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A Need for Modifying the Soil-Block Method for Testing Natural Resistance to White Rot?

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1. Introduction

In testing decay resistance by the agar-block method, large differences have been reported between the amounts of decay (measured by weight loss) by brown- and white-rot fungi in South and Central American handwoods [T.C SCHEFFER and C.G. DUNCAN, 1947]. With the agar-block method, in which the test specimen is supported on glass rods resting on inoculated malt-agar substrate, the white-rot fungi generally produced markedly more decay than did the brown-rot fungi T. C. SCHEFFER and C. G. DUNCAN observed. Therefore, it was concluded white rotters rather than brown rotters should in laboratory tests give results more indicative of the relative decay resistance of hardwoods in service situations highly favorable for decay.

In recent tests of 34 tropical handwoods (mostly from Peru) by T. C. SCHEFFER and J. W. KULP at the Forest Products Laboratory, the results were the reverse of those of T. C. SCHEFFER and C. C. DUNCAN by the agar-block method. Polyporus versicolor, the standard fungus for appraising white rot in hardwoods when comparing with brown rot, was

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deficient in producing decay. Testing was by the standard ASTM (American Society for Testing and Materials) soil-block method D 2017 in which the test specimen is placed on a small block of a nondurable wood (feeder block) that rests on an inoculated substrate of damp soil. In almost every species of hardwood tested, the brown-rot fungi, Poria monticola (Madison 698) and *Lenzites trabea* (Madison 617), produced more decay than did *P. versicolor.* The differences were particularly pronounced with *P. monticola.* Because these differences were the reverse of those obtained earlier with the agar-block method, two questions arose concerning the soil-block method. Was the white-rot test by the standard sail-block method sufficiently severe to provide results indicative of the relative decay resistance of different wood species to be expected in service? Might severity be limited by some factor of the culture environment that was less favorable in the soil-block method than in the agar-block method? The objective here was to find answers through comparative testing.

The possibility that the standard soil-block method might not allow adequate wetting of test woods for optimum fungus growth was considered first as a factor that limited decay by the white rotter. Generally, higher wood moisture contents were developed in agar-block than in soil-block testing. The *P. versicolor* isolate had recently been passed through wood; hence loss of degradative capacity by the fungus apparently was not the limiting factor.

Two preliminary trials were then conducted to determine if the severity of white rot could be increased in the soil-block test by a simple modification or a substitution of the wood feeder block to favor increased moisture movement into the test specimen.

2. Preliminary Trials of Modified Methods

To increase the movement of moisture into specimens in soil-block testing of hardwoods to increase severity of decay, two techniques were considered. (1) Adding water directly to the specimen or (2) modifying the feeder component to allow the fungus itself to transport more water into the specimen. The second technique was used because it could be performed easily and would require less change from the standard test than would the first technique.

In the first of the two preliminary trials, selected species of tropical hardwoods in which brown rot had significantly exceeded white rot by the standard soil-block method were again tested but by modifications of the standard test *Poria monticola* and *Polyporus versicolor* were the assay fungi, and sweetgum (standard and with modifications) or filter paper were used as the feeders on the soil. The duration of the tests was 6 weeks.

The test method, the feeder, and the modifications included the following:

1. Standard; sweetgum feeder block, 0.3 by 2.9 by 4.1 cm ($^1/_8$ by 1-$^1/_8$ by 1-$^5/_8$ inch), the long axis in the grain direction.
2. Modified standard; thinner sweetgum feeder block, 0.15 cm ($^1/_{16}$ inch).
3. Modified standard; sweetgum, short axis in the grain direction to expose a large cross-sectional area to the soil.
4. Modified; filter-paper strip (Whatman No. I), cut the same size as the standard wood feeder.

Slightly more white rot occurred in specimens on the thin wood feeder blocks and on the feeder blocks with large crass section than did on the standard feeder block. Generally, the largest increases were obtained on specimens with the filter-paper feeder strip; in some woods the difference was considerable.

Despite the increase in white rot by using a filter-paper feeder, brown rot still exceeded white rot in most of the woods. Moreover, P. versicolor growth while getting established in the culture bottles was less on the filter-paper feeder than on the wood feeder. This was interpreted as evidence that the filter paper was deficient nutritionally. The (importance of the wood feeder in providing nutrients to the decay fungus in the soil-block test has been demonstrated by C. G. DUNCAN (1953). She found that some wood destroyers grew poorly-if they grew - in the soil of the culture bottle when the wood feeder was absent, but with the wood feeder these fungi could rapidly establish themselves in the soil. Since the filter-paper feeder did not have the nutritive value of the wood feeder, a second trial was undertaken to determine whether the deficiency could be overcome by supplementing the soil with nutrients, and if so, whether this would further increase the white rot.

Therefore, in the second trial, sail was brought to its desired water-holding capacity by adding water containing 0.23 % malt extract based on the ovendry weight of the soil. This supplementary nutrition improved initial growth of *P. versicolor* on the filter-paper feeder, but the growth still appeared to be less than that in the bottles with a wood feeder. It was encouraging, however, that the white rot was greater in the specimens on filter paper over supplemented soil than on unsupplemented soil. The malt-extract supplement did not similarly increase the white rot of specimens on a wood feeder, and the brown rot was not significantly increased by any of these modifications of the standard soil-block method.

It was concluded from these two trials that for evaluating the resistance of hardwoods to brown rot, the standard ASTM soil-block method provides conditions for decay that are close to optimum. But for evaluating the resistance of hardwoods to white rot, conditions for decay can be brought much nearer to an optimum by using a filter-paper rather than a wood feeder and by adding malt extract to the soil To confirm the validity of these conclusions, a comprehensive test was conducted on the 34 tropical hardwoods.

3. Resistance of 34 Hardwoods by Standard and Modified Soil-Block Methods

3.1 General Procedure

Resistance to white rot, by *Polyporus versicolor,* was determined both by the standard soil-block method and by the modified soil-block method in which filter paper was substituted for the wood feeder block and the soil amended with malt extract. Resistance to brown rot was determined only by the standard soil-block method, with *Poria monticola* as the fungus.

All test specimens were of standard dimensions: 2.6 by 2.6 by 0.9 cm [1 by 1 by $^3/_8$ inch (grain direction)]. Percent weight loss, the measure of decay, was calculated from the conditioned air-dry weights before and after exposure to the decay fungus.

Conforming to ASTM procedure D 2017, reference blocks of sweetgum sapwood, of the same dimensions as the test blocks, were subjected to decay in the same manner and at the same time as the test blocks. When approximately 60% weight loss was reached in the reference blocks, the test was terminated.

3.2 Decay in Sweetgum Reference Blocks

The rates of decay in the reference blocks strikingly showed that a marked increase in intensity of white rot by *P. versicolor* can be obtained in a relatively nonresistant wood by using the modified method. The progress of brown rot and white rot in the sweetgum is illustrated in Fig. 1. With the filter-paper feeder, white rot progressed linearly to cause a weight loss of about 60 % in 10 weeks and of 90 % in 16 weeks. With the standard wood feeder, the white rot also proceeded linearly, but at little more than half the rate of the rot of specimens on the paper feeder.

The finial moisture content (based on ovendry weight) of the sweetgum blocks subjected to white rot on filter paper was 120% and that of the blocks on the wood feeder was 40%. This marked difference supports the view that the standard wood feeder does not permit adequate water transport by white-rot fungi for optimum decay Intensity.

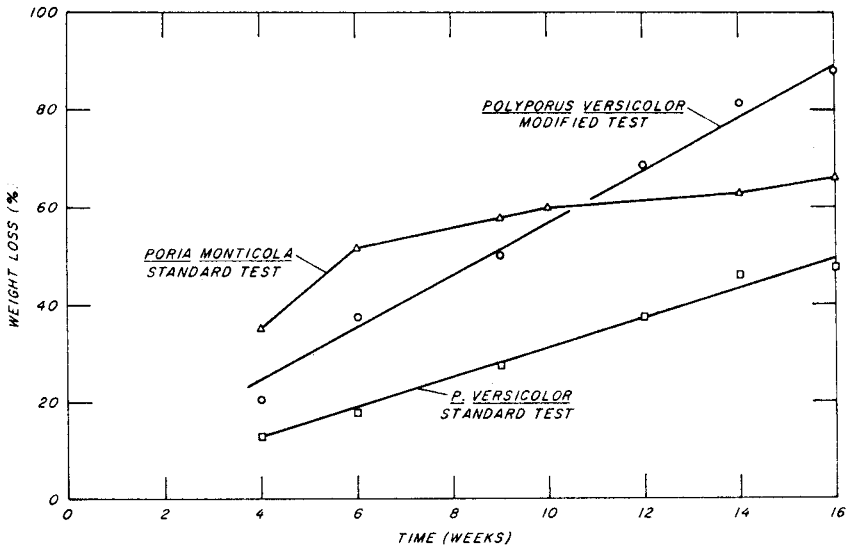

Fig. 1. Relationship of weight loss in sweetgum by *Poria monticola* (brown rot) and *Polyporus versicolor* (white rot) to time. (Filter-paper feeder was substituted for wood feeder and soil amended with malt extract in modified soil-block test.)

Brown rot in the sweetgum blocks on the wood feeder was at first more rapid than was the white rot on the filter-paper feeder, but it leveled off and at about 10 weeks the weight loss by both brown and white rot was the same - 60 %. At 16 weeks, the weight loss produced by the brown-rot fungus was almost 65 %; the final moisture content of the sweetgum blocks was 70 %.

The exceedingly rapid decline in the rate of brown rot when 60 % weight loss was approached reflects the inability of brown-rot fungi to utilize more than the carbohydrate component of the wood - which commonly amounts to about 70 %. White-rot fungi, in contrast, metabolize both the carbohydrate and the lignin portions of wood; therefore decomposition can continue without retardation.

3.3 Decay in 34 Tropical Hardwoods

The tropical hardwoods subjected to brown rot by the standard method and to white rot by the modified soil-block method were removed at the end of 10 weeks when 60 % weight loss was attained in the sweetgum reference blocks. Specimens subjected to white rot by the standard method were held for the entire test period of 16 weeks because a 60 % weight loss was not attained in the corresponding reference blocks.

Tab. 1 Weight losses in 34 hardwoods caused by white rot in the standard and the modified soil-block tests and by brown rot in the standard test

Wood species	Weight loss[a)] %		
	White rot (*Polyporus versicolor*)		Brown rot (*Poria monticola*)
	Standard soil-block[b)]	Modified soil-block[c)]	Standard soil-block[b)]
Alseis peruviana Standl.	18	20	40
Aspidosperma cylindrocarpon Muell.-Arg.	12	4	8
A. macrocarpon Mart.	0	0	1
Batesia floribunda Spruce ex. Benth.	5	9	12
Calycophyllum spruceanum (Benth.) Hook. f.	8	29	17
Caryocar coccineum Pilger	9	9	0
Cedrela odorata L.	12	12	43
Cedrelinga catenaeformis Ducke	15	23	36
Chimarrhis hookerii Schum.	29	25	43
Diplotropsis martiusii Benth.	1	0	0
Dipteryx alata (Vog.) Traub.	0	0	0
Eschweilera timbuchensis Knuth	24	40	37
Gilbertiodendron preussii (Harms) J. Leonard	26	20	29
Guatteria chlorantha Diels	36	58	48
Guazuma crinita Mart.	48	68	43
Hirtella triandra Swartz	33	33	36
Humiriastrum excelsum (Ducke) Cuatr.	18	14	27
Hymenea oblongifolia Huber	7	8	17
Inga alba (Sw.) Willd.	30	36	44
Ladenbergia latifolia L. Wms.	17	27	18
Macrosamanea pedicellaris (DC.) Kleinh.	20	37	53
Micropholis venulosa (Mart. and Eichl.) Pierre	35	26	25
Nectandra pichurim (H. B. K.) Mez	32	41	47
Nectandra (not determined)	26	28	46
Ouratea (not determined)	22	39	39
Schizolobium amazonicum Huber	40	64	59
Sclerolobium micranthum L. Wms.	12	27	18
S. setiferum Ducke	42	45	47
Symphonia globulifera L. f.	11	18	28
Tarrietia utilis Spr.	49	54	50
Terminalia amazonia (Gmel.) Exell.	11	8	18
Tetroberlinia tubmaniana J. Leonard	38	54	47
Trattinickia lawrancei Standl.	54	61	58
Ziziphus cinnamomum Tr. and Pl.	1	0	0

a) Average of three replications.

b) ASTM Standard D-2017. Testing with *P. monticola* was terminated at 10 weeks, when weight losses in reference blocks of sweetgum sapwood reached 60 %. The prescribed 60 % weight loss was not reached in the standard test with *P. versicolor*, consequently this test was continued for 16 weeks.

c) Modification of ASTM Standard D-2017, consisting of the substitution of a filter-paper feeder for the usual wood-feeder block and the addition to the soil of a nutrient supplement of malt extract. The duration of this test, dictated by a 60 % weight loss in the reference blocks, was also 10 weeks.

Table 1 shows the average weight losses in the 34 hardwoods. In twenty-one, or 62%, of the species, weight losses by white rot were greater for specimens on the filter-paper feeder than in those on the standard wood feeder even though the test time using the paper feeder was 6 weeks shorter. In these cases the median increase in weight loss over the corresponding loss on the wood feeder was about 40 percent. In five wood species the weight loss from white rot was the same by both methods, and in eight species it was less by the modified method than by the standard method. The lower weight losses, however, averaged only about 4 percentage points less than those by the standard test.

Results obtained with the standard and the modified soil-block methods can also be examined for the change in class of decay resistance affected by the modified procedure. Classes of resistance delimited by weight loss in test, as suggested in the ASTM standard procedure D 2107, are the following:

Decay resistance class	Average weight loss (%)
Very resistant (VR)	0 - 10
Resistant (R)	11 - 24
Moderately resistant (MR)	25 - 44
Nonresistant (NR)	45 +

In these classifications, 10 wood species moved to a less resistant class (one, VR to R, five R to MR, and four, MR to NR) when assayed by the modified soil-block method, and three species moved to a higher resistance class The three species that moved to a higher resistance class did so despite very small changes in weight loss, which averaged only 6 percentage points This is attributed to the losses in these species being very close to their class boundaries

The moisture content of 13 of the species, covering the range of the decay-resistance classes, was determined at the end of the test (Table 2). The object was to further confirm that modification of the soil-block method by using a filter-paper feeder and supplementary nutrients had resulted in better wetting of the test blocks subjected to white rot. Each specimen subjected to white rot in the modified method had a higher moisture content at the end of the test than the corresponding specimen subjected to white rot in the standard method. The increases ranged from 13% to more than 100%, and the median increase was 47 %.

Tab. 2. Moisture content of 13 hardwoods exposed to white rot *(Polyporus versicolor)* in standard and modified[a] soil-block tests and brown rot *(Poria monticola)* in standard soil-block test

Wood species	Moisture content %		
	Standard soil-block test, white rot[b]	Modified soil-block test, white rot[c]	Standard soil-block test, brown rot[c]
Alseis peruviana	40	59	63
Cedrelinga catenaeformis	39	47	68
Eschweilera timbuchensis	40	59	63
Gilbertiodendron preussii	44	54	71
Humiriastrum excelsum	36	42	47
Hymenea oblongifolia	32	65	48
Inga alba	43	76	62
Macrosamanea pedicellaris	66	104	83
Guatteria chlorantha	60	79	79
Schizolobium amazonicum	57	188	101
Symphonia globulifera	38	43	60
Tarrietia utilis	54	62	79
Tetroberlinia tubmaniana	58	141	79

a) Test modified by using a filter-paper feeder and adding a nutrient supplement of malt agar.
b) Test woods removed after 16 weeks.
c) Test woods removed after 10 weeks.

Test blocks subjected to brown rot were also relatively high in moisture content, suggesting that a brown-rot fungus such as *P. monticola* has no trouble transporting water from the soil and through a wood feeder to the test block in optimum quantities for decay.

4. Comparison of Brown Rot by the Agar-Block and Standard Soil-Block Methods

Although the white rot generally was greatly increased by modifying the standard method, the amount of white rot still did not predominantly surpass that of the brown rot (Table 1) as it had in the earlier agar-block tests of T. C. SCHEFFER and C. G. DUNCAN (1947). The brown-rot fungus was the most 'destructive fungus in 18 (53 %) of the species. It appeared, therefore, that the inferiority of the brown rot in earlier tests might have been due more to less favorable culture conditions for the brown-rot fungi than to an intrinsic greater capacity of the white rotters to decay the particular hardwoods used.

The possibility that the agar-block tests might not have provided appropriate conditions for representative attack by the brown-rot fungi was investigated. Comparisons were made between weight losses with the agar-block and the standard soil-block method by the brown rotter in 10 of the hardwoods.

Tab. 3. Weight losses caused by brown rot in 10 hardwoods during 6-week or 16- and 10-week testing by the agar-block and standard soil-block methods

Wood species	Test method[a]	Duration of test Weeks	Weight loss in test blocks % [Brown rot (*Poria monticola*)]
Alseis peruviana	A	6	3
	S	6	15
Cedrela odorata	A	6	0
	S	6	21
Calycophyllum spruceanum	A	6	0
	S	6	7
Gilbertiodendron preussii	A	6	0
	S	6	8
Ladenbergia latifolia	A	16	0
	S	10	18
Macrosamanea pedicellaris	A	16	45
	S	10	48
Nectandra (not determined)	A	16	8
	S	10	46
Ouratea (not determined)	A	16	12
	S	10	38
Tarrietia utilis	A	6	1
	S	6	26
Tetroberlinia tubmaniana	A	6	0
	S	6	27

a) A = agar-block, S = soil-block.

The comparative amounts of decay (Table 3) bear out the view that the agar-block conditions tend to be less suitable than those of the standard soil-block for developing brown rot in some hardwood species by a fungus such as *Poria monticola.* When tested over agar, 9 of the 10 woods were only slightly decayed, but over sail with the standard wood feeder the less resistant woods were substantially decayed.

5. Summary and Conclusions

Intensity of white rot by Polyporus versicolor was greatly increased in sweetgum and in a number of tropical hardwoods by substituting filter paper for the wood feeder block and by amending the soil with malt in the standard ASTM soil-block test for natural decay resistance. These modifications did not increase the rate of brown rot by Poria monticola.

Moisture determinations indicated that better wetting of the test blocks was obtained with the filter-paper feeder than with the standard wood feeder; this probably accounted for the increased white rot.

In the majority of the wood species the increases in white rot brought about by the filter paper and malt modification of the soil-block method did not result in decay greeter than that by the brown-rot fungus, Poria monticola. This result is contrary to that of earlier evaluations of decay resistance in hardwoods; in the earlier evaluations by the agar-block test method, the rot by white-rot fungi usually was considerably greater than that by the brown-rot fungi. The present experiments indicate that the superiority of white rot in the agar-block testing was due not to an intrinsically greater ability of the white rotter to attack hardwoods but, rather, to less favorable conditions in the agar-block method for brown rot than for white rot.

Differences in order of relative susceptibility to decay by Polyporus versicolor and by Poria monticola were large among some of the tropical woods; consequently the use of both fungi—or species comparable physiologically - is warranted for appraising the natural resistance of hardwoods. For soil-block assaying, the standard method appears well suited for appraising the resistance of hardwoods to brown rot and the modified method for appraising white rot. With either method, hardwoods in the lowest level of decay res:-stance may be expected to show a weight loss of 60% in 10 to 12 weeks. Because of the insufficient wetting of the test specimen when using a white-rot fungus such as *P. versicolor,* the standard soil-block method does not appear as suitable as the modified soil-block test for evaluating the resistance of hardwoods to white rot.

Zusammenfassung

Ist für die Prüfung der natürlichen Widerstandsfähigkeit gegen Weißfäule das Erde-Klötzchen-Verfahren zu ändern?

In Versuchsreihen erwies sich das genormte ASTM-Erde-Klötzchen-Verfahren zur Bestimmung der natürlichen Widerstandsfähigkeit von Laubhölzern gegen Braunfäule-Erreger als gut geeignet, aber als nicht so gut zur Bestimmung der Widerstandsfähigkeit von Laubhölzern gegen Weißfäule-Erreger.

Durch zwei Änderungen - Ersatz der Holzunterlage durch eine Filtrierpapier-Lage, die ein besseres Feuchthalten der Klötzchen ermöglichte, und Verbesserung der Erde mit Malzextrakt - wurde der Abbau durch den Weißfäulepilz *Polyporus versicolor* in Sweetgum (*Liquidambar styraciflua*) und einer Anzahl tropischer Laubhölzer stark erhöht. Die Änderungen erhöhten jedoch nicht den Abbau durch den Braunfäulepilz *Poria monticola.* Die in früheren Prüfungen der Pilzwiderstandsfähigkeit von Laubhölzern beobachtete Überlegenheit der Weißfäule gegenüber der Braunfäule wurde auf die beim Agar-Klötzchen-Verfahren für Braunfäule ungünstigeren Bedingungen als fur Weißfäule turückgeführt.

Résumé

Est-il nécessaire de modifier la méthode des blocs déposés sur le sol pour évaluer la résistance naturelle à la pour riture blanche?

Dans une série d'essais, la méthode normalisée ASTM des blocs déposés sur le sol (ASTM soil-block method) s'est révêlée très bien adaptée à l'évaluation de la résistance naturelle des bois feuillus contre la pourriture brune. Deux modifications substituant un papier filtre nutritif a la place du bois pour permettre une meilleure humidification de l'échantillon d'essai et améliorant le sol à l'aide d'extrait de malt ont permis un accroissement de la pourriture blanche du *Polyporus versicolor* dans le copalme (*Liquidambar styraciflua* L.) et dans de nombreux bois feuillus tropicaux. Ces modifications n'ont pas accéléré la pourriture brune provoquée par le *Poria monticola.* La predominance de la pourriture blanche par rapport à la pourriture brune dans les premieres evaluations de resistance des bois feuillus a été attribuée à des conditions moins favorables à la pourriture brune qu'à la pourriture blanche dans la méthodes des blocs déposé sur la gélose.

Resumen

Habrá que modificar el metodo de cubitos depositados sobre tierra (ASTM soil-block method) destinado a la determinación de la resistencia natural a la pudrición blanca?

En diversas series de experimentos, el metodo ASTM, standard, de cubitos depositados sobre tierra (ASTM soil-block method) demostró ser apto para la determinación de la resistencia natural de la madera de fronda a los agentes de la pudrición parda; menos apto, empero, para la determinación de la resistencia de tal madera a los agentes de la pudrición blanca. Mediante dos modificaciones. - sustituyendo el basamento de madera por una capa de papel-filtro, lo cual permitió un mejor humedecimiento de los cubitos, y mejorando la tierra mediante extracto de malta —, se aumentó considerablemente la degradación causada por el hongo de pudrición blanca, el *Polyporus versicolor,* en ,,Sweetgum" (*Liquidambar styraciflua*), así como en algunas maderas de fronda tropicales. No obstante, dichas modificaciones no produjeron incremento alguno en la degradación causada por el hongo de pudricion parda, *Poria monticola.* La superioridad de la pudricion blanca sobre la parda, observada en anteriores esperimentos sobre la resistencia de la madera de fronda a los hongos, fue atribuída a condiciones menos favorables para el desarrollo de la pudrición parda, comparado con la pudricion blanca. en el procedimiento de los cubitos depositados sobre agar.

Literature

American Society for Testing and Materials: ASTM D 2017. Standard method for accelerated laboratory test of natural decay resistance of woods. 1963.

DUNCAN, C. G.: Soil-block and agar-block techniques for evaluation of oil-type preservatives: creosote, copper napthenate, and pentachlorophenol. Forest Path. Spec. Rel. No. 37. 1953. 39 p.

SCHEFFER, T. C., and DUNCAN, C. G.: The decay resistance of certain Central American and Ecuadorian woods. Tropical Woods 92 (1947). 1 - 24.

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