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Durability Performance of *Gigantochloa scortechinii* Through Laboratory Fungal Decay Tests*

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Abstract: Durability performance of chemically treated bamboo *Gigantochloa scortechinii* were evaluated through laboratory fungal tests. Soft rot and white rot caused high weight loss to *G. scortechinii* in the monoculture decay tests. The 2 year-old *G. scortechinii* are more susceptible than the 4 year-old to the attack of soft, white and brown rot. Vacuum pressure treated blocks shows the best performance against decaying fungi. This is followed by soaking treated blocks. CCA and ACQ shows good resistance against decaying fungi with CCA performing slightly better than the ACQ. The 4% chemicals solution strength were found to be sufficient in controlling the decaying fungi. Similar results were observed in the pattern attack of soft rot in the monoculture tests.

Key words: Bamboo *Gigantochloa scortechinii*, laboratory fungal test, basidiomycete fungi, soft rot, resistance to decaying fungi, weight loss

INTRODUCTION

Bamboo deterioration are caused by various types of organisms, but the greatest damage is by fungi (Razak, 1998; Othman, 1993). Decay is by far the most serious kind of microbiological damage as it caused structural failure. It is virtually impossible to assess accurately the monetary loss caused by decay in bamboo products since records are rarely kept. The chemical treatments of bamboo are intended to prevent or to retard the decay once their performances against fungi are proven in the laboratory and field trial.

The objective of the laboratory test conducted here was to rapidly determine which of the selected chemicals, their concentration and application techniques are effective against test isolates of fungi. The selection of fungi was based on their economic importance, general resistance to chemicals, noted decay capacity and rapid growth under laboratory conditions.

The investigation comprised the exposure of bamboo blocks to fungal culture for a predetermined period of time. The weight loss of agar block samples indicates the overall resistance of untreated and treated *G. scortechinii* following the principle of established standard tests such as European Standards EN 113 and EN 807.

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MATERIALS AND METHODS

Bamboo culms were taken from the Forest Reserve areas in Nami, Kedah, Malaysia and within 7 days after harvesting, they were taken to FRIM for chemical treatments, processing and sampling. Fungal testing using agar-blocks techniques as in European Standard EN113 (Anonymous, 1982) were conducted both in UMS and FRIM. Studies were conducted from Jan. 2004 to Aug. 2005.

Agar Block Tests

The bamboo blocks used in this investigation were treated with Ammoniacal Copper Quaternary (ACQ), Boron Boric Acid (BBA) and Copper Chrome Arsenate (CCA) by soaking, vacuum pressure impregnating and high pressure sap-displacement process. Blocks chosen were those in the middle of internode 7 of each culm where the basic density was at the highest level. These blocks were converted into the dimension of 10×30 mm × culm wall thickness (between 8 to 12 mm). The total numbers of 900 test blocks were used and these include 2 age groups of bamboo, 3 types of fungi, 3 number of treatments, 3 type of chemicals, 4 level of concentrations and 4 replication.

The bamboo blocks used for weight loss were oven dried in 105± 2°C for 24 h to obtain the initial oven dry weight, while blocks used for microscopy were air dried. After recording the initial oven dried they were allowed to condition in the laboratory for 2 h before being placed in conditioning room for one week at 20°C and 65% RH respectively. The blocks were then sealed in polythene and sterilised by gamma irradiation in Co^{60} source at a dose of 2.5M rad.

Two species of wood rotting Basidiomycetes-*Coriolus versicolor* (a white rot) and *Coniophora puteana* (a brown rot) and one soft rot fungus-*Chaetomium globosum* were used in the decay test. The fungi were recommended in British Standard B.S. 838: 1961 (Anonymous, 1961).

Basidiomycete Tests (brown-rot and white-rot)

Four percent of MEA (Malt Extract Agar) was used as the medium in this investigation. The agars were autoclaved at 15 psi for 30 min and then poured in sterilized plastic petri dishes under UV light and left overnight. Each plate contained approximately 25 mL agar medium. Cultured fungi were then introduced into the petri dishes and left to grow for 7 days. After that sterilized plastic mesh was placed on top of the growing fungi before the bamboo blocks were introduced into the petri dishes and sealed. Two blocks from same treatment were used in every plate. This is to avoid effect of chemicals leaching from some blocks. The dishes were then kept in the incubation room at 22°C for 8 weeks. After incubation the blocks were cleared of surface mycelium, weighed, oven dried at 105°±2°C for 24 h and re-weighed again to enable dry weight losses due to decay to be calculated.

Soft Rot Test

Soft-rot cultures were grown using the techniques described by Gersonde and Kerner-Gang (1975) modified by Gray (1983). The pH of the medium was adjusted to 5 (using either dilute H_2SO_4 or NaOH). A 1% gelatin solution was prepared by mixing 2 g of gelatin powder with 200 mL of distilled water and together with the agar medium, the solution were autoclaved for 30 min at 15 psi and the agar poured in sterilized agar plates under UV light and left overnight. Each plate contained approximately 25 mL agar medium. *C. globosum* was then introduced into the petri dishes and left to grow for 12 days. Bamboo blocks were placed directly onto the fungal culture in the petri dishes and sealed. Two blocks were used in every plate. The dishes were then kept in the incubation room at 30°C for a period of 8 weeks. At harvesting the blocks were cleared of surface mycelium, weighed, oven dried at 105±2°C for 24 h and re-weighed again for calculation of weight losses due to decay.

RESULTS

Agar Block Tests

Mean weight loss of untreated (control) bamboo blocks were 19.6-30.6% (Table 1) in comparison to the chemicals treated 0.0-19.1% for ACQ treated blocks, 0.01-19.2% for BBA treated blocks and 0.0-18.1% for CCA treated blocks (Table 2). Within the untreated blocks the soft-rot inflicted higher weight loss to the bamboo (26.9-30.6%) compared to white-rot 23.9-27.9% and 19.6-24.5% (Table 2). In the treated blocks the soft-rot inflicted weight loss of 0.0-19.2%, white-rot inflicted weight loss of 0.1-15.5% and brown-rot inflicted weight loss of 0.0-11.0%.

Variation also were observed among the treated blocks by the bamboo age, type of treatment applied, type of chemical and concentration used and on the type of fungi introduced (Table 3).

Table 1: Weight loss of untreated bamboo blocks

	Weight loss (%)		
Untreated bamboo blocks	Brown-rot	White-rot	Soft-rot
2 year-old	24.5 (5.14)	27.9 (6.27)	30.6 (6.68)
4 year-old	19.6 (3.57)	23.9 (4.48)	26.9 (4.76)

Standard deviations are given in brackets

Table 2: Means weight loss (%) of *G. scortechinii* with *C. puteana*, *C. versicolor* and *C. globosum*

	Chemical concen-	*Coniophora puteana*			*Coriolus versicolor*			*Chaetomium globosum*		
	tration (%)	ACQ	BBA	CCA	ACQ	BBA	CCA	ACQ	BBA	CCA
Soaking										
	1	8.3 (1.12)	8.7 (1.26)	7.2 (1.19)	13.4 (1.67)	14.3 (1.78)	12.9 (1.61)	18.3 (2.79)	18.7 (2.82)	16.9 (1.91)
	2	4.4 (0.81)	5.5 (0.92)	3.1 (0.83)	7.5 (0.69)	7.6 (0.83)	6.3 (0.74)	8.9 (1.09)	9.8 (1.17)	7.3 (0.62)
2year-old	4	1.0 (0.27)	1.3 (0.29)	0.8 (0.15)	2.4 (0.42)	2.6 (0.45)	2.0 (0.39)	2.8 (0.29)	3.2 (0.34)	2.1 (0.30)
	8	0.1 (0.02)	0.3 (0.03)	0.1 (0.01)	0.8 (0.06)	0.9 (0.06)	0.7 (0.05)	0.5 (0.03)	0.9 (0.43)	0.3 (0.05)
	1	7.2 (1.55)	8.2 (1.74)	6.9 (1.51)	12.1 (1.68)	13.3 (1.71)	11.9 (1.61)	15.7 (1.72)	16.9 (2.28)	14.7 (1.75)
	2	3.6 (0.32)	5.3 (0.46)	2.4 (0.42)	6.3 (0.76)	6.3 (0.69)	6.0 (0.80)	8.8 (0.96)	9.7 (0.67)	7.1 (0.87)
4year-old	4	0.8 (0.04)	1.1 (0.06)	0.5 (0.02)	1.8 (0.29)	2.1 (0.35)	1.7 (0.25)	2.4 (0.61)	2.9 (0.54)	1.5 (0.61)
	8	0.1 (0.01)	0.1 (0.02)	0.0 (0.00)	0.8 (0.06)	0.8 (0.05)	0.5 (0.03)	0.4 (0.02)	0.8 (0.06)	0.4 (0.03)
Vacuum pressure										
	1	7.0 (1.67)	7.4 (1.59)	6.4 (1.53)	12.1 (1.61)	13.1 (1.67)	11.9 (1.57)	15.4 (1.65)	16.8 (1.70)	12.1 (1.73)
	2	3.5 (0.11)	4.9 (0.52)	2.4 (0.13)	5.9 (0.70)	6.2 (0.64)	4.9 (0.63)	7.7 (0.62)	8.3 (0.74)	6.0 (0.72)
2year-old	4	0.8 (0.04)	1.3 (0.07)	0.1 (0.00)	1.7 (0.50)	1.7 (0.41)	1.0 (0.11)	2.3 (0.42)	2.4 (0.44)	1.6 (0.35)
	8	0.0 (0.00)	0.1 (0.00)	0.0 (0.00)	0.6 (0.01)	0.7 (0.01)	0.2 (0.01)	0.5 (0.02)	0.5 (0.02)	0.1 (0.00)
	1	5.9 (0.81)	7.0 (0.94)	5.3 (0.68)	11.9 (0.53)	12.6 (0.65)	10.0 (0.49)	13.7 (1.78)	14.9 (1.81)	11.4 (1.87)
	2	3.0 (0.14)	4.1 (0.19)	2.0 (0.11)	5.3 (0.41)	6.0 (0.50)	4.1 (0.34)	7.1 (0.73)	8.1 (0.87)	5.2 (0.79)
4year-old	4	0.4 (0.01)	0.7 (0.03)	0.1 (0.00)	1.5 (0.21)	1.6 (0.22)	1.0 (0.09)	1.6 (0.41)	2.1 (0.52)	1.4 (0.30)
	8	0.0 (0.00)	0.1 (0.00)	0.0 (0.00)	0.5 (0.00)	0.6 (0.00)	0.1 (0.00)	0.2 (0.02)	0.3 (0.01)	0.0 (0.00)
High Pressure Sap-Displaced										
	1%	9.4 (1.71)	11.0 (1.86)	7.4 (1.55)	14.4 (1.76)	15.5 (1.82)	13.7 (1.74)	19.1 (2.85)	19.2 (2.86)	18.1 (2.81)
	2%	4.6 (0.40)	5.8 (0.45)	3.3 (0.18)	7.1 (0.72)	7.6 (0.95)	6.9 (0.83)	9.9 (2.72)	10.3 (2.73)	8.9 (2.62)
2year-old	4%	1.3 (0.07)	1.9 (0.08)	1.2 (0.06)	3.0 (0.52)	3.1 (0.44)	2.1 (0.34)	3.5 (0.62)	4.2 (0.78)	2.4 (0.69)
	8%	0.2 (0.00)	0.5 (0.02)	0.1 (0.00)	1.1 (0.09)	1.2 (0.07)	0.7 (0.08)	1.2 (0.30)	1.5 (0.35)	0.8 (0.04)
	1%	8.4 (1.63)	9.7 (1.82)	6.8 (1.51)	14.3 (1.76)	14.6 (1.81)	12.5 (1.62)	18.1 (2.78)	18.3 (2.81)	17.8 (2.74)
	2%	4.2 (0.34)	5.6 (0.42)	3.2 (0.31)	6.7 (0.74)	6.9 (0.64)	6.0 (0.81)	9.6 (1.63)	9.7 (1.65)	8.6 (1.54)
4year-old	4%	1.1 (0.04)	1.5 (0.07)	0.9 (0.41)	2.5 (0.44)	2.5 (0.43)	1.9 (0.53)	2.9 (0.71)	3.4 (0.74)	1.7 (0.95)
	8%	0.1 (0.00)	0.3 (0.00)	0.0 (0.00)	1.0 (0.03)	0.8 (0.02)	0.7 (0.03)	0.8 (0.03)	1.1 (0.31)	0.5 (0.09)

Standard deviations are given in brackets

Table 3: Analysis of variance on the weight loss on laboratory decay tests

SV	Sum of square	df	Mean square	F-ratio
Age of bamboo	15.2854	1	15.2854	6.616*
Treatments type	83.3550	2	41.6775	18.038*
Chemicals type	58.2000	2	29.1000	12.595*
Percentage used	4675.7370	3	1558.5790	674.567*
Fungi type	529.9921	2	264.9961	114.693*

** significant at $p<0.01$

DISCUSSION

Chaetomium globosum clearly caused the highest weight loss to the tested bamboo followed by *Coriolus versicolor* and *Coniophora puteana* both in the untreated and chemical treated blocks. Similar finding was also observed by Othman (1993), Liese (1985) and Othman and Murphy (1994). The mean weight losses of the control blocks depending on their age varies between 19.6 and 24.5% for *C. puteana*, 23.9 and 27.9% for *C. versicolor* and 26.9 and 30.6% for the *C. globosum*. The mean weight losses for treated blocks varies depending on age, treatments, chemicals and strength solution. Generally the weight loss of blocks inoculated with *C. puteana* varies between 1 to 11.0%, *C. versicolor* between 0.1 to 15.5% and *C. globosum* between 0 to 19.3%.

The results also showed that 2 year-old bamboo culms are more susceptible to the attack by the test fungi than the 4 year-old culms. These are supported by the analyses of variance table (Table 3) conducted on all the treated bamboo blocks. The analyses of variance indicated that there are significant difference ($p<0.05$) in the use of these two age groups of bamboo. The higher chemical uptake by the 2 year-old bamboo does not seem to override this effect of decay by fungi. Othman (1993) and Othman and Murphy (1994) also observed similar behaviour in their study of CCA treated bamboo between the young and mature culms of *Phyllostachys virideglaucescens* (Carr.) A.C. Riv.

Blocks treated by the vacuum pressure process showed the best performance against the decay fungi. It is assumed that this process was able to give good chemical penetration into the cell walls throughout the bamboo blocks thus giving superior performance. However, the chemical absorption and retention were also the highest in all of the bamboo blocks treated by this process. High chemical absorption and retention was also noted on blocks treated with soaking process. As expected, blocks treated with high pressure sap-displacement process showed the least effective performance against the decaying fungi. However, their performance was not bad when compared to those blocks treated by soaking process.

Analyses on the various types of chemicals used in treating the blocks indicate that the weight loss was somewhat higher in the boron treated bamboo blocks eventhough the chemical uptakes in them were the highest compared with CCA and ACQ. This might be due to the leachability properties of BBA although, in all cases, control of decay was achieved at about 2% solution strength. The CCA and ACQ showed good resistance effects against decaying fungi. This might be due to the fact that these two chemicals are fixed waterborne chemicals. The strength of chemical solution played an important role in preventing the attack of decaying fungi. The 4 and 8% solution strength were seen to be an effective in controlling the decaying fungi. However, considering the costing factor, the 4% solution strength should be sufficient in controlling the fungi since the weight loss in the tested blocks were less than 2% depending on type of treatment process.

On the process of treatment, the high-pressure sap-displacement shows higher weight loss; followed by soaking and vacuum pressure process respectively. This was supported by the analyses of variances ($p<0.05$) on treatment comparisons. This corroborated the finding by Razak (1998).

The results obtained from this study would be recommended to be use by the bamboo-based industry in planning the suitability of chemically treated bamboo for ground contact application.

CONCLUSIONS

- Soft rot were more aggressive in inflecting high weight loss to both untreated and chemically treated bamboo *G. scortechinii*, followed by the white and brown rots.

- The 2 year-old *G. scortechinii* are more susceptible than the 4 year-old to the attack of the soft, white and brown rot.
- Within the treatment techniques applied, the vacuum pressure treated blocks shows good resistance against the decaying fungi. This is followed by soaking and HPSD treated blocks.
- Within the various chemicals used the CCA and ACQ shows good resistance against decaying fungi with CCA performing slightly better than the AC.
- The 4% chemicals solution strength was found to be sufficient in controlling the decaying fungi.

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