Performance of Traditional Wood Protection Measures in Controlling Termite and Fungal Attack in Pawe Wereda

Behailu Kebede
Yigremachew Seyoum
Getachew Desalegn
Melaku Abegaz
Demelash Alem

Research Report 92

የኢትዮጵያ የግብርና ምርምር ኢንስቲትዩት
Ethiopian Institute of Agricultural Research

Performance of Traditional Wood Protection Measures in Controlling Termite and Fungal Attack in Pawe Wereda

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

ISBN: 978-99944-53-69-6

Copyediting: Tedla Pascal
Page Design: Tedla Pascal
Printing: Abesolom Kassa
Binding and collation: Abesolom Kassa Miftah Argeta, and Wudnesh Mamo
Distribution: Solomon Tsega and Tigist Beshir
Bibliographic input to WAICENT (FAO): Tigist Beshir

Contents

Introduction

The damage caused by biodeteriorating agents in construction and furniture areas has been significantly noticed. In an effort to offset subterranean termites' damage, farmers have practiced traditional termite protective techniques where the extent of effectiveness was not studied.

Termites, sometimes erroneously called *white ants* are social insects; polymorphic, dwelling in large communities and sometimes in elaborate nests both above and below the ground. These insects and fungi are consistently found damaging structural timbers, furniture, standing trees, and agricultural crops such as groundnuts, fruit trees, sugarcane, rice, and other food products, as well as range lands.

In Ethiopia, termites' damage on crops and wooden constructions is estimated 20% to 50%, which in some places has led to total crop and construction losses (Wood, 1986). In Manasibu Wereda of western Ethiopia, termites, especially microterms, were the major species attacking crops such as teff, maize, sorghum, and rangelands (Ofgaa Djirata et al., 2007). One hundred and forty-two wood decaying basidiomycetes species have been recorded on *Pouteria adolfi-friederici*, *Juniperus procera* and *Podocarpus falcatus* tree species fallen logs in Menagesha, Munessa-Shashemene and Teppi forests of the country (Adane Bitew, 2002).

Therefore, in addition to finding resistant and fast growing tree species, it is necessary to protect the newly established plantations and forest products from damages caused by biodeteriorating agents by applying effective protective measures including insecticides and fungicides.

The general objective of the experiment is to investigate the natural durability, variation, and effectiveness of commonly practised traditional methods to resist damages caused by biodeteriorating agents.

The specific objectives of the study were:

- to investigate the natural durability of the sawn timber species namely *Croton macrostachyus*, *Cordia africana*, *Syzygium guineense*, *Combretum molle* and *Acacia caffra* at field;
- to evaluate performance of applied biodeteriorating protection measures on timber stakes against subterranean termites and fungal attack at Pawe Research Station, and
- to select naturally durable timbers and effective wood preservatives that will assist prolonged utilization of the susceptible species in the area.

Material and Methods

Study site

The study site was located in Pawe Wereda of the Benshangul Gumuz Regional State (Figure. 1). Pawe is located at 578 Km from Addis Ababa and located at 11°19'N and 36°24'E.

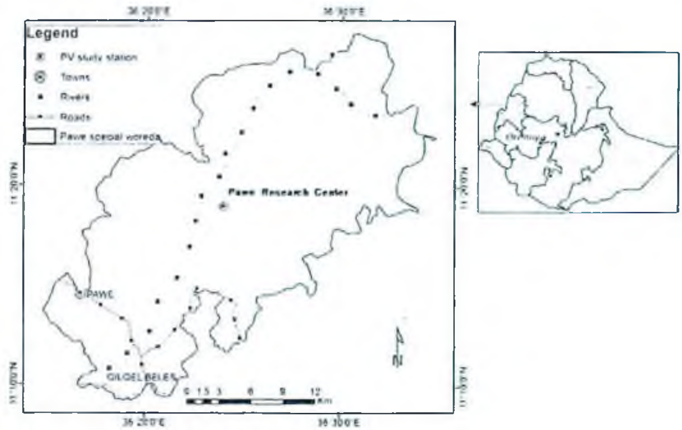

Figure 1. Location of Pawe graveyard station

The area is found in the tepid to cool sub-humid highland major, and tepid to cool sub-humid mountains sub agro ecologies, and the major soil types are Nitosols, Vertisols, and Livesols (EARO, 2001). It has an altitude of 1100 m. Pawe has a mean annual rainfall of 1000 to 1500 mm. The mean annual minimum and maximum temperatures are 25 °C and 30 °C, respectively.

Study site was selected taking into account hazardous areas of biodegrading agents (termites and fungi), where timber resource and/or its demand is high as alternative construction and furniture materials for ground and moisture contact construction, outdoor and furniture production purposes.

Study species and protection measures

Questionnaires and checklists were prepared to assess and identify the commonly grown indigenous and exotic timber species that are preferred by the communities for construction, furniture and other services. Five commonly used tree species in the area and two traditional protection techniques were used in the experiment.

Four indigenous tree species namely *Croton macrostachyus* Del., *Cordia africana* Lam., *Syzygium guineense* (Willd.) DC., *Combretum molle* R.Br.ex G. Don and the homegrown exotic tree species *Acacia caffra* (Thunb.) Willd. were selected for this research. *A. caffra* is the species suited and widely distributed only in this wereda and zone. The non-chemical/traditional protective measures applied besides the untreated control were used motor-oil of vehicles and ash obtained from *A. caffra* wood. Thirty timber samples, hereafter called stakes, per species and 50 stakes per protection measure including the control were used. One hundred and fifty timber stakes were used for all the tests.

Treatment of stakes

Hot and cold dipping

The stakes of sawn timbers were treated with used motor oil preservative, a mixture of diesel oil 40 and Helix Ultra 40 engine oil was used. The stakes were treated using the hot-and-cold dipping open tank thermal method (FAO, 1994). The 50 stakes were dipped in a tank containing 50 l of cold used motor oil. Used motor oil was gradually heated by burning wood under the dipping tank to about 90 °C to reduce viscosity of the oil and maintained for four hours (FAO, 1994). Treated stakes were withdrawn from the dipping tank after 24 hours of cooling. As the stakes cool down, they absorb the preservative (BS, 1975). After treatment, the stakes were drained from excess oil with cloth rags and air-dried for two weeks before field installation to allow re-settling and fixation of the preservative inside the stakes (Willeitner and Liese, 1992).

Ash soil treatment

The stakes installed in the pits were partially filled with ash of *A. caffra* wood as traditional protection measure against subterranean termite and fungal attack.

Treatment of control stakes

The untreated (control) stakes for testing the natural durability of each species were not subjected for preservative treatments, instead, they were receiving appropriate handling during seasoning and processing so as to avoid discoloration and deterioration before field installation.

Field tests

Graveyard installation of stakes

At the field, the contributing effects of wood, preservative, weather, termite fauna and fungus flora were all interacting as they would occur on treated and untreated wood in practical commercial and local uses. Tests on the natural durability of stakes and performance of traditional protection measures were conducted simultaneously. This graveyard test is a type of accelerated field test since stakes were small in size, exposed to actual field/service conditions of wood and the test would take relatively short term compared with structural size wood that would require at least 25 years of research.

The trial plot was demarcated on an area of 30 x 30 m, cleared, and fenced with wooden posts and wire. The station was well drained, fairly leveled, having uniform soil conditions and easily accessible. Treated and untreated control stakes were installed to an experimentally set up termite-invaded field of Pawe Research Center. Stakes were installed in pits of 25 cm depth at a spacing of 50 cm between rows and 25 cm between stakes (NWPC, 1971). The test stakes were installed randomly in the prepared installation pits with half their lengths (25 cm) in the ground and the rest half was remaining above the ground bearing identification tags fixed 5 cm from the top end.

The position of the stakes where each stake is located in each test plot was marked on the layout map of the experiments. All the stakes were having their identification tags facing the same direction so that they were replaced easily in exactly the same position after every inspection and evaluation.

Evaluation of stakes resistance and effectiveness of preservatives

During each evaluation, the resistance and/or deterioration rate of each test stake and protection measures against subterranean termites and fungal attack was determined by visual inspection/observation supported by sounding and indenting methods. This was done according to the parameters and symptoms of biodeterioration attack outlined by Nicholas (1985) and Eaton and Hale (1993). Earthen tunnels, termites mud tubes, and exit holes or galleries on the stakes were used to denote the presence and damage by subterranean termites. Visual assessment of external decay, i.e. hype growth, softness, a hollow and/or dull sound while jabbing stakes with blunt side of the inspection knife and indenting with thumbnail were used to indicate fungal damage.

The main data collected at the field over the study period were resistance of untreated stakes to biodeterioration and performance of preservatives. In this study, damage grades from 1 to 5 were used to determine biodeterioration rate of stakes, where 1 represented sound, no decay and/or termite attack (100% resistance); 2 represented local, superficial/moderate attack (75% resistance); and 3 represented slight attack, limited attack (50% resistance); 4 represented sever and deep attack (25% resistance); and 5 represented failure/complete attack (0% resistance or ≥ 50% of the cross-section destroyed) (Gjovik and Gutzmer, 1986; Highley, 1995).

The controls and treated stakes inspection and evaluation of performance of preservatives was carried out at three, six and 12 months after installation of the stakes, and thereafter every year (Zawde Berhane and Yusuf, 1974; Purslow, 1976; Getachew Desalegn et al., 2003) for three continuous years. The inspections were carried out, mostly after rainy seasons and by the same experts. Each stake was carefully removed from its pit, the part that was placed under ground was scraped off to facilitate inspection, the presence and extent of damage by termites and/or fungal attack was assessed, evaluated and recorded (Table 1) following the method used by Gjovik and Gutzmer (1986) and Highley (1995) before its reinstallation into the original pit of the plots, unless its condition indicated severe/complete damage and removal.

Natural durability of each species and effectiveness of preservatives under tropical conditions based on the stated findings were assessed and categorized as very perishable (less than 6 months), perishable (6 months to 1 year), non-durable (1 to 5 years), moderately durable (5 to 10 years), durable (10 to 15 years) and very durable (more than 15 years) against biodeteriorating agents (Bryce, 1976; Purslow, 1976; Mealku

Abegaz and Addis Tsehay, 1988; Willeitner and Liese, 1992; Eaton and Hale, 1993; Getachew Desalegn et al., 2003).

Experimental design and data analysis

The experiment was laid out in split plot design by setting the five tree species as main plots and the traditional protective measures as sub plots. The design of the experiment was spilt plot in complete randomized complete design (RCD), a factorial experiment with two main factors, five timber species and three biodeterioration protection measures, i.e. used motor oil, wood ash and the untreated control.

One-way analysis of variance (ANOVA) was used to determine preservative treatability and penetration of each timber species. To determine natural durability of stakes and performance of preservatives against subterranean termites and fungal attack multifactor ANOVA was used. For the analysis mean of the 10 stakes that became continuous values were used in the standard ANOVA (SAS Institute, 2000). Since species were not structured, Duncan's multiple range tests were employed to determine significantly different treatment means, thereby helping determine which timber species, protective measures and filed exposure periods were superior or inferior in their resistance or deterioration against subterranean termites and fungal attack.

Results and Discussion

Natural durability of timbers and effectiveness of treatments

For subterranean termite and fungal attacks, the multi-factor ANOVA indicated significant differences ($P < 0.05$) among used motor oil, ash treatment and the control; preservative application techniques (hot and cold dipped with used motor oil and ash soil treatment); among the timber species and length of field exposures and evaluation periods and in the interactions between timber species, preservatives and field exposure time.

Performance of untreated stakes and effectiveness of preservatives against subterranean termites and fungal attack were different. The resistance of stakes treated with used motor oil to biodeterioration in the ground and moisture contact applications was significantly prolonged compared with those of the ash treatment and the controls (Table 1 and Figure 2-4). The results revealed that subterranean termites were superior agents of biodeterioration at Pawe.

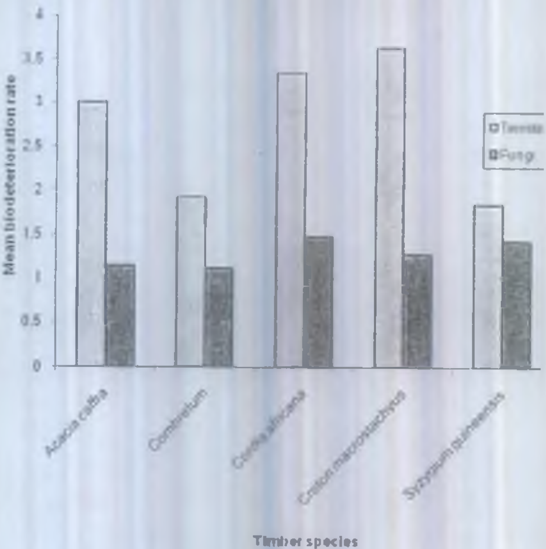

Figure 2: Natural durability of timbers

Natural durability of timbers

There was a significant difference between mean resistance/durability of timber species. At this station, *Combretum molle* was more durable species among the study timbers. Underground parts of all the untreated stakes of *Croton macrostachyus* were completely (100%) degraded and fell down to the ground line zone by subterranean termites attack during the first year field exposure period, and that of *S. guineense* stakes were 47.5% resistant up to the third year inspection and evaluation period. At the third year, all the used motor oil treated stakes of *Cordia africana* were degraded and fell down by termite attack. Natural durability and ash treatment resisted only up to the first year since installation.

Table1: Mean resistance of timbers and preservatives (%) to subterranean termites and fungal attack

Timber species and preservatives applied	1/4 year		1/2 year		1st year		2nd year		3rd year	
	T	F	T	F	T	F	T	F	T	F
Acacia caffra *Ash	60	100	55	100	17.5	57.5	12.5	62.5	12.5	62.5
A. caffra *Control	75	100	85	100	35	82.5	17.5	85	15	77.5
A. caffra *UMO	92.5	100	95	100	82.5	97.5	67.5	92.5	27.5	75
Combretum *Ash	92.5	100	92.5	100	60	100	37.5	80	17.5	80
Combretum *Control	97.5	100	100	100	85	100	67.5	100	37.5	100
Combretum *UMO	100	100	100	100	100	100	100	100	70	100
Cordia *Ash treatment	65	100	72.5	100	22.5	77.5	0	77.5	0	77.5
Cordia *Control	60	100	67.5	100	40	97.5	0	85	0	85
Cordia *UMO treatment	100	100	100	100	60	82.5	35	82.5	0	57.5
Croton *Ash	20	100	10	100	0	77.5	0	77.5	0	77.5
Croton *Control	35	100	20	100	0	90	0	90	0	90
Croton *UMO	100	100	100	100	90	100	75	100	65	95
Syzygium *Ash	90	100	85	100	70	92.5	40	80	35	45
Syzygium *Control	87.5	100	90	100	87.5	100	77.5	82.5	47.5	42.5
Syzygium *UMO	97.5	100	100	100	92.5	100	92.5	100	92.5	100

** indicates applied treatments: Ash - ash from A. caffra wood as soil treatment; UMO - used motor oil treatment; Control - untreated timber stakes.*

Among the five timber species tested for their termite and fungal attack tolerance, *C. molle* and *S. guineense* were found to be more tolerant than others. *C. africana* and *A. caffra* showed moderate tolerance compared to other species. *C. macrostachyus* showed the least tolerance than the other species. It can be concluded that attention should be given to species selection for different construction and furniture purposes in the study area and elsewhere.

According to Duncan's multiple range tests, the resistance of timbers against termites in descending order was *S. guineense* (80%), *C. molle* (77.5%), *A. caffra* (50%), *C. africana* (42.5%) and *C. macrostachyus* (35%). The mean fungal resistance of timbers in a descending order was *C. molle* (97.5%), *C. macrostachyus* (92.5%), *S. guineense* (90%), *A. caffra* (90%), *C. africana* (87.5%).

Effectiveness of protection measures

Among the tested protection methods, used motor oil was more effective protection measure against termite and fungal attack on these timber species (Table 1 and Figure 3). From the present study, it was noted that ash treatment was not significantly different from the control and in some cases even weaker than the untreated control. From these results we can conclude that ash treatment has not effectively contributed to protect termite and fungal attack.

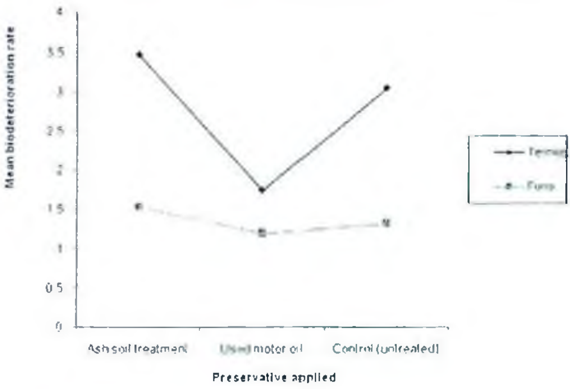

Figure 3: Effectiveness of preservatives

Regarding effectiveness of used motor oil and ash treatments, similar results were obtained at Zeway, Bako, Mersa, Negele Borena, Gonder and Bahir Dar Wood Preservation Research Stations (Getachew Desalegn et al., 2003, 2007; Wubalem Tadesse and Getachew Desalegn, 2008).

There was a significant difference (P < 0.05) in the damage caused by subterranean termites among timber species, preservatives, exposure periods, and in the interactions between timber species and preservatives, timber species and exposure periods. There was also a significant difference (P < 0.05) in the damage caused by fungi among timber species, preservatives, exposure periods, but not for the interactions (Table 2 and Figure 2-4).

The variation in the extent of damage against termites among the timbers was very significant, which may be attributed to age and other variations, while for the majority of the stakes the extent of fungal damage and the variation among the timber species was low.

Table 2: Analysis of variance on subterranean termite (T) and fungal (F) damages, preservatives and inspection periods (Time)

Source	Biodeteriorating agent	DF	Type III SS	Mean Square	F Value	Pr > F
Timber species	T	4	40.58	10.15	55.27	<.0001
	F	4	1.26	0.32	2.91	0.0369
Preservative	T	2	39.89	19.95	108.67	<.0001
	F	2	1.40	0.70	6.42	0.0045
Time	T	4	50.52	12.63	68.80	<.0001
	F	4	7.85	1.96	18.05	<.0001
Timber species* Preservative	T	8	11.35	1.42	7.73	<.0001
	F	8	1.44	0.18	1.66	0.1473
Preservative* Time	T	8	2.17	0.27	1.48	0.2034
	F	8	1.0	0.13	1.15	0.3582
Timber species* Time	T	16	9.37	0.59	3.19	0.0025
	F		2.59	0.16	1.49	0.1648

R^2 termite = 0.9632, Cov = 15.61; R^2 fungi = 0.8171, Cov= 24.62

Compared with control and ash treatments, used motor oil was the most effective preservative to control termite and fungal attack at Pawe area. Ash treatment from *A. caffra* wood revealed least effective, even less than the control while used motor oil was best effective.

Least square means method helped detect the possible variations among interactions. From the results, it was noted that *A. caffra* is better with used motor oil and without any treatment. Addition of ash as soil treatment has reduced its tolerance. There was no significant variation among treatments in *C. molle*, indicating an inherent tolerance of this species. *C. africana* and *C. macrostachyus* showed the best tolerance when treated with used motor oil. For *S. guinense* there was difference among inspection periods.

Duncan's multiple range tests revealed that there was a significant difference among mean resistant of preservatives against subterranean termites and fungal attack. Up to the last inspection period (third year), the resistance of ash against termite attack was 37.5%, control 50% and used motor oil 82.5%. The resistance of ash against fungal attack was 87.5%, control 92.5% and used motor oil 95%, indicating that ash was the least effective against subterranean termite and fungal attack.

Duration of field exposure

The analysis made among the traditional protection methods for the five inspection periods, i.e. from the third month to the third year, indicated significant differences ($p < 0.05$). Highest damage was obtained at third year and least at third and sixth months (Figure 4).

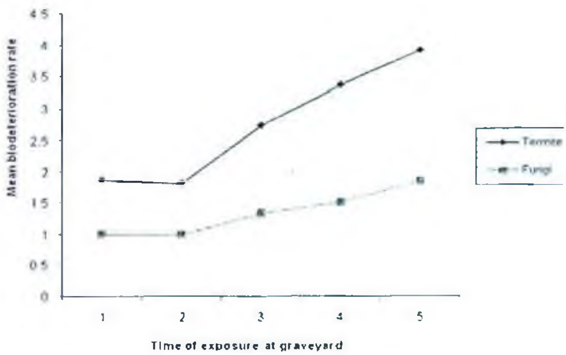

Figure 4: Biodeterioration rate against field exposure time

As the duration of exposure increased, the extent of attack also increased (Table 1 and Figure 4 and 5).The third year was the highest attack recorded as compared to the duration of 3rd month to 2nd year.

Figure 5: Biodeterioration attack trends at Pawe Station.

The trend and extent of attack varied with timber species, preservatives and application techniques, field station, biodeteriorating agents (termite and or fungi) and length of exposure time (Getachew Desalegn et al., 2003, 2007; Wubalem Tadesse and Getachew Desalegn, 2008; Getachew Desalegn and Alemu Ggezahegn, 2010; Getachew Desalegn 2010; Getachew Desalegn and Wubalem Tadesse, 2010).

The results of this study are in agreement with previous studies stated above. The more durable timber species may be indebted for their resistance mainly to their extractives and densities, which serve them as natural preservatives and resistance (Nicholas, 1985; Shirvastava, 1997) to biodeterioration. For both untreated and preservative treated timber stakes, subterranean termites were superior agents, indicating more significant damage than fungi.

Recommendations

Appropriate conservation and utilization strategies should be devised for termite and fungal damage tolerant species. Non-durable timbers such as *C. macrostachys*, *C. africana*, *A. caffra* etc. should not be used at Pawe and similar hazardous areas for moisture and soil contact construction applications without applying effective preservation measures adequately. The natures and properties of woods of these timber species should also be studied in order to identify the basic traits that make them tolerate termite and fungal attacks.

Besides, used motor oil, more effective, environment friendly and competent chrome and arsenic free preservatives such as Tanalith E or Celcure AC type wood preservatives are recommended where available in domestic markets. While selecting and applying potential wood preservatives, the service life intended for the purpose, whether short or long service life, place of use such as ground contact, above the ground, or in damped conditions; pressure and non-pressure application techniques to obtain adequate loading of the preservative and its cost have to be considered.

The development programs on industrial and construction wood production in Ethiopia, especially in Pawe and similar areas, should give priority to the naturally durable and/or treatable timbers with preservative chemicals as well as potentially valuable and fast-growing timber species such as *A. caffra*, *C. molle*, *C. macrostachys*, *C. africana*, and *S. guineense*.

Research activities involving prolonged time, other timber species, other potential, commercial preservatives, and application techniques are further recommended to fill up the knowledge gaps in timber species natural durability, preservation measures and sustained rational utilization of timbers for construction and furniture purposes in Pawe and in different agro-ecological zones of Ethiopia where biodegradation has become a crucial economic issue.

References

Adane Bitew. 2002. Wood decay basidiomycetes: Biodiversity and decay of the three indigenous tree species in Ethiopia. PhD thesis. Addis Ababa University, Addis Ababa. 142 pp.

EARO. 2001. Forestry Research Strategy. Forestry Research Sector. Ethiopian Agricultural Research Organization, Addis Ababa, 90 pp.

Bryce JM. 1967. Commercial timbers of Tanzania. Tanzania Forest Division. Utilization Section. Moshi, Tanzania.

BS (British Standard). 1975. Guide to the choice, use, and application of wood preservatives. BS: 1282. British Standard Institution, 2 Park Street, London.

Eaton RA and MDC Hale. 1993. Wood decay, pests, and protection. Chapman and Hall, London.

FAO (Food and Agricultural Organization). 1994. Wood preservation manual. Mechanical Wood Products Branch. Forest Industries Division, FAO Forestry Department. FAO forestry paper 76. International Book Distributors, Dehradum, India.

Getachew Desalegn. 2010. Treatability and effectiveness of preservatives against subterranean termites and fungi on *Juniperus procera* and *Eucalyptus deglupta* sawn timbers. Research Report No. 87. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.

Getachew Desalegn and Alemu Gezahegn. 2010. Timber properties of Eucalyptus species. Research Report No. 81. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.

Getachew Desalegn and Wubalem Tadesse. 2010. Major characteristics and potential uses of eucalyptus timber species grown in Ethiopia. *In:* Gil L, Tadesse W, E Tolosana and R López (eds). Eucalyptus Species Management, History, Status and Trends in Ethiopia. Proceedings from the Conference held in Addis Ababa. 15-17 September, 2010.

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 Sciences, 2: 189-216. Addis Ababa, Ethiopia.

Getachew Desalegn, Wubalem Tadesse, Demel Teketay, Worku Fekadu, Gemechu Kaba and Girma Taye. 2007. Performance of preservatives applied on 32 timber species against deterioration by subterranean termites and fungi at Bako, Southwestern Ethiopia. SINET 30 (2): 103-116. Addis Ababa, Ethiopia.

Gjovik LR and DI Gutzmer. 1986. Comparison of wood preservatives in stake tests (progress report). United States Department of Agriculture. Forest service, Forest Products Laboratory. Research Note FPL-02. USA, 13 pp.

Highley TL. 1995. Comparative durability of untreated wood in use above ground. Journal of International biodeterioration and biodegradation. Elsevier Science Limited. Great Britain, pp. 409-419.

Melaku Abegaz and Addis Tsehay. 1988. Wood preservation in Ethiopia. Ministry of Agriculture, Natural Resources Conservation and Development Main Department. Wood Utilization and Research Center. Addis Ababa, Ethiopia, 22 pp.

Nicholas DD (ed). 1985. Wood deterioration and its prevention by preservative treatments. Volume 1, Degradation and protection of wood. Syracuse University Press. Syracuse wood science series, 5, New York. 380 pp.

NWPC standard (Nordic Wood Preservation Council). 1971. Testing of wood preservatives. Mycological test. A field-test with stakes. NWPC standard No. 1.4.2.1/71.

Ofgaa Djirata, Bekele Jembere, Emana Getu and Seyoum Mengistou. 2007. Prevalence of termites and level of damage on major field crops and rangelands in the Manasibu District, Western Ethiopia. Ethiopian Journal of Biological Sciences, 6(2):115-128. Addis Ababa, Ethiopia.

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

SAS (Statistical Analysis Systems) Institute. 2000. Statistical software package. SAS program for windows, Course note, 35 pp.

Shrivastava MB. 1997. Wood technology. Vikas Publishing House, Pvt Ltd., New Delhi. India.180 pp.

Willeitner H and W Liese. 1992. Wood protection in tropical countries. A manual of the Know-how. Technical Cooperation of Germany (GTZ), Federal Republic of Germany, 228 pp.

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, 58 pp.

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

Wubalem Tadesse and Getachew Desalegn. 2008. Durability of five timber species against termite and fungal attack. Research Report 75. Ethiopian Institute of Agricultural Research, Addis Ababa.

Zawde Berhane and Yusuf E. 1974. Effect of different preservatives on the termite resistance of some common Ethiopian timbers. Haile Selassie I University, Materials Research and Testing Department, Addis Ababa, 19 pp.