J. Bamboo and Rattan, Vol.6, Nos. 1&2, pp. 33-39 (2007)

Durability assessment of chemically treated *Gigantochloa scortechinii* in unsterile soil laboratory burial tests

W. Razak[1,*], M. Tamizi[2], S. Othman[3] and W. S. Hashim[2]
[1]*School of International Tropical Forestry, Universiti Malaysia Sabah, 88999 Kota Kinabalu, Sabah*
[2]*Forest Research Institute Malaysia, Kuala Lumpur 52109, Malaysia*
[3]*Universiti Sains Malaysia, Penang 11800, Malaysia*

Abstract: Culms of *Gigantochloa scortechinii* belonging to two age groups, 2 and 4 years, were chemically treated with ammoniacal-copper-quaternary (ACQ), borax-boric acid (BBA) and copper-chrome-arsenate (CCA) at 1, 2, 4 and 8 per cent solution strength by soaking, vacuum impregnation and high pressure sap-displacement processes. Unsterile soil laboratory burial tests were then conducted on 2- and 4-year-old bamboo blocks. At the end of the testing period (8 weeks), the 2-year-old culms showed higher weight loss than the 4-year-old culms to attack of decay fungi. Among the treatments, the vacuum pressure treated blocks showed lower weight loss against decay fungi. The 4 per cent preservative solution strength was found to be sufficient in controlling the decay fungi.

Key words: *Gigantochloa scortechinii*, preservative treatment, soft rot fungi, preservative treatments.

INTRODUCTION

Biodeterioration in bamboo has been found to be caused by different types of organisms (Razak, 1998). The greatest damage is done by fungi and to a minor extent, by bacteria. It is virtually impossible to assess the monetary loss caused by decay of bamboo products. The preservative treatments of bamboo are intended to prevent or retard the decay and their efficacy against decay fungi is evaluated by laboratory and field trials.

Laboratory tests are designed to determine over a short period of time which of the selected preservatives, concentration and application methods are effective against representative decay fungi chosen. The essence of this part of the testing procedure is to use a repeatable, simple and quick method of assessment of soft rot in unsterile soil. The laboratory test involves exposing the bamboo blocks to soil burial for a certain period of time. The weight loss of the bamboo samples indicates the overall

* To whom correspondence should be addressed: E-mail: razyat@tm.net.my

resistance of untreated and treated culms following the established standard tests such as EN 113 (BSI, 1982) and EN 807 (BSI, 1993) to decay by various test fungi.

The unsterile soil laboratory burial method has the advantage of creating a simulated field situation in the laboratory, whereby test samples are exposed to a natural microflora that includes all types of decay fungi and bacteria. The moist soil condition enhances the activity of soft rot fungi on test samples. The present study was based on the technique used by Gray (1986), with some modification.

MATERIALS AND METHODS

Culms of *Gigantochloa scortechinii* were obtained from the managed natural bamboo stands of Forest Reserve areas in Nami, Kedah, Malaysia. Portions of culms comprising sixth, seventh and eighth internodes from 2- and 4-year-old culms were treated with ammoniacal copper quaternary (ACQ), borax and boric acid (BBA) and copper-chrome -arsenate (CCA) by soaking, vacuum pressure impregnation and high pressure sap-displacement processes at 1, 2, 4 and 8 per cent concentrations. Bamboo blocks chosen were those from the middle of sixth internode of each culm. These blocks were then converted into 10 mm x 20 mm x culm wall thickness. The total number of blocks tested were 324 and these included 2 age-groups, 3 treatments, 3 chemicals, 4 concentrations and 4 replications.

The test was made in accordance to the British Standard Institute EN 113 (BSI, 1982) and EN 807 (BSI, 1993). The test blocks were buried in unsterile forest soil. Two test blocks were placed on 150 ml air dried soil in each (375 ml capacity) glass jar, and buried with a further 100 ml soil. The assembly was moistened with water to 130 per cent of the water holding capacity (WHC) of the soil. The jars were then placed in a dark chamber for 8 weeks at 27 °C.

At the end of the 8 weeks, the samples were removed from the soil, wiped gently with a soft brush to remove the adhering soil as well as fungal hyphae. The samples were then weighed and placed in an oven at 105 ± 2 °C for 24 h to determine their moisture content and weight loss. Samples for microscopy were fixed and stored in Formalin Acetic Acid Alcohol (FAA) solution.

RESULTS

The mean weight loss from test blocks and control blocks is presented in Tables 1 and 2 respectively. Preservative retention (kg/m^3) of 2- and 4-year-old culms treated by soaking, vacuum pressure impregnation and high pressure sap-displacement processes are shown in Table 3. The results show that the weight loss experienced by the control blocks was relatively higher than that of the treated blocks. Among the different treatment methods, the bamboo treated by vacuum process showed lower weight loss

Table 1. Weight loss (%) of *G. scortechinii* culm blocks in unsterilized soil burial tests

Treatment	Preservative concentration (%)	Preservatives ACQ	BBA	CCA
Soaking				
	1	12.4 (4.13)	13.5 (2.91)*	10.8 (2.35)
2-year-old culm	2	4.9 (0.87)	5.2 (1.07)	4.0 (0.74)
	4	0.7 (0.11)	1.1 (0.21)	0.6 (0.16)
	8	0.1 (0.02)	0.1 (0.00)	0.1 (0.01)
	1	10.4 (2.68)	12.6 (2.22)	10.0 (2.08)
4-year-old culm	2	3.1 (0.92)	4.1 (0.65)	2.9 (0.71)
	4	0.3 (0.09)	0.8 (0.09)	0.3 (0.04)
	8	0.1 (0.00)	0.1 (0.00)	0.1 (0.00)
Vacuum pressure				
	1	11.1 (3.93)	12.9 (3.03)	10.4 (2.68)
	2	4.1 (1.04)	4.9 (0.68)	3.3 (0.63)
2-year-old culm	4	0.7 (0.10)	0.9 (0.13)	0.6 (0.05)
	8	0.1 (0.00)	0.1 (0.00)	0.0 (0.01)
	1	9.3 (2.85)	11.9 (1.96)	9.1 (1.68)
	2	2.9 (0.68)	3.6 (0.07)	2.8 (0.92)
4-year-old culm	4	0.3 (0.07)	0.7 (0.1)	0.2 (0.04)
	8	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)
HPSD				
	1	13.0 (2.56)	13.9 (3.03)	11.5 (1.84)
	2	5.5 (1.94)	5.8 (2.05)	5.3 (0.92)
2-year-old culm	4	1.5 (0.21)	2.0 (0.23)	0.8 (0.02)
	8	0.2 (0.02)	0.2 (0.01)	0.1 (0.00)
	1	11.2 (2.09)	12.9 (1.98)	11.1 (1.72)
	2	4.3 (0.83)	4.8 (0.16)	3.7 (0.19)
4-year-old culm	4	0.9 (0.07)	1.0 (0.12)	0.7 (0.03)
	8	0.1 (0.00)	0.1 (0.00)	0.1 (0.00)

*Standard deviations are given in parenthesis.

Table 2. Weight loss of *G. scortechinii* culm blocks in control

Control blocks	Weight loss (%)
2-year-old culm	26.9 (8.12)*
4-year-old culm	22.8 (6.83)

*Standard deviations are given in parenthesis.

Table 3. Preservative retention (kg/m³) of *G. scortechinii* culm blocks in different treatments

Chemical	Treatment	2-year-old	4-year-old
ACQ (1%)	Soaking	1.39	1.29*
	Vacuum	3.23	2.96
	High pressure sap-displacement	1.05	1.15
ACQ (2%)	Soaking	2.90	2.03
	Vacuum	6.45	4.54
	High pressure sap-displacement	2.06	1.93
ACQ (4%)	Soaking	4.59	4.46
	Vacuum	9.93	7.89
	High pressure sap-displacement	4.32	4.04
ACQ (8%)	Soaking	9.84	8.76
	Vacuum	21.38	14.75
	High pressure sap-displacement	8.44	8.31
BBA (1%)	Soaking	2.60	2.15
	Vacuum	3.22	2.62
	High pressure sap-displacement	1.27	1.16
BBA (2%)	Soaking	4.24	3.58
	Vacuum	6.30	4.41
	High pressure sap-displacement	2.18	2.15
BBA (4%)	Soaking	7.32	5.19
	Vacuum	9.36	7.65
	High pressure sap-displacement	5.30	4.78
BBA (8%)	Soaking	14.90	11.03
	Vacuum	20.05	14.07
	High pressure sap-displacement	8.99	7.56
CCA (1%)	Soaking	2.26	1.99
	Vacuum	3.73	2.86
	High pressure sap-displacement	1.20	1.08
CCA (2%)	Soaking	4.09	3.49
	Vacuum	7.74	4.93
	High pressure sap-displacement	2.50	2.31
CCA (4%)	Soaking	5.87	5.21
	Vacuum	12.15	8.46
	High pressure sap-displacement	5.14	4.93
CCA (8%)	Soaking	11.12	9.92
	Vacuum	24.64	19.62
	High pressure sap-displacement	10.91	9.46

*Mean of 6 replicates.

followed by soaking and high pressure sap-displacement. Among different chemicals used, the CCA treated bamboo blocks showed lower weight loss followed by ACQ and BBA treated blocks. These results are further supported by the analysis of variance as shown in Table 4.

DISCUSSION

The results of the soil laboratory burial test showed a very similar pattern to that of the *G. scortechinii* blocks tests in the monoculture soft rot study conducted by Othman (1993) and Razak (1998). The mean weight loss of the control blocks varied between 27.8 per cent and 31.9 per cent depending on the age of the culms. These values were relatively higher than the treated bamboo blocks, where the mean weight loss (depending on age, treatment, preservative and solution strength) varied from 0 to 19.9 per cent.

The 2-year-old culms were more susceptible to attack by decay fungi than the 4-year-old culms, even though, they contained high net dry salt retension (NDSR) of chemical. Similar observations were also made by Razak *et al.* (2005). As reported earlier, the higher preservative uptake by the 2-year-old culms did not prevent the attack by the decay fungi. The 4-year-old culms showed consistently more resistance to the decay fungi than the 2-year-old culms. According to Othman (1993) this behaviour is probably due to different chemical composition, particularly the higher lignin content, approximately 24 per cent in the 2-year-old to 28 per cent in the 4-year-old culms. Levi (1965) reported that the presence of lignin forms a barrier that inhibit decay development at the cell wall level in bamboo.

Comparison between different methods of treatment showed that blocks treated by vacuum pressure were more resistant to soft rot than those treated by soaking and the high pressure sap-displacement. CCA treated blocks showed slightly more resistance than the ACQ and BBA treated blocks at equivalent solution strength. There was significant difference between 2- and 4-year-old culms, different types of preservatives, their solution strengths and different types of treatment processes.

Table 4. Analysis of variance on the weight loss of bamboo culm blocks

S.V.	Sum of square	d.f.	Means square	F-ratio
Age	32.5376	1	32.5376	52.156*
Chemical	55.9618	2	27.9809	44.852*
Treatment	22.2811	2	11.1405	17.858*
Concentration	6039.6414	3	2013.2138	3227.063*

*Significant at $P<0.05$ level.

Bamboo blocks treated by the vacuum pressure process showed less weight loss against the decay fungi. It is assumed that this process is able to give good chemical penetration into the culm walls thus giving more resistance to decay. However, the chemical absorption and retention were also the highest in all of the bamboo blocks treated by this process. The next higher chemical absorption and retention was by the soaking process. As expected, blocks treated by high pressure sap-displacement process showed the least effectiveness against the decay fungi, but was better than the soaking method.

Analysis of the various types of preservative chemicals indicates that the weight loss was somewhat higher in the boron treated bamboo blocks even though, the chemical uptakes in them was the highest compared with CCA and ACQ. This might be due to the leachability of BBA although, in all cases, control of decay was achieved at about 2 per cent solution strength. The CCA and ACQ showed better resistance against decay fungi. This might be due to the fact that these two are fixed waterborne chemicals. As expected, the chemical solution strength played an important role in preventing the attack of decay fungi. The 4 per cent and 8 per cent solution strengths were seen to be effective in controlling the decay fungi. However, considering the cost factor, the 4 per cent solution strength should be sufficient in controlling the fungi, since the weight loss in the tested blocks was less than 2 per cent depending on the type of treatment process.

CONCLUSIONS

i) Culms of 2-year-old *G. scortechinii* were more susceptible to attack of decay fungi than the 4-year-old culms even though, these bamboos contained the highest NDSR during the chemical treatment.
ii) The vacuum pressure impregnation process was the best method of treatment of bamboo against decay fungi. This is followed by soaking and high pressure sap-displacement.
iii) The CCA and ACQ treated bamboo blocks showed good resistance against decay fungi with CCA performing slightly better than the ACQ.
iv) The 4 per cent solution strength of CCA and ACQ was found to be sufficient in controlling the decay fungi.

REFERENCES

BSI, 1982. Wood preservatives determination of toxic values against wood destroying basidiomycetes cultured on an agar medium. BS 6009 (EN 113). British Standard Institute.

BSI, 1993. Wood preservative determination of toxic effectiveness against soft-rot microfungi and other soil inhabiting micro-organism. EN 807. British Standard Institute.

Gray, S.M. 1986. Effect of soil type and moisture content on soft rot testing. International Research Group on Wood Preservation Document No. IRG/WP/2270.

Levi, J.F. 1965. The soft rot fungi: Their mode of action and significance in the degradation of wood. *Advances in Botanical Research* 2: 323-357.

Othman, S. 1993. The Development of Soft Rot Decay in Bamboo Cell Wall. Ph.D. Dissertation, University of London.

Razak, W. 1998. Effect of Selected Preservatives on the Durability of *Gigantochloa scortechinii*. Ph.D. Dissertation, University of London.

Razak, W., Mahmud, S., Janshah, M. and Awang, M.Y. 2005. Penetration class and net dry salt retention of ammoniacal copper quaternary, borax boric acid and copper chrome arsenic in 2- and 4-year-old bamboo *Gigantochloa scortechinii*. *Journal of Biological Science* 5 (4): 511-518.