natural durability. On the other hand, Lahiry (1994) explained that, sapwood of all timber species are non durable because prepared food materials, e.g., protoplasm, nuclei, fats, starches, etc., remain unchanged and stored in sapwood for easy up taking of wood by decay offences. Therefore, it could be assumed that the resistance of heartwood to fungi is higher than that of sapwood as stated by Suprapti *et al.* (2007) and Coggins (1980).

To justify the resistance of a wood species, it should be stated clearly from which part and portion in the log the sample is taken. It is generally accepted that the natural decay resistance of wood varies along the length of the trunk and also depends on the radial position in a specific cross section (Van Acker *et al.*, 2003). Difference in weight loss has also

Table I: Weight loss of heartwood and sapwood at different height position of *Acacia auriculiformis* and *Dalbergia sissoo* wood blocks after 12 weeks exposure to *Schizophyllum communie*

Species	Height position	Weight loss in percentage	
		Heartwood	Sapwood
Acacia auriculiformis	Top	2.10 (0.4)	25.8 (3.4)
	Middle	2.02 (0.3)	21.7 (2.3)
	Bottom	1.88 (0.4)	19.0 (2.4)
Dalbergia sissoo	Top	4.89 (0.4)	15.9 (3.4)
	Middle	4.37 (0.3)	13.9 (2.3)
	Bottom	3.83 (0.4)	11.0 (2.4)

Note: Values in parenthesis are standard deviation

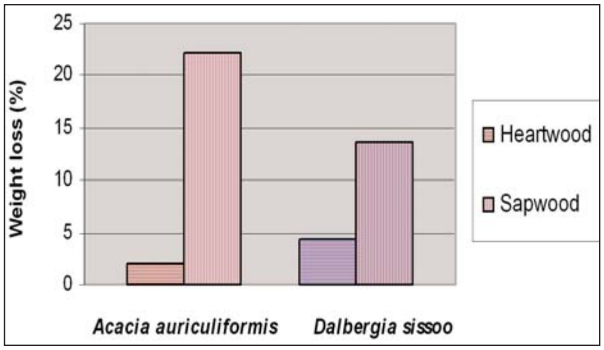

Fig. 1. Weight loss of heartwood and sapwood after 12 weeks exposure to white rot fungus in *Acacia auriculiformis* and *Dalbergia sissoo*

been found among the length of the trunk or height position of the sampled tree stem (i.e., top, middle and bottom) for both the species (Table I). Weight loss increased from bottom to top of the tree trunk and statistically significant variation has been observed for both *A. auriculiformis* and *D. sissoo* (Table II). It is noted (Anon, 1999) that considerable difference in service life can be obtained from pieces of wood cut from the same tree, and used under apparently similar condition. Bakshi *et al.* (1967) also reported the variation in decay resistance among individual trees within a species.

Table II. Summaries of analysis of variance of the weight loss among the radial (heartwood and sapwood) and height position (top, middle and bottom) of the stem for *Acacia auriculiformis* and *Dalbergia sissoo*

Source of variation	*Acacia auriculiformis*	*Dalbergia sissoo*
Radial position of the stem	*	*
Height position of the stem	*	*

Note: * = Significant at 95% probability level

This study showed that the heartwood of *D. sissoo* had a higher weight loss than the heartwood of *A. auriculiformis* (Fig. 1). This differences was statistically significant (df = 4, t = -7.56 and P<0.05). On the other hand, higher weight loss has been observed in sapwood of *A. auriculiformis* than the sapwood of *D. sissoo,* which was also statistically significant (df = 4, t = 3.52 and P<0.05). It is known to have variation in the natural durability of timbers from different sources, and characteristics of timbers such as growth rate, can also affect the durability (Van Acker *et al.* 2003). Suprapti (2010) reported growth site of the tree has influence the natural decay resistance of wood. Timber properties in general may vary to a rather high extent not only between different regions of growth but also between different trees even within one tee (Willeitner, 1984). Difference of mass losses between tree species could be explained by the variation in wood properties such as extractive content, color and density (Yamamoto *et al.* 2003). Seeva *et al.* (1991) found higher amount of extractives (5.56%) in *A. auriculiformis* than *D. sissoo* (4.32%), which may impart the higher decay resistance in heartwood of former species. On the other hand, sapwood contains food material which ultimately is converted into extraneous component or extractives in heartwood (Panshin and De Zeeuw, 1984). So, the higher weight loss in sapwood of *A. auriculiformis* than *D. sissoo* is due to the presence of higher food material in sapwood. The higher natural decay resistance of *A. auriculiformis* heartwood than the heartwood of *D. sissoo* which may be due to the growth rate. The mean annual increment of *A. auriculiformis* is 15 m3/ha (Boland, 1989) and *D. sissoo* is 18.1 m^3/ha (Jackson, 1987). Species with slower growth rate generally exhibit higher decay resistance. Da costa and Osborne (1967) and Akther *et al.* (1992) found inverse correlation between density and percentage weight loss. The weight loss decreased (or durability increased) with increase in density. Though, the wood density of *D. sissoo* is higher than *A. auriculiformis* (Sattar *et al.* 1999), the weight loss found in the present study was higher in the former. Again, Balasundaran *et al*. (1985) found no consistent correlation between density and weight loss (%). Variability in natural durability may occur between trees due to inherent genetic variation.

Generally, weight loss of wood caused by fungal attack depends on wood species and also species and strain of fungi (Pildain *et al.* 2005). The ability of fungi to cause weight loss in wood depends on their ability to degrade lignin (Harsh and Tiwari, 1990). White rot fungi grow better on wood samples dominated by broad-leaved wood species (hardwood) over conifer (softwood) (Schmidt, 2006). Naturally, *S. commune* are able to grow on almost any kind of wood. Suprapti (2010) reported higher weight losses on samples exposed to *S. commune* than other white rot fungi *Pycnoporus* and brown rot fungi *Dacryopinax spathularia*, when examined the decay resistance of 84 Indonesian wood species.

An accelerated decay test on *A. auriculiformis* for 12 weeks exposure (Yamamoto *et al*. 2003) showed significant greater mass loss due to white rot fungus *Trametes versicolor* in sapwood (18.6%) than heartwood (2.35%). Natural decay resistance of sapwood was also low similar to other species examined (Matsuoka *et al.* 1984; Wong, 1988). Suprapti (2010) reported that *A. auriculiformis* from West Java showed higher weight loss when exposed to *S. commune* (19.12%) than other white rot fungus *P. sanguineus* (1.79%) and brown rot fungus *D. spathulari* (2.58%). Growth sites of trees (source of wood sample) seem to influence wood resistance and this agrees with findings by Salmiah and Amburgey (1992).

Classification of natural durability is evaluated based on the weight loss of heartwood specimens by a fungus in the laboratory test and the weight loss ranges proposed differ somewhat in the literature. According to European Standard EN 350-1 (Anon, 1994) species with weight loss less than 5% is classified as very durable, 5 to 10% as durable, 10 to 20% as moderately durable, 20 to 30% as slightly durable and above 30% as not durable. Again, ASTM (1989) classify very resistant showing weight loss of 0 to 10%, resistant 11 to 24%, moderately resistant 25 to 44%, non resistant above 44%. On the other hand, according to Anon (1972) species showing weight loss of less 1% is classified as very durable, 1 to 5% as durable, 5 to 10% as moderately durable, 10 to 30% as non-durable and over 30% as perishable. In this study, from the above classifications it has been found that *A. auriculiformis* and *D. sissoo* fall in durable or very durable class. The weight loss of heartwood of both the species was below 5%. In a symbolic classification Lahiry (1994) stated the natural durability of *A. auriculiformis* and *D. sissoo* as not durable and very durable respectively. *A. auriculiformis* was, however, classified as durable in Vietnam (Yamamoto *et al.* 2003), but Suprapti (2010) classified it as moderately resistant in Indonesia.

Conclusion

The natural decay resistance determined by an accelerated decay test, concludes that *Acacia auriculiformis* and *Dalbergia sissoo* can be classified as durable wood species. Wood products from *A. auriculiformis* and *D. sissoo* have a possibility for outdoor uses. Further study examining the trees from different localities, age groups etc., is needed to confirm the natural durability of these species, because of the variation in wood properties among trees. To fully understand the natural decay resistance of timbers it would be necessary for assessments of resistance to fungal decay using a wide range of species of wood rotting fungi. The performance of a wood in service is likely to be determined by those fungi which it is particularly susceptible.

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