Journal of Tropical Forest Science 1 (2): 162 -169

NATURAL DECAY RESISTANCE OF KEMPAS *(KOOMPASSIA MALACCENSIS)* WITH INCLUDED PHLOEM AGAINST ROT FUNGI: A LABORATORY EVALUATION

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Received October 1988, accepted December 1988.

WONG, A.H.H. 1988. Natural decay resistance of kempas *(Koompassia malaccensis)* with included phloem against rot fungi : a laboratory evaluation. The natural decay resistance of tissues of included phloem, heartwood and sapwood of kempas *(Koompassia malaccensis)* was assessed by a modified ASTM soil-block test. The tissues were exposed to the rot fungi *Chaetomium globosum* (soft rot), *Pycnoporus sanguineus* (white rot) or *Tyromyces palustris* (brown rot). After six weeks' incubation, there was little decay of the included phloem (average mass loss: 0.7%), slightly for heartwood (3.7%) and considerably for sapwood (23.6%), irrespective of the fungi. The greatest and lowest mass losses were of the brown and soft rot type of decay, respectively. The superior natural durability of phloem tissues suggests that the decay resistance characteristics of kempas and related timbers with included phloem when used in contact with the ground should be reconsidered.

Key words: Fungal decay resistance - included phloem - *Hevea brasiliensis* - *Koompassia malaccensis* - *Chaetomium globosum* - *Psycnoporus sanguineus* - *Tyromyces palustris.*

Introduction

The tropical hardwood kempas *(Koompassia malaccensis* Maing. ex Benth.) owes its popularity in the Malaysian timber industry to its desirable structural properties and its good treatability with wood preservatives. Increased use of this timber is anticipated in the future as other quality tropical hardwoods become less available.

Kempas is characterized by the embedment of abnormal tissue, the included (inter-xylary) phloem (Hodgson 1937, Menon 1967, Wong & Kochummen 1973). This is an inherent defect which is also present in a few other tropical timbers (Chalk & Chattaway 1937, Philipson *et al.* 1971). In kempas, such tissues are scattered over the cross section of a roundlog, sometimes in a ring or often as bands of circumferentially orientated islands which can comprise up to *ca.* 15% of the cross sectional area of mature logs. The other related species, tualang *(Koompassia excelsa* Taub.), seems to contain much more of the included phloem (Ser 1984).

The random distribution of included phloem in wood often presents problems in sawing clear faces of timber. Also, the wood normally checks in the region of such tissues during seasoning. Wood strength can thus be affected by both the included phloem (Lee & Shum 1962) and associated checks, and the latter may allow fungal invasion of the wood if exposed.

The in-ground natural durability of kempas heartwood varies between non-durable (service life: < 2 years; Foxworthy 1930, Thomas 1937, Jackson 1957) and moderately durable (2-5 years; Mohd. Dahlan & Tam 1985). The results from such field tests usually denote the destruction of wood by termites and often mask the simultaneous decay from wood-rotting fungi. In order to examine the latter, *in vitro* evaluations of the resistance of wood to fungal decay have been made, based on the post-decay wood block mass loss values. Kempas wood was subjected to decay by either whiterot, brownrot or soft rot fungi (Seehan 1973, Takahashi & Kishima 1973, Yamamoto & Hong unpublished). Such assessments could have limited significance if the possible contributory influence of included phloem on the natural decay resistance of kempas used in contact with the ground is not considered. This paper reports on the natural decay resistance of kempas stemwood and the included phloem against rot fungi. For comparison of relative resistance, rubberwood *(Hevea brasiliensis)*, a non-durable species (Ali *et al.* 1980, Hong 1982) was also included in this study.

Materials and methods

Selection of wood material

Wood stakes of kempas, from a single tree of unknown origin, with included phloem and/or sapwood were cut into separate test blocks containing heartwood, sapwood and included phloem of dimensions 5.0 (radial) x 15.0 (tangential) x 10.0 (longitudinal) *mm*. Both heartwood and sapwood blocks were sampled *ca.* 20 *mm* above the zones of phloem tissues and sapwood-heartwood boundary respectively (Figure 1). Rubberwood stakes, also from one tree (the species does not appear to form heartwood), were randomly converted into wood blocks of similar dimensions. All the blocks were weighed and sterilized by gamma irradiation prior to the natural decay resistance test.

Natural decay resistance test

Twelve test blocks of each of the four types of stem tissues were subjected to decay by *T. palustris* (Berk. et Curt)Murr. [brown rot JIS[1] Strain No .0507], *P. sanguineus* (L. ex Fr.) Murr. [white rot MI[2] 032] and *C. globosum* Kunze ex Stundel [soft rot MI 089] according to the general procedure of ASTM D2017 (ASTM 1984) with a few modifications, example, basal semisynthetic medium of Lilly and Barnett (1951) was the nutrient source for the test fungi. Decay chambers, consisting of 375 *ml* soda-glass screw-cap jars contained a mixture of

[1] JIS Japanese Industrial Standard culture accession number
[2] MI Forest Research Institute of Malaysia culture accession number

top soil and sand (1:1 v/v) to 100 *ml*. Each jar held two randomly chosen blocks.
After incubation at 25° *C* and >80% relative humidity for six weeks, the loss in mass of test blocks (in % w/w) was compared to the loss in mass of control blocks (i.e. without fungi) to provide a measure of the natural decay resistance of the treated samples.

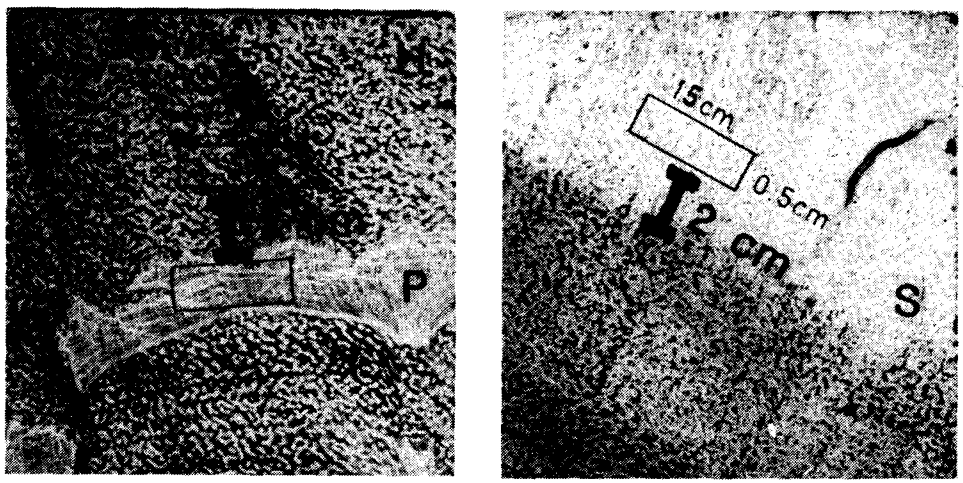

Figure 1. Sampling positions of included phloem (P), heartwood (H) and sapwood (S) of dimensions 15 x 5 *mm* on cross-sections of kempas *(K. malaccensis)* stakes

Analysis of data

Data (total of 144 observations among fungus-stem tissue combinations) were tested for the basic assumptions of the analysis of variance (ANOVA) by least squares estimation. Mean values between treatment combinations were compared at the 95% probability level by least significant differences (LSD).

Results

The ANOVA results (Table 1) showed that both main effects (stem tissue and decay fungus) were important determinants of percentage mass losses of test blocks. The first order interactions were significant (P = 0.05), suggesting that there were exceptions in the various trends. Therefore multiple comparisons of mean percentage mass losses of replicate blocks were made between individual stem tissue-decay fungus combinations using a calculated LSD value (Table 2) from the ANOVA. The low within-tree variations in tissue decay resistance (Table 2) is expected. Such variations would however be considerable if a number of tree samples are included (Da Costa *et al.* 1962, Rudman *et al.* 1967).

Table 1. Analysis of variance of wood block mass losses between four stem tissues and three decay fungi

Sources of variation	Degrees of freedom	Mean square	Variance ratio[1]
Stem tissue	3	9714	109.6
Decay fungus	2	3894	43.9
Interaction	6	884	10.0
Residual	132	89	-
Total	143	377	-

[1]All F values are significant (P = 0.05).

Table 2. Variation in natural decay resistance of kempas *(K. malaccensis)* with included phloem, and rubberwood

	Mass loss of Stem tissue (%)			
	Koompassia malaccensis			*Hevea brasiliensis*
Decay fungus	Included Phloem	Heartwood	Sapwood	
Chaetomium globosum (soft rot fungus)	0.02 a (0.06)	0.5 ab (0.12)	10.9 c (5.01)	15.4 cd (2.99)
Pycnoporus sanguineus (white rot fungus)	0.7 ab (0.48)	1.9 ab (0.33)	20.5 d (0.95)	40.6 e (4.49)
Tyromyces palustris (Brown rot fungus)	1.3 ab (0.22)	8.7 bc (1.37)	39.4 e (2.63)	49.6 f (4.93)
Mean	0.7 (0.19)	3.7 (0.76)	23.6 (2.73)	35.2 (3.41)

[1] Decay resistance assessed as a percentage mass loss in test blocks incubated for six weeks with test fungi in a modified soil-jar test.

[2] Statistical comparison of row means is not appropriate since interactions occur between the factors (see Table 1). Least significant difference (P=0.05) for comparisons between isolated decay organism / stem tissue cell means - 8.6 (Row means excluded). Cell mean values based on 12 replications (36 for row means). Cell means sharing the same letter (a, b, c, d, e, f) do not differ significantly.

[3] Values in parentheses - standard errors of cell means.

Stem tissue effect

Variations in block mass losses between three tissues of kempas and rubberwood were relatively high, particularly the variations between included phloem and the other stem tissues (Table 2). Rubberwood was the least decay resistant (mean % mass loss: 35.2%) followed by kempas sapwood (23.6%), kempas heartwood (3.7%) and included phloem (<1%).

Decay fungus effect

Mean percentage block mass losses between fungal species showed distinct differences in the wood-decaying abilities of the three fungi, *C. globosum* (soft rot type) was the least active and *T. palustris* (brown rot) the most. The interaction term indicated that between fungus variations were largely non-significant for the two most decay resistant stem tissues, but were significant with the rubberwood and kempas sapwood (Table 2).

Discussion

The very low average mass losses of the included phloem are opposed to the popular opinion that such tissues originating from and apparently quite similar in anatomy to bark tissues (Saiki & Ohnishi 1976), are decay susceptible. The general description of natural decay resistance (from block mass losses) of the wood tissues are suitable for comparing tissue mass losses only within the present decay system designed. The modified ASTM procedure used in this study expectedly differs from standard tests and duration of decay adopted by others. This is reflected by the resultant percentage mass losses. For example, Takahashi and Kishima (1973) using the sand-block test [JIS Z 2119-63 (JIS 1969)] obtained relatively greater mass losses from white rotted [*C. versicolor* (L. ex Fr.) Quel (Strain No. 1030)] and soft rotted [*C. globosum* (No.0590)] kempas heartwood averaging 17.8 and 13.9% respectively after eight weeks' decay. Recently Yamamoto and Hong (unpublished) using a modified JIS Z 2119 method and *C. versicolor*, recorded 10 and 42% mass loss for kempas heartwood and rubberwood respectively. An agar-block test on kempas heartwood decayed for 16 weeks (Seehan 1973) showed a greater decay due to the white rot *Polystictus versicolor* L. ex Fr. (= *C. versicolor*) (17.3%) than to the brown rot fungus *Daedalea quercina* L. ex Fr. (7.2%), with lower mass losses for the soft rot species *C. globosum* (3.8%) and *Paecilomyces* sp. (<1 %). Nevertheless, the results of the present study (Table 2) generally agree with the relative order of natural decay resistance between stem tissues and between the types of decay organisms (white or brown rot vs. soft rot).

To fully understand the natural decay resistance of timbers, it would be necessary for assessments of resistance to fungal decay of stem tissues to be carried out using a wide range of species of wood-rotting fungi (*e.g.* Da Costa 1979, Wong *et al.* 1983) and soft rot fungi (*e.g.* Takahashi & Nishimoto 1973, Greaves 1979).

This might more clearly represent the combined decay activities of various soil fungi which can attack wood exposed to the ground where a normally mixed microbial population of the mycoflora are considered to play a role in the colonization and decay of a wood substrate (Levy 1968, Greaves 1972). Similarly, variation in natural decay resistance within a tree cannot be ignored since included phloem is permitted in the timber species graded according to the Malaysian Grading Rules (MGR 1984). Indeed it might be expected that the decay resistant included phloem present in variable proportions in the heartwood of kempas would improve its decay resistance, and although such tissues resist impregnation of wood preservatives (M.K. Tam personal communication), this feature would be of limited importance in the overall treated durability of the timber.

The extent to which the decay resistance of phloem tissues could affect overall strength properties of kempas is not known; the strength of the wood material is also crucial for various in-ground vertical structural uses, example timber foundation piles or overhead powerline transmission poles. Whilst the permissible levels of included phloem have been clearly defined by the Malaysian Grading Rules (MGR 1984), there is little information on the influence of the embedded tissues on wood strength. Presumably, frequent splits associated with the included phloem in seasoned kempas could further complicate the strength and/or natural decay resistance relationships of the timber. A preliminary analysis of tualang *(K. excelsa)*, a species also with included phloem, revealed a 13% reduction in average compression parallel-to-the-grain (Lee & Shum 1962). Further studies to ascertain strength properties of woods with included phloem are necessary.

Initial studies on properties of the included phloem and normal stem tissues of kempas and rubberwood have shown that susceptibility to decay might be explained by the relatively high content of nutrients in the less durable stem tissues (Wong unpublished) which accords with an earlier work on sapwood of *Pinus radiata* D. Don (Wong & Wilkes 1988, 1989). Alternatively, it is possible that extractive levels, tissue density or cell wall lignification are causally related to the high natural decay resistance of included phloem of kempas (Wong unpublished).

Acknowledgements

I wish to thank Dahlan Hj. Mohd. (Nuclear Energy Unit, Prime Minister's Department, Bangi, Selangor) for the irradiation sterilization of the wood samples, M.K. Tam (Forest Research Institute Malaysia) for discussions on the treatability of kempas, and J. D. Thornton (CSIRO Division of Forestry and Forest Products) for his helpful comments on a previous draft.

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