International Biodeterioration & Biodegradation 65 (2011) 768–776

Contents lists available at ScienceDirect

International Biodeterioration & Biodegradation

journal homepage: www.elsevier.com/locate/ibiod

Comparative natural durability of five wood species from Mozambique

Alexandre Charifo Ali [a,b,*], Ernesto Uetimane Júnior [a,b], Ulrika Råberg [a], Nasko Terziev [a]

[a] Swedish University of Agricultural Sciences, Department of Forest Products, Box 7008, SE-750 07 Uppsala, Sweden
[b] Universidade Eduardo Mondlane, Departamento de Engenharia Mecânica/Engenharia Florestal, Caixa Postal 257, Maputo, Mozambique

ARTICLE INFO

Article history:
Received 20 October 2010
Received in revised form
8 March 2011
Accepted 8 March 2011
Available online 26 May 2011

Keywords:
Basidiomycetes
Lesser-used wood species
Natural durability
Soft-rot fungi
Termites

ABSTRACT

The objective of this study was to evaluate the natural durability of five lesser-utilized wood species from Mozambique. Both laboratory methods and field tests were applied for assessing wood decay of muanga (*Pericopsis angolensis*), metil (*Sterculia appendiculata*), namuno (*Acacia nigrescens*), ncurri (*Icuria dunensis*), and ntholo (*Pseudolachnostylis maprounaefolia*). Laboratory tests involved soft-, brown-, and white-rot fungi and termites. Heart- and sapwood of ncurri and ntholo were exposed in above-ground field tests; additionally, all species were exposed to in-ground contact tests. The results indicated that namuno, muanga, ncurri, and ntholo are resistant to soft-, brown- and white-rot fungi and the termite species *Reticulitermes grassea* and *Mastotermes darwiniensis*. Comparatively, soft-rot caused more severe decay on the studied wood species than did basidiomycete fungi. The brown-rot fungi *Coniophora puteana*, *Gloeophiyllum trabeum*, and *Postia placenta* caused less decay on the tested species than did the white-rot *Trametes versicolor*. Metil was not resistant to any of the mentioned hazards. Therefore, this species is not recommendable for exterior use if untreated.

1. Introduction

Natural durability, weathering characteristics, and dimensional stability are important properties of timber for outdoor use (Miller et al., 2003). In Mozambique, exterior wood items have traditionally been made of untreated timbers from native species such as mecrusse (*Androstachys johnsonii*), messassa (*Brachystegia manga*), messinge (*Terminalia* sp.), mangal branco (*Ceriops tagal*), luabo (*Heritiera littoralis*), and mangal encarnado (*Rhyzophora mucronata*). In urban areas, the outdoor wooden structures are mainly benches and tables for public places. In rural areas, common exterior wood uses include fence posts, timber constructions, decking, and bridges. Another outdoor use of wood is for transmission poles across the country.

Recent studies have described and classified the natural durability of tropical wood species in terms of resistance against fungal attack (Miller et al., 2003; Nzokou et al., 2005; Paes et al., 2007; Carneiro et al., 2009). Other studies have assessed durability of various tropical timbers against termite attacks (Supriana, 1988; Tsunoda, 1990; Takamura, 2001; Peralta et al., 2004; Arango et al., 2006). These studies found that certain wood species are resistant against fungi and termites. However, no studies concerning natural durability of Mozambican wood species are available. Thus, the present research aims to provide a comprehensive assessment of natural durability of five lesser-used species through laboratory and field tests.

According to Miller et al. (2003) much is known about some tropical wood species, but there is a significant gap in the knowledge about lesser-known or lesser-used species. This is particularly true for wood species from Mozambique. Due to lack of data concerning wood's natural durability, the exterior use of timber in Mozambique is based solely on past experiences. This situation hinders introduction of lesser-used timbers into the country's market. Therefore, there is an urgent need of trustworthy knowledge related to wood species durability.

Laboratory and field methods for assessing wood durability are widely used based on diverse standards such as American Society for Testing and Material (ASTM) Standards, Australian Standards (AS), European Standards (EN), and Japanese Industrial Standards (JIS). The testing principles described in these standards are very similar. In this study European standards were used.

Van Acker et al. (1999) states that using classification system for natural durability based solely on fungal testing is only relevant when the risk of termite attack on wood can be excluded. Classifications of durability against fungi and termites are different and independent from each other. Laboratory testing creates a situation that can be defined as unnatural, and therefore the results should

* Corresponding author. Swedish University of Agricultural Sciences, Department of Forest Products, Box 7008, SE-750 07 Uppsala, Sweden. Tel.: +46 18 672484; fax: +46 18 673489.
E-mail addresses: alexandre.charifo.ali@sprod.slu.se, acali@eng.uem.mz (A.C. Ali).

0964-8305/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ibiod.2011.03.010

be used comparatively (Van Acker et al., 1999). Thus, the purpose of this work is to evaluate, through various methods, the natural durability of five lesser-utilized wood species from Mozambique for outdoor applications.

2. Materials and methods

2.1. Wood species and sampling

The wood species evaluated in this study are listed in Table 1. Scots pine (*Pinus silvestris* L.) sapwood, beech (*Fagus silvatica* L.), and black locust (*Robinia pseudoacacia* L.) were used as references. The sampling process of Mozambican wood species was carried out according to COPANT (1972). Five trees of each of the listed species were obtained from Cabo Delgado and Nampula provinces in northern Mozambique. The climate of the sampling sites is characterised as subtropical, with cool and dry winters lasting from April to September and hot and rainy summers from October to March. The average annual precipitation ranges from 800 to 1000 mm and the average annual temperature from 20 to 26 °C (MAE, 2005a,b).

2.2. Laboratory tests

Soft-rot and basidiomycete fungi, termite standard, and feeding choice tests were used in this study. For the fungal tests, the specimens were kiln dried at 103 °± 2 °C to absolute dry weight and conditioned in a climate chamber (20 °C and 65% relative humidity [RH]) to 12% moisture content (MC) before exposure. After exposure the soil and fungal mycelia grown over the specimens were gently removed and the specimen weighed. The specimens were dried to absolute dry weight, and reweighed. The collected data were used to determine the wood MC and the mass loss (ML) after exposure.

2.2.1. Soft-rot fungi test

The soft-rot fungi test was performed according to the European standard prENV 807 (1993), which uses Scots pine sapwood and beech as reference species. The test soil was obtained from the Ultuna test field in Uppsala, where the main hazards are the soft-rot fungus *Phialophora hoffmanni* and bacteria (Edlund and Nilsson, 1998; Råberg et al., 2009). The soil was watered to reach about 95% of its holding capacity. The samples were taken and analysed after 8, 16, 24, and 32 weeks.

Before exposure, bending tests were carried out to determine the modulus of elasticity (MOE) for all specimens. After each of the four exposure periods, the specimens were conditioned to 12% MC and bending tests were carried out again to monitor strength loss based on MOE. The average values of MOE after exposure were compared to the respective average values of MOE before exposure as proposed by Bekele et al. (1997). The durability factor (DF) is the ratio of loss in MOE of each studied species in relation to that of the reference species. The DF value is an estimate of natural durability and is determined according to the formula given in Eq. (1). The closer the DF is to zero, the more durable the species is in relation to the reference species.

$$DF = \frac{S_{iE} - S_{jE}}{S_{iE}} \div \frac{S_{iR} - S_{jR}}{S_{iR}} \quad (1)$$

where: DF is the durability factor, S_{iE} is the initial MOE of the tested species, S_{jE} is the MOE of the tested species after exposure, S_{iR} is the initial MOE of the reference species, and S_{jR} is the MOE of the reference species after exposure.

After exposure to soft-rot fungi, small pieces (from the buried part of the samples) were cut, autoclaved in 10% glycerin, and sectioned (20–40 μm thickness) using a Leitz microtome sledge. The sections were stained with 1% safranin and micrographs were taken by camera to reveal soft-rot features in the wood structure.

2.2.2. Test with basidiomycete fungi

Assessment of natural durability against fungal attack by basidiomycetes was carried out according to the European standard EN 113 (1996). The test used three brown-rot fungi (*Coniophora puteana* BAM Ebw. 15, *Gloeophyllum trabeum* BAM Ebw. 109, and *Postia placenta* FPRL 280), and a white-rot fungus (*Trametes versicolor* CTB 863A). The criterion used for the classification of natural durability of wood is given in the standard EN 350-1 (1994). The evaluation of the laboratory decay test is based on recorded mass loss after a fixed period of exposure. The ratio of ML of test specimens to the ML of the reference specimen is expressed in Table 2.

2.2.3. Termite standard and choice tests

Determination of natural durability against termite attack was carried out through termite standard and choice tests. The termite standard test (EN 118, 2005) consisted of placing the wood specimens in a conditioning chamber at 20 ± 2 °C and 65 ± 5% relative humidity for 4 weeks before exposure. Once the colonies of termites were formed, the exposure was initiated. The termites were put in contact with the specimens and the test containers were placed in a culture chamber (27 ± 2 °C and 75 ± 5% RH) for 8 weeks. The termite species used in this test was *Reticulitermes grassea*.

The termite choice test (aiming to determine the feeding preference of termites on the studied wood species) followed European standard EN 117 (2005). Black locust and Scots pine sapwood were used as references. The termite species used was *Mastotermes darwiniensis*. Five replicates were used; the number of termites in each test vessel was 100 workers and three soldiers. For virulence control another test vessel was equipped with eight Scots pine sapwood blocks. The exposure period in the termite choice test was 8 weeks. A visual rating system was used for termite attack assessment as follows: 0 – no termite attack; 1 – attempt to attack; 2 – slight attack; 3 – medium attack; and 4 – intense attack.

2.3. Field tests

In- and above-ground tests were carried out according to the European standards EN 252 (1989) and ENV 12037 (1996).

Table 1
Scientific, vernacular names and family of the studied wood species.

Scientific name	Vernacular name	Family
Acacia nigrescens Oliv.	Namuno	*Leguminosae-Mimosoideae*
Icuria dunensis Wieringa	Ncurri	*Leguminosae-Caesalpinioideae*
Pericopsis angolensis Meeuwen	Muanga	*Leguminosae-Papilionoideae*
Pseudolachnostylis maprounaefolia Pax	Ntholo	Euphorbiaceae
Sterculia appendiculata K. Schum	Metil	Sterculiaceae

Table 2
Classification of wood natural durability according to EN 350-1 (1994).

Durability class	Description	Results of laboratory tests expressed as x[a]
1	Very durable	$x \leq 0.15$
2	Durable	$0.15 < x \leq 0.30$
3	Moderately durable	$0.30 < x \leq 0.60$
4	Slightly durable	$0.60 < x \leq 0.90$
5	Not durable	$x > 0.90$

[a] value: $x = \frac{\text{averege corrected mass loss of test specimens}}{\text{averege mass loss of reference specimens}}$