Durability of Timber Species against Termite and Fungal Attack

Wubalem Tadesse
and
Getachew Desalegn

Research Report 75

የኢትዮጵያ የግብርና ምርምር ኢንስቲትዩት
Ethiopian Institute of Agricultural Research

Durability of Timber Species against Termite and Fungal Attack

Website:http://www.eiar.gov.et
Tel: +251-11-6462633
Fax: +251-11-6461294
P.O. Box: 2003
Addis Ababa, Ethiopia

ISBN 978-99944-53-14-6

Copyediting: Simachew Manaye, Elizabeth Baslyos
Page layout and design: Simachew Manaye

Printing: Abesolom Kassa

Binding and Collation: Wuodnesh Mamo, Miftah Hargeta, Meseret Kebede

Bibliographic input to WAICENT (FAO): Mintilu Tekle, Solomon Tsega, and Amare Molla

Contents

Introduction	1
Materials and methods	3
Samples and treatments	6
Results and discussion	10
Natural durability of timber species	16
Conclusion	18
Acknowledgements	19
References	20

Introduction

Timber, in its various forms, looses its natural durability and is subjected to several types of deterioration. It is susceptible to fungi, wood boring insects, subterranean termites (the most wood destructor pests in all tropical and sub-tropical regions of the world (Richardson, 1978), marine borers, etc. (Nicholas, 1973).

Natural forests are vanishing at an alarming rate (estimated at 150,000 to 200,000 ha per year) as a result of the ever-increasing demand for fuel wood as well as crop and grazing land, stimulated by rapid growing human and animal populations. Besides, the overlooked but significantly contributing to major causes of forest destruction is the severe degradation of wood and wood products by different bio-deteriorating agents (Getachew Desalegn et al., 2003).

The greatest threat to wooden houses in Ethiopia is posed by subterranean termites, which lead at least to partial rebuilding in 3-5 years (Wood, 1986). The undesirable consequence of repeated rebuilding is deforestation of the remaining scarce forests.

In Canada, the average timber loss caused by insects and other wood deteriorating agents is 15-33% of the total volume of the country's wood consumption (Anderson, 1966). Decay/rot damage to farm and house buildings in the USA amounts to at least US $255 million annually, and including marine borers' damage it is US $500 million (Nicholas, 1973; Haygreen and Bowyer, 1989).

The enormous damage by subterranean termites and other wood deteriorating agents on forest products in Ethiopia and throughout the tropics is an important economic consideration. Bio-deteriorating agents directly affect the forest products of the country and have negative influence on the poor economy of the rural people, who had to rebuild their wooden constructions frequently. Therefore, this serious problem needs solution to alleviate the destruction on wooden constructions.

The need to preserve timber is to increase its service life. Therefore, research on the selection of effective preservative application and selection of naturally durable timber species used for construction purposes are the most important issues in many countries.

Due to enormous destruction by different wood deteriorating agents in Ethiopia, different traditional protection measures and modern commercial preservatives were used in different parts of the country. Ash, plastic cover and used motor oil are among the traditional protection measures used to increase the service life of wood construction materials. Modern preservative (CCA) is used in telephone and electric transmission poles. Therefore, the main objectives of this study were to examine the most effective traditional and commercial wood preservatives and application methods and to determine the natural durability of the five timber species against termite and fungal attacks.

Materials and Methods

Study species

This study was carried out on five timber species (four indigenous and one homegrown exotic) (Table 1). The study was carried out during 1994 to 1996.

Table 1. Description of timber species

Scientific name	Local name	Description and use *
Croto machrostachyus	Bissana	• A deciduous tree reaching 25 m • Sample trees have mean height of 26 m and breast height diameter of 48 cm. • Grows mostly on volcanic soils in dry, moist and wet weyna-degas and degas as well as in upper altitudes of 1 100–2 500 m. • Used for wood, charcoal, poles, timber, tool handles, forage, medicine, bee forage, mulch and soil conservation (Azene *et al.*, 1993).
Antiaris toxicaria	Tengi	• The tree may reach a height of 36 to 45 m with a diameter of 0.6 to 1.5 m. • Sample trees have mean height of 30 m and breast height diameter of 30 cm. • It is lowland forest (500–1 900 m) • Widespread in West Tropical Africa • The species and its variety are recorded with certainty in Ethiopia. • It is used for light construction and as quarter sliced veneer for furniture (TRADA, 1979).

Table1. Continued

Scientific name	Local name	Description and use *
Ekebergia capensis	Sombo	• An indigenous tree reaching 20–30 m, occasionally higher • Sample trees have mean height of 30 m and breast height diameter of 40 cm. • A semi-deciduous to evergreen, with a spreading crown • Widely distributed in a variety of habitats, often a shady meeting place in open grassland • Occurs in dry, moist and wet weyna-dega and dega agro-climatic zones (1 600–3 000 m). • Used for firewood, poles, timber (furniture, light construction, etc.), tool handles, medicine, fodder (leaves), bee forage, soil conservation, ornamental shade and wind break (Azene et al., 1993).
Eucalyptus grandis	Grandis-Bahir zaf	• An evergreen tree, 40–55 m, with an excellent straight trunk and wide spreading thin crown, self-pruning of branches in plantation • Sample trees have mean height of 40 m and breast height diameter of 40 cm. • Grows successfully in moist and wet weyna-dega agro-climatic zones, (1 600–2 300 m). • Uses for wood, charcoal, poles (electricity transmission, etc), posts, timber (heavy and light construction, etc), bee forage, shade, ornamental, windbreak, short-fiber pulp for paper (Azene Bekele et al., 1993)
Podocarpus falcatus	Zigba	• An evergreen tree with a straight bole, 25m or more • Sample trees have mean height of 22 m and breast height diameter of 49 cm. • *Podocarpus* trees are conifers, which have no cones and are also known as yellow wood. • Grows in moist and wet weyna-dega and dega agro-climatic zones (1 600–2 500 m). • Used for firewood, poles, timber, ornament and shade (Azene et al., 1993).

* Sources of sample trees mean height and breast height diameter WUARC (1995) and Getachew Desalegn (1997).

Study site

The study was carried out at Mersa and Negele Borena research sites (Figure 1). Mersa site is located in Amhara Region, North Wello Zone, 5 km from Mersa Town and 490 km from Addis Ababa. Its geographical location is 11° 49′ N and 39° 36′E. Negele Borena site is in Oromiya Region, at 5 km from Negele Borena Town and 600 km from Addis Ababa. It is located at 5°17' N and 39° 45' E. Both sites are relatively flat and have been grazing lands so long.

Both sites were selected based on mainly the presence of severe termite attack on wooden constructions. People at these areas have been suffering from termite problems. Wooden made houses, fences, etc., are always being destructed by these deteriorating agents. This in turn has forced the surrounding dwellers to go to the forest areas, fell down the trees, and construct their houses and fences once or twice a year. This contributes to the decrease of the forest cover in Ethiopia.

Figure 1. Location of the study sites

Samples and Treatments

Samples

Ten test samples with 2 x 5 x 50 cm were prepared from each timber species for each test. Identification tags were prepared for each test sample and tagged at 5 cm from the top. All test samples were free from visible defects that may affect the uniformity of the material and treatments.

Treatments

Control samples (natural durability): Untreated samples were used for testing natural durability of each timber species.

Used motor oil: The test samples were submerged in a dipping tank containing cold used motor oil (Fig. 2). Then, the solution was gradually heated, by burning wood under the dipping tanker, to about 90 °C and maintained for four hours. The samples were withdrawn from the dipping tank after 24 hours of cooling, and they were air- dried for two weeks before field installation so as to allow fixation of preservative.

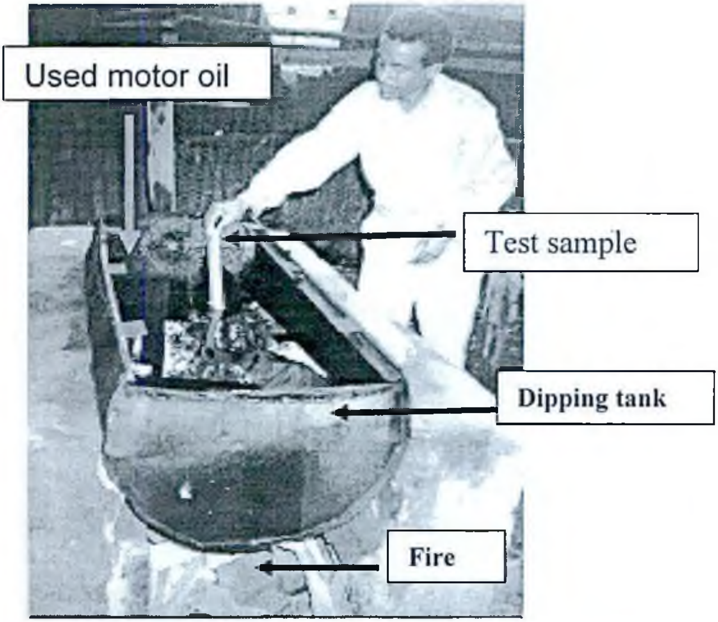

Figure 2. Test samples treatment with used motor oil using dipping tank.

Copper Chromium Arsenic (CCA): Commercial preservative Celcure K33 was applied with pressure treatment using Rentokil impregnation machine and 3% of chemical concentration. Chromium is responsible for the fixation; copper is effective against soft rot and arsenic acts against white and brown rot and insects, and some of them also act against subterranean termites (Willeitner and Liese, 1992). The stakes were seasoned at least for two weeks to allow fixation of the preservative and evaporation of the solvent.

Polyethylene plastic cover: Test samples were covered by plastic bandage (transparent polythene tube used for seedling production in the nursery). More than half of the length of the samples were covered by plastic, and their bottom ends were well sealed to avoid the entrance of termite and fungi into the wood surface.

Ash: The soil was treated with ash during site preparation and sample installation. The installation holes were filled with ash prior to sample installation to avoid direct ground contact of the samples.

Preparing graveyards and installing samples

The preparation of graveyards started with demarking a specific location with an area of 20 m^2. The site was fenced to avoid disturbance. Holes for the installation of sample stakes were prepared with 25 cm depth at a spacing of 50 cm between rows and 25 cm between sample stakes (Figure 3).

The test samples (for natural durability and chemical effectiveness tests) were randomly installed in the holes at half their length. The position of the samples where each sample was located in each test plot was marked on the sketch.

Figure 3. Test samples installed in Negele Borena graveyard (left) and Mersa (right)

Inspection/data collection

Visual inspection (sound method) was applied to determine the survival rate or resistance of each sample and preservative treatment against termite and fungal attack (Nicholas, 1973). Inspections were done at the third and sixth months, and then after first and second years from the time of installation. During inspection, each test sample was carefully removed from its hole and the presence and extent of attack by subterranean termites and/or fungi was inspected, evaluated and recorded based on the adopted standard (Gjovik and Gutzmer, 1986; Melaku and Addis, 1987).

In this trial research, the applied bio-deterioration grades were one to five (Gjovik and Gutzmer, 1986), where 1=sound, no decay and/or termite attack (100% resistance); 2=local, superficial/moderate (75%); 3=slight, limited (50%); 4= severe and deep (25% resistance); and 5=failure/complete attack (0%). The main data collected were natural resistance of untreated stakes and performance of preservative treated stakes and/or preservatives and application methods over the study period.

During inspection, in the same season each year, mostly after rainy season and by the same experienced experts, each stake was carefully removed from its pit and the presence and extent of attack by termites and/or fungi was assessed, evaluated and recorded using the method of Gjovik and Gutzmer (1986) before its reinstallation into the pit.

Data analysis

Multifactor analysis of variance was used to determine the relationship among treatments and natural durability of timber species. One-Way Analysis of Variance was used to determine the natural resistance of each timber species. The statistics program used to determine both analyses was Stat Graphics Plus 2.1.

Results and Discussion

Effectiveness of wood preservatives

To preserve timber is to increase its service life. Therefore, research on the selection of effective and economical protection methods and selection of naturally durable timber species used in construction could be one of the most important issues in many countries.

At Mersa station, during the first year, in natural durability stakes, *E. capensis* was the best while *A. toxicaria* was the least resistant species against termite. But, there was no difference in fungal attack among timbers (Table 2). In the second year, there was no significant difference in natural durability of stakes and treatments: ash and plastic cover. CCA was the best effective and used motor oil the second effective treatments (Table 2). CCA treated stakes of *E. capensis* were attacked to 85%, whereas other species were attacked from 55% to 100% (complete failure).

During the first year at Negele Borena, *E. grandis* was the best but Tengi was the least resistant species against termites attack (Table 3). There was no significant difference among used motor oil, plastic cover and CCA control measures. Ash was the least, whereas CCA was the best resistant. At the second year, *E. grandis* was once more the best, whereas *A. toxicaria* and *E. capensis* were the least resistant species. Ash was the least resistant control. CCA was the top and used motor oil was the second resistant preservatives against bio-deteriorating agents (Table 3). As the duration increases, both at Mersa and Negele Borena, the resistance of timbers and effectiveness of preservatives decreases (Table 2 and 3; Fig. 3)

Table 2. Mean inspection results of stakes at Mersa station.

1st year										
Timber species	Natural durability		Ash		Used motor oil		Plastic cover		CCA	
	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus
E.Grandis	40	92.5	42.5	65	85	100	17.5	97.5	100	100
C. machrostacyus	0	92.5	12..5	50	80	75	40	67.5	100	100
A. toxicaria	32.5	50	15	45	100	100	0	0	100	100
E. capensis	57.5	95	72.5	72.5	72.5	82.5	25	45	100	100
P. falcatus	25	85	2.5	100	100	100	10	100	100	100
2nd year										
Timber species	Natural durability		Ash	Used motor oil			Plastic cover	CCA		
	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus
E.Grandis	0	0	0	0	10	10	0	97.5	45	50
C. machrostacyus	0	0	0	0	0	0	0	0	100	100
A. toxicaria	0	0	2.5	2.5	20	20	0	0	72.5	72.5
E. capensis	0	0	0	0	0	0	0	0	15	15
P. falcatus	0	0	0	100	67.5	67.5	0	100	100	100

Table 3. Mean inspection results of stakes at Negele-Borena station

1st year										
Timber species	Natural durability		Ash		Used motor oil		Plastic cover		CCA	
	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus
E. grandis	50	100	30	67.5	100	100	92.5	97.5	100	100
C. machrostacyus	2.5	82.5	0	72.5	80	80	22.5	55	100	100
A. toxicaria	0	80	2.5	60	100	100	15	25	100	100
E. capensis	15	67.5	5	77.5	100	100	65	42.5	100	100
P. falcatus	42.5	100	32.5	80	95	100	80	92.5	100	100
2nd year										
Timber species	Natural durability		Ash		Used motor oil		Plastic cover		CCA	
	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus	Termite	Fungus
E.Grandis	25	100	12.5	67.5	87.5	90	67.5	97.5	95	100
C. machrostacyus	2.5	82.5	0	0	32.5	25	0	55	100	100
A. toxicaria	0	0	0	60	97.5	90	5	25	100	100
E. capensis	0	67.5	0	77.5	55	87.5	2.5	35	100	100
P. falcatus	12.5	95	17.5	80	85	92.5	30	92.5	100	100

The one way analysis of variance used to analyze the possible difference on the hazardous rate of Mersa and Negele Borena sites reveals that there is not significant difference between the two research sites (Table 2). Subterranean termites were the most aggressive/dangerous wood destroying agents ($P < 0.01$) than fungi in both sites. Many authors have also confirmed that subterranean termites are the most wood deteriorating pests in all tropical and sub-tropical regions of the world (Richardson, 1978; Wong and Cheok, 2001).

The multifactor analysis of variance among treatments reveals that there is significant difference among treatments ($P = 0.01$), in each inspection period. The modern preservative CCA has been the most effective one in every inspection period and at both sites (Figure 4).

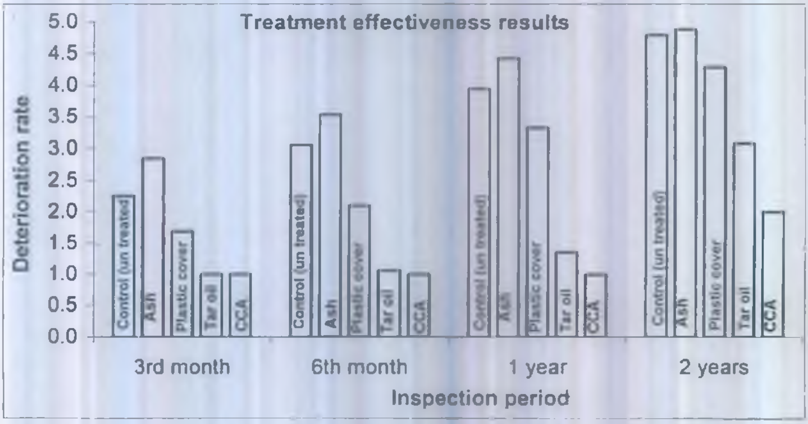

Figure 4. Mean treatment effectiveness results against termite versus inspection periods.

Used motor oil was the second effective protection measure (Fig. 3). If used motor oil is applied properly (as described in this study), it can be one of the most important protection measures in the country. This is because it is found in many vehicle garages, and it does not require sophisticated equipment or trained professional to apply it, unlike CCA.

In many rural parts of the country, ash is used to reduce termite attacks in wooden constructions. However, unexpectedly, in this study, ash treated samples in all inspection periods had higher deterioration rate than untreated control samples (natural durability tests) (Table 2 and figure 3). Polyethylene plastic cover is also of the locally used protection measures for wooden constructions in the rural and urban areas. The main poles in wooden constructions are covered by plastics to avoid the ground contact, and therefore, to increase the service life of the construction materials. In this study, polyethylene plastic cover tests were effective in the third and sixth month's inspection periods. The deterioration rate of the polyethylene plastic cover increased in the third and further inspection periods because of the unwanted damage on the polyethylene plastic cover during the extraction and reinsertion of the test samples. Therefore, in the absence of this mechanical destruction, polyethylene plastic cover could be more effective than the control (untreated) ones.

Natural durability of timber species

The one-way analysis of variance reveals that there is significant difference in natural durability among timber species ($P = 0.001$), in each inspection period (Figure 5).

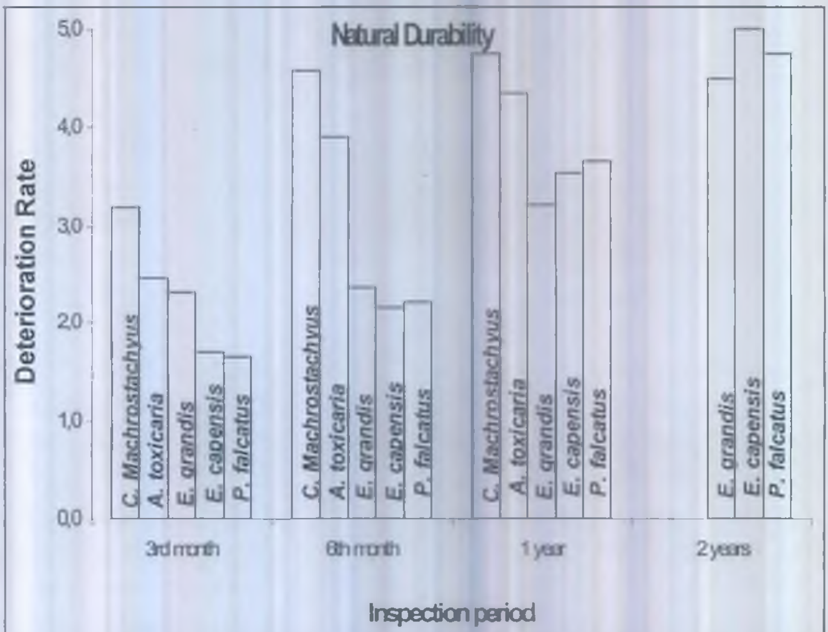

Figure 5. Mean natural durability of the two sites and each timber species against termite versus inspection periods.

C. machrostachyus and *A. toxicaria* were the most perishable timber species in all inspection periods. All test samples of both species were completely destroyed within the first two years exposure by subterranean termite and fungal attack (Fig. 4). Tack (1969) and Getachew Desalegn et al. (2003) also classified both species as perishable timber species. *C. machrostachyus* is one of the widely distributed timber species and is used for different construction purposes in the country. The perishability of *C. machrostachyus* is also known in the rural and urban areas. Therefore, the use of these species for construction without adequate preservation should be stopped, especially in termite areas. The main reason is that this causes reconstruction in a few periods and this in turn leads to the acceleration of deforestation in the country.

P. falcatus and *E. grandis* are durable timber species (Table 2 and figure 4). Getachew Desalegn et al. (2003) also classified the species as moderately durable that have been completely destroyed after 12 years of exposure by termite and fungal attack in Ziway, one of the termite hazardous regions in the country. *P. falcatus* is one of the highly utilized timber species for different construction purposes and manufacturing of furniture in Ethiopia.

E. grandis is one of the fast growing exotic species distributed in different agro-ecological zones of the country and is used for different construction purposes. Getachew Desalegn et al. (2003) classified this species as non-durable and the test samples were destroyed after four years of exposure in Ziway. However, the durability of this species is very encouraging, since the species is fast growing and is more durable than many indigenous timber species. In a very few years of plantation, the species can be used for construction.

Applying preservative treatments for structural size wood prolongs its service life 40-50 years (Hunt and Garratt, 1953), or 50-60 years (Richardson, 1978) and pressure treated creosote 30-50 years (Eaton and Hale, 1993). As an approximate guide, the life of timber structure in service is directly proportional to the thickness (least dimension). For instance, a 100 x 100 mm stake will last about twice as long as a 50 x 50 mm stake (Purslow, 1976). The life expectancy of wood in soil contact is directly proportional to its thickness but not to its cross-sectional area. Therefore, the structural size of the timber species treated with CCA and used motor oil, and selection and utilization of naturally durable timber species, increases its service life significantly since durability is strongly correlated with thickness of timbers.

Conclusion

The modern preservative CCA has been the most effective one in every inspection period. Used motor oil has been the second effective protection measure. Based on the cheapest price to get used motor oil and its simplicity to treat timber with it, used motor oil can be one of the most important protection measures in the country, whenever timbers are well treated as described in this study. In cases where CCA treatment is needed, more environmental friendly types such as tanalith E or Celcure AC-500 preservatives are recommended.

In all inspection periods, ash treated test samples have deteriorated more than other preservatives and even than untreated control samples (natural durability tests). Therefore, ash cannot be recommended as protection measure, rather further study is needed to determine its fate. *C. machrostachyus* and *A. toxicaria* were the most perishable timber species. Therefore, these species should not be utilized for construction purposes in termite hazardous areas, without prior treatment with proper protection measures.

P. falcatus, one of the most important and valuable indigenous timber species, and *E. grandis*, one of the fast growing home grown exotic species, have been the durable timber species. Therefore, constructions on ground contact (for short periods) for less than 10 years of service in termite hazardous regions can be carried out with durable species like these ones.

Timbers, which are perishable to wood damaging agents, should be treated by protection measures that can give long time services to the end users. Treating method is one of the factors that determine the effectiveness of any wood preservatives. Therefore, to protect timber from any bio-deteriorating agents, selecting the best preservatives and treating methods, which is either pressure or non-pressure, is very important.

Acknowledgments

The authors would like to thank Worku Fekadu and Gemechu Kaba for their strong technical assistance in sample preparation, treatments and data collection. The authors also thank the Ethiopian Science and Technology Agency for the financial assistance of this research project, and the then Wood Utilization and Research Center now Forest Products Utilization Research Coordination Office for providing research facilities and logistics. We thank Melaku Abegaz for his valuable advice and follow up during the implementation of the project.

References

Anderson R.F. 1966. Forest and shade tree entomology. New York: J. Willey

Azene Bekele, A Birnie and B Tengnas. 1993. Useful trees and shrubs for Ethiopia: Identification, propagation and management for agricultural and pastoral communities. Technical hand book no 5. Regional Soil Conservation Unit, SIDA, Nairobi.

Eaton R A and MDC Hale. 1993. Wood decay, pests and protection. London.

Getachew Desalegn, Wubalem Tadesse, Worku Fekadu, Gemechu Kaba, Demel Teketay and Girma Taye. 2003. Effectiveness of protection measures on 32 timber species against subterranean termites and fungi at Zeway District, Zeway Research Station and Central Ethiopia. Ethiopian Journal of Biological Society 2: 189-216.

Getachew Desalegn. 1997. The analysis and application of potential timbers small clear specimens results in Ethiopia. M.Sc. thesis. Faculty of Forest, Geo and Hydro Sciences of Technische Universität Dresden, Germany.

Gjovik LR and DI Gutzmer. 1986. Comparison of wood preservatives in stake tests. 1980 progress report. United States Department of Agriculture. Forest service, Forest Products Laboratory, Research Note FPL-02. USA.

Haygreen JG, JL and Bowyer. 1989. Forest products and wood science: An introduction. 2nd edition. IOWA State University Press/Ames, USA.

Hunnt GM and JA Garratt. 1953. Wood preservation. 2nd edition. New York: Mcgraw-Hill Book Company, IWC.

Melaku Abegaz and Addis Tsehay. 1987. Wood preservation in Ethiopia. Ministry of Agriculture. Natural resources conservation and development main department. Wood utilization and research center. Addis Ababa, Ethiopia.

Nicholas Darrel D (ed). 1973. Wood preservation and its prevention by preservative treatments. Volume 1. Degradation and protection of wood. Syracuse wood science series 5, New York: Syracuse University Press

Purslow DF. 1976. Results of field tests on the natural durability of timbers (1932-1975). Building research establishment. Princes Risborough Laboratory, U.K.

Richardson AB. 1978. Wood preservation. The construction Press. Great Britain.

Tack CH. 1969. Uganda timbers. Ministry of Agriculture and Forestry, Forest Department, Government Printer, Entebbe, Uganda.

TRADA. 1979. Timbers of the world. Volume 1. Timber Research and Development association. New York: Longman Inc.

Willeitner H and W Liese. 1992. Wood protection in tropical countries: A manual of the know-how. Technical Cooperation (GTZ), Federal Republic of Germany.

Wong AHH and KS Cheok. 2001. Observations of termite-fungus interactions of potential significance to wood bi-deterioration and protection. Timber technology bulletin no. 24. FRIM, Kepong, Kuala Lumpur, Malaysia.

Wood TG. 1986. Assessment of termite damage in Ethiopia and recommendations for short-term control and development of long-term pest management practices. Tropical Development Research Institute. Overseas Development Administration, London. Prepared on behalf of World Bank for the Ministry of Agriculture, Government of Socialist Ethiopia. Addis Ababa.

WUARC (Wood Utilization and Research Center).1995. Commercial timbers of Ethiopia. Research repot. Technical bulletin no.2. Revised and enlarged edition. Ministry of Natural Resources Development and Environmental Protection. Addis Ababa, Ethiopia.