ISSN impresa 0717-3644
ISSN online 0718-221X
Maderas. Ciencia y tecnología 20(3): 353 - 358, 2018
DOI: 10.4067/S0718-221X2018005003601

LABORATORY DECAY RESISTANCE OF PALMYRA PALM WOOD

Xiaoping Li[1], Scott Leavengood[2], Jed Cappellazzi[2], Jeffrey J. Morrell[2,♣]

In memoriam of Dr. Thomas C. MANNES

ABSTRACT

The decay resistance of Palmyra palm wood (*Borassus flabellifer*), also referred to as sugar palm, was assessed in laboratory soil block tests against *Oligoporus placenta*, *Gloeophyllum trabeum*, *Irpex lacteus,* and *Trametes versicolor* as well as in a non-sterile soil burial test designed to encourage soft rot attack. Mass losses on pine control blocks were consistent with aggressive decay conditions for all but those exposed to *Irpex lacteus*, while mass losses for palm wood blocks exposed to the same fungi ranged from 0,46% to 10,6%. The magnitude of mass losses would categorize palm wood as resistant to highly decay resistant, suggesting that these materials might perform well in exterior above ground applications. Mass losses were weakly correlated with density suggesting that selection of denser wood will result in better performing materials in these applications. Field tests to confirm these results are encouraged.

Keywords: AWPA E10 soil block test, *Borassus flabellifer*, brown rot, white rot, soft rot.

INTRODUCTION

Palm trees are widely grown across the tropical parts of the globe. Among the most common species is the coconut (*Cocos nucifera*), date palm (*Phoenix dactilifera*) and oil palm (*Elaeis guineesis*), but there are a number of other species planted for the production of nuts and other edibles (Bailleres *et al.* 2010). Among these is Palmyra palm (*Borassus flabellifer*), also referred to as sugar palm, which is native to the Indian sub-continent as well as parts of southeast Asia where it is grown for its fruit, sap, edible sprouts, and foliage (Davis and Johnson 1987, World Agro Forestry Centre 2017). Eventually, productivity of the trees declines and they are cut down and replanted. For many years, the boles of these trees were left to rot in the fields. Declining supplies of more traditional wood species led to the development of local markets for sawn Palmyra palm wood in many countries where they had reputation for durability, although no test data were available (World Agro Forestry Centre 2017). More recently, products produced from these trees have begun to be exported to Europe and North America. As a monocot, the structure of Palmyra palm differs from that of traditional dicots where the conducting elements are distributed in bundles throughout the cross-section and the stem is determined at the time of formation. Furthermore, woody tissue density as well as sugar and starch content in many palms differ both radially and with distance above the ground (Schmidt *et al.* 2016). As a result, considerable care must be taken to ensure the utilized material is sufficiently dense to perform in a given application (Bailleres *et al.* 2010).

The wood of many palms was traditionally considered to be non-durable and to require preservative treatment for use in exterior applications. However, these reports reflect the use of these materials under more tropical conditions and there are no reports of field trials of Palmyra palm wood in temperate

[1]Yunnan Key Lab. of Wood Adhesives and Glue Products, Southwest Forestry University, Kunming, Yunnan, China.
[2]Department of Wood Science and Engineering, Oregon State University, Corvallis, Oregon, USA.
[♣]Corresponding author: jeff.morrell@oregonstate.edu
Received: 18.10.2017 Accepted: 30.01.2018

applications, although other species, such as cocowood, have been subjected to limited testing (Peek 1994, Amartey *et al.* 2006). For example, Jourez *et al.* (2012) evaluated the relationship between density and decay resistance of cocowood and found materials with densities greater than 900 kg/m^3 were classified as either Class 1 or 2 in the European Durability system described in EN 335/355 (EN 1994, EN 2013, CEN/TS 2005).

Palmyra palm wood could also be used for exterior decking in the U.S., but there are few data evaluating the decay resistance of this material using U.S. standards. The goal of this study was to evaluate the decay resistance of palm wood using soil block tests as the first step in assessing the suitability of this material for exterior above ground applications.

MATERIALS AND METHODS

Palmyra palm wood boards were obtained from an importer and cut into 19 mm cubes for testing. The source of the parent material could not be determined; however, density measurements made before exposure indicated that density ranged from approximately 700 to 1065 kg/m^3. While not originally a part of the test protocol, the relationship between density and fungal associated mass loss became a part of the experiment.

The cubes were oven-dried (104 °C) and weighed (nearest 0,001 g) prior to being allocated to one of five exposure groups. Similar blocks were prepared from southern pine sapwood (*Pinus* spp.) to serve as decay susceptible controls. The blocks of both species were then briefly soaked in distilled water before being subjected to 2,5 mrad of ionizing radiation from a cobalt 60 source. The sterile blocks were then assessed for decay resistance using procedures described in American Wood Protection Association Standard E10 (AWPA 2017).

Decay chambers were prepared by half-filling 454 ml french squares with moist forest loam and placing a western hemlock (*Tsuga heterophylla* (Raf) Sarg) (for brown rot fungi) or red alder (*Alnus rubra* Bong) (for white rot fungi) feeder strip on the soil surface. The bottles were loosely capped and autoclaved for 45 minutes at 121 °C. After cooling, the bottles were inoculated with 3 mm diameter malt agar disks cut from the actively growing edges of cultures of the test fungi. The fungi evaluated in these procedures were *Gloeophyllum trabeum* (Pers.ex. Fr.) Murr. (Isolate # Madison 617), *Oligoporus placenta* (Fr) Gilv & Ryvarden (Isolate # Mad 698), *Trametes versicolor* (L. ex Fr.) Pilat (Isolate # R-105), and *Irpex lacteus* Fr. (Isolate Mad 517). The former two fungi produce brown rot, while the latter two species produce white rot. The agar plugs were placed on the edges of the wood feeder strips, then the jars were loosely capped (to allow air exchange) and incubated until the feeder strip was thoroughly covered with fungal mycelium. Finally, sterile test blocks were placed on the surfaces of the feeder strips, the bottles were loosely capped and incubated at 28 °C for 12 weeks for all but the blocks exposed to *T. versicolor*, which were exposed for 16 weeks. Ten blocks of each wood material were evaluated per fungus. Non-fungal exposed controls were included to provide a measure of the mass losses that occur from block handling.

In addition, 10 Palmyra palm wood and 10 southern pine blocks were buried in non-sterile soil to evaluate the potential for soft rot attack. Briefly, 454 ml french squares were half-filled with non-sterile soil mixed with compost, a 10 mm square of filter paper was placed on the surface, two blocks were added, and an equal amount of soil was placed on top. The soil was wetted to 100% of water holding capacity to create conditions that would be more conducive to soft rot attack. The jars were loosely capped and incubated at 28 °C for 12 weeks. While this non-sterile test could allow for attack by any organisms in the soil, the moisture levels in the jars were raised to levels more typically capable of supporting soft rot attack (Zabel and Morrell 1992, Nilsson 1974). At the end of the test, thin sections were cut from the surfaces of selected blocks with higher weight losses. These sections were examined under a light microscope for evidence of diamond shaped cavities typical of Type 1 soft rot attack.

At the end of the incubation period, the blocks were removed, scraped clean of adhering mycelium or soil, and weighed to determine wet weight. The blocks were then oven dried (104 °C) and weighed. The difference between initial and final oven-dry weight was used as a measure of the decay resistance of each material.

Density (oven dry basis) of each block was calculated using the original dimensions and the oven dry weight prior to fungal exposure. Those values were compared with mass losses. Previous studies have indicated that denser cocowood was more resistant to decay and we wanted to determine if this was also true for Palmyra palm wood (Jourez *et al.* 2012, Peek 1994).

RESULTS AND DISCUSSION

Mass losses in southern pine blocks ranged from 15,5% for *I. lacteus* to 49,8% for *O. placenta* (Table 1). While the mass losses were somewhat low for *I. lacteus*, weight losses in this range would be more typical of white rot fungi on a softwood in this test. *Irpex lacteus* mass losses may have been more comparable to *T. versicolor* had this fungus been exposed to the wood for the standard 16 weeks instead of 12.

Table 1. Mass losses of southern pine sapwood and Palmyra palm wood exposed for 12 weeks to selected decay fungi in an AWPA E10 soil block test or a non-sterile burial test.

Test Fungus	Average mass loss (%)[1]	
	Southern Pine	Palmyra palm wood
None	-1,23 (0,97)	0,06 (0,19)
Oligoporus placenta	49,80 (4,67)	0,46 (0,41)
Gloeophyllum trabeum	27,94 (2,45)	6,39 (2,24)
Trametes versicolor	31,80 (4,66)	10,86 (1,82)
Irpex lacteus	15,46 (6,83)	3,50 (1,26)
Non-sterile soil	6,07 (1,08)	1,33 (0,20)

[1]Values represent means of 10 replicates per fungus per wood species while values in parentheses represent one standard deviation.

Palm wood samples exposed to *O. placenta* experienced less than 0,5% mass loss. Palm wood exposed to *I. lacteus* or *G. trabeum* experienced slightly higher weight losses averaging 3,5 and 6,4% respectively. Mass losses for blocks exposed to *T. versicolor* averaged 10,6%; however, these results must be compared with the understanding that they represent a longer incubation period. There are no specific standards for categorizing durability of wood in North America, but ASTM Standard D2017 categorizes durability on the basis of average mass loss in a soil block test (ASTM 2001). Highly decay resistant woods are those that experience mass losses averaging less than 10%. Palm wood would be classified as durable to highly durable under these criteria.

Burial of palm wood in non-sterile soil resulted in mass losses that averaged 1,3% while those for southern pine averaged 6,1% (Table 1). Mass losses in soil burial tests pushed to encourage soft rot attack are typically low because the fungi involved tend to degrade wood more slowly than basidiomycetes. No evidence of diamond-shaped cavities typical of Type 1 soft rot attack were observed in cells in thin sections cut from the surfaces of palm wood blocks and examined under a light microscope. These results suggest that palm wood was also resistant to degradation under conditions that favored soft rot attack.

Previous studies have suggested a strong relationship between density and decay resistance for cocowood and oil palm. As noted earlier, density as well as sugar and starch content varies radially as well as vertically on the stem. These variations suggest that attempts to use palm wood require at least some degree of sorting for density, although they may also require some care to ensure that trees are cut in seasons where starch and sugar storage are reduced. The densities of the palm wood used in the current study had a relatively narrow range (740 to 1065 kg/m^3), limiting the potential for examining the density relationship with decay resistance. Lower weight losses for blocks exposed to either *O. placenta* or the soil burial further limited comparisons. Plots of density vs mass loss for blocks exposed to either *G. trabeum* or *I. lacteus* did show slight trends for decreased mass loss with increased density, but the correlations were low (Figure 1). Correlations between mass loss and density were much better for *T. versicolor* (R^2= 0,64).

The results highlight the importance of using only the denser parts of the stem in exterior applications. These results also correlate with previous results produced using the European test methodologies on other palm species and suggest that dense palm wood could be used in exterior decking applications without supplemental treatment (Jourez *et al.* 2012). One approach to limit the risk of early decay would be to limit exterior exposures to those boards having densities above 800 kg/m^3 since *T. versicolor* appeared to be active against samples with densities between 700 and 800 kg/m^3. Further field trials would be advisable to confirm that this approach would be functional.

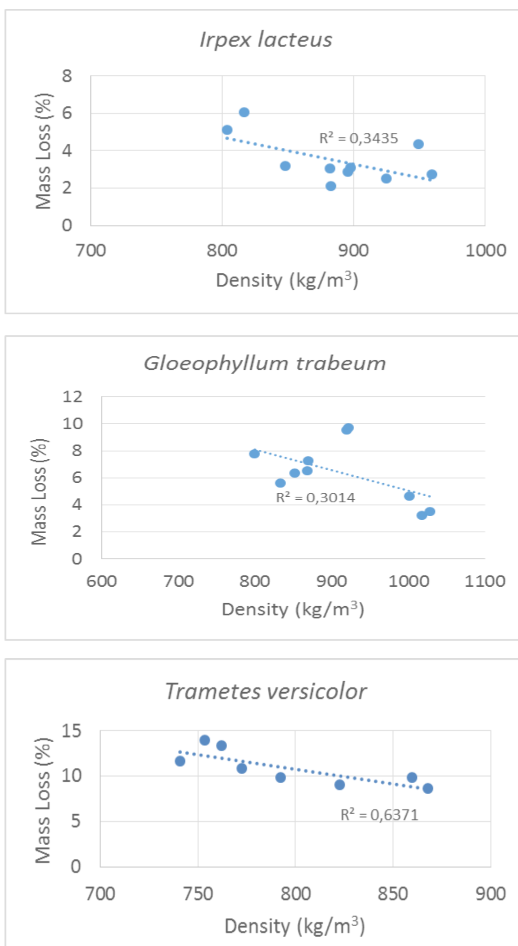

Figure 1. Relationship between original density and mass loss in Palmyra palm wood blocks exposed to *Gloeophyllum trabeum*, *Irpex lacteus,* or *Trametes versicolor* in a soil block test.

CONCLUSIONS

Palmyra palm wood was classified as resistant to highly resistant to fungal attack in soil block evaluations suggesting it might provide good performance in above ground applications in North America. The establishment of field trials are planned to confirm these results.

REFERENCES

Amartey, S.; Humar, M.; Donkor, B.; Pohleven, F.2006. Decay resistance of coconut and rubber woods: Alternative wood species from Ghana. Document No. IRG/WP/12-10596. International Research Group on Wood Protection, Stockholm, Sweden. 7 p.

ASTM. American Society for Testing Materials. 2001. Standard D-2017. Standard method of accelerated laboratory test of natural decay resistance of woods. In: ASTM Annual Book of Standards, Volume 4.10 Wood. ASTM, West Conshohocken, PA. Pages 322-326.

AWPA. American Wood Preservers' Association. 2017. Standard E10-16. Standard method of testing wood preservatives by laboratory soil-block cultures. In: AWPA Book of Standards. Birmingham, Alabama.

Bailleres, H.; Hopewell, G; House, S.; Redman, A.; Francis, L.; Ferhman, J. 2010. Cocowood processing manual: From coconut wood to quality flooring. Department of Employment Economic Development and Innovation, Brisbane, Queensland, Australia. 44 p.

CEN/TS 15083-1. 2005. Durability of wood and wood-based products: Determination of the natural durability of solid wood against wood-destroying fungi, test methods. Part 1. Basidiomycetes. European Committee for Standardization, Brussels, Belgium.

Davis, T.A.; Johnson, D.V. 1987. Current utilization and further development of the Palmyra palm (*Borassus flabellifer* L.) in Tamil, Nadu. *Economic Botany* 41(2):247-266.

EN 335. 2013. Durability of Wood and Wood-based Products - Use Classes: Definitions, Application to Solid Wood and Wood-based Products. Berlin, Germany.

EN 350-1. 1994. Durability of wood and wood-based products- Natural durability of solid wood. Part 1. Guide to the principles of testing and classification of the natural durability of wood. Berlin, Germany.16 p.

Jourez, B.; Verheyen, C.; Van Acker, J. 2012. Coconut lumber or wood decks (*Cocos nucifera* L): Decay resistance against Basidiomycetous fungi. Document no. IRG/WP/12-10784.International Research Group on Wood Protection, Stockholm, Sweden. 9 p.

Nilsson, T. 1974. Studies on wood degradation and cellulolytic activity of microfungi. Studia Forestalia Suecica 104, Royal College of Forestry, Stockholm, Sweden.

Peek, R.-D. 1994. Utilization of coconut timber from North Sulawesi, Indonesia. Part 1: Durability. Document No. IRG/WP/12-10596.International Research Group on Wood Protection, Stockholm, Sweden. 11p.

Schmidt, O.; Magel, E.; Frühwald, A.; Glukhykh, L.; Erdt, K.; Kaschuro, S. 2016. Influence of sugar and starch content of palm wood on fungal development and prevention of fungal colonization by acid treatment. *Hozforschung* 70:783-791.

World Agroforestry Centre. 2017. Online <www.worldagroforestry.org>. [Accessed October 17, 2017].

Zabel, R.A.; Morrell, J.J. 1992. *Wood microbiology*. Academic Press, San Diego, CA.