Influence of Various Initial Moisture Contents on Decay of Sitka Spruce and Sweetgum Sapwood by Polyporus versicolor in the Soil-Block Test

Charles A. Peterson and Ellis B. Cowling

Former Graduate Student and Assistant Professor, Yale University School of Forestry, New Haven, Connecticut. Present addresses: Lovelace Clinic, Albuquerque, New Mexico 87108, and Department of Plant Pathology, North Carolina State University, Raleigh, North Carolina 27607, respectively.

The authors are indebted to Edson Setliff, who developed and kindly provided the data on changes in moisture content in noninoculated spruce wafers.

Accepted for publication 18 August 1972.

ABSTRACT

Thin wafers of Sitka spruce and sweetgum wood were adjusted to moisture contents of 6, 40, 45, 50, 60, 75, and 116 (spruce) or 122% (sweetgum) and then incubated with *Polyporus versicolor* in ASTM Standard soil-block chambers for 4 and 8 weeks. Initial moisture content had no effect on rate of decay. Sitka spruce proved highly resistant to decay by *P. vesicolor*; sweetgum, highly susceptible. Moisture contents of test wafers decreased substantially after 4 weeks, indicating that the atmosphere within the decay chambers was unsaturated. Increases in moisture content above the fiber saturation point apparently resulted from water of metabolism, and water moved into the test wafers through invading fungus mycelium.

Phytopathology 63:235-237

Additional key words: white rot, decay resistance.

Decay of wood generally is inhibited when its moisture content is below its fiber saturation point or so high that lack of oxygen probably prevents respiration by wood-destroying fungi (4, 5). Optimum moisture contents are between these extremes (2).

In an earlier experiment, Sitka spruce wood was shown in soil-block tests to be exceptionally resistant to decay by *Polyporus versicolor* (L.) ex Fr., a typical white-rot fungus (3). This decay resistance was shown not to be due to inhibitory extractable constituents of the wood, but was an attribute of the structural materials of the wood cell walls, possibly resulting from the nature of the interrelationship between the carbohydrates and lignin of the wood. At that time, no evidence was available to suggest that the moisture content of the test wafers might have limited the capacity of *P. versicolor* to cause decay under the test conditions. This possibility was brought to our attention by the late Catherine Duncan. The present investigation, therefore, had a threefold objective: (i) to show the influence of a wide range of initial moisture contents on the rate of decay of Sitka spruce and sweetgum woods by *P. versicolor* in the ASTM soil-block test; (ii) to determine the changes in moisture content that occur after various periods of incubation of these two wood species with *P. versicolor*; and (iii) to demonstrate the far greater resistance of Sitka spruce as compared to sweetgum sapwood to decay by *P. versicolor*.

MATERIALS AND METHODS.—Sitka spruce wood (*Picea sitchensis* [Bong] Carr.) and sweetgum sapwood (*Liquidambar styraciflua* L.) were chosen because they are typical gymnospermous and angiospermous woods, respectively. The spruce was part of the same board, and the isolate of *P. versicolor* (Mad. 697) was the same as one used previously to demonstrate the decay resistance of Sitka spruce (3). ASTM Standard soil-block chambers (1) were prepared as before with sugar maple (*Acer saccharum*

Marsh.) feeder strips. Three weeks after inoculation, sterile test wafers were installed in the chambers aseptically. The assembled chambers were incubated at 26.7 ± 1 C and 70% relative humidity for 4 or 8 weeks.

Preparation of the test wafers.—Cross-sectional wafers (25 X 25 X 3 mm parallel to grain) were machined from single sticks of each wood. After labeling, the wafers were randomly divided into seven groups, brought to equilibrium with an atmosphere controlled at 23.4 C and 50% relative humidity, and weighed to the nearest mg. From these equilibrium weights, the moisture-free weight of each wafer was calculated. Using the latter weights, weights of the individual wafers at their assigned moisture contents were calculated.

Seven moisture contents ranging from 6 to approximately 120% dry weight were employed to provide a wide range of initial conditions. Four replicate wafers were prepared for each combination of wood species, moisture content, and incubation period. Control specimens (air-dry wafers with no treatment to adjust their moisture content) were sterilized according to the ASTM Standard method. They had an initial moisture content of 6%. The adjusted moisture contents used were 40, 45, 50, 60, 75, and 116 (Sitka spruce) or 122% (sweetgum) of the moisture-free weight. The highest moisture content was calculated from specific gravity measurements to be 80% of the void volume of the wood – the maximum moisture content that Snell et al. (5) reported will permit rapid decay.

Water was added to the wafers to bring them to the calculated weights by two techniques: (i) Wafers in the 40-50% moisture content groups were "wetted up" to the desired weights by pressing them into damp blotters; and (ii) wafers in the 60-122% moisture content groups were vacuum impregnated and "dried down" on dry blotters until the desired weights were achieved. Fine reductions in moisture content were made by circulating air over the speciments, resulting in an accuracy of ±1% of the desired moisture contents.

Maintenance of the adjusted moisture contents during steam sterilization proved difficult. Placing the wafers in various chambers over a free-water surface, wrapping in vinylidene chloride sheeting (Saran), or sealing in an emulsion of neoprene rubber during the sterilization period all failed to produce consistent results. It was found that wrapping the specimens in 5 X 25 cm strips of aluminum foil (Reynolds Wrap, 0.01 mm thick) with the edges of the packet tightly crimped at least twice resulted in consistent moisture losses of 5 and 7.5% of the moisture contained in the spruce and sweetgum wafers, respectively. The desired wet weights were adjusted to allow for these losses. All test wafers, except the controls, were wrapped in foil before sterilization in steam at 100 C for 20 min. After sterilization, the wafers were allowed to cool and aseptically placed in the decay chambers.

Determination of moisture contents and weight losses.—After the 4- and 8-week incubation periods, the test wafers were removed from the chambers, carefully brushed free of surface mycelium, and immediately weighed to obtain their wet weight after decay. They were then dried to constant weight at 100 C. The weight loss due to decay was calculated as the difference between the moisture-free weight before and after decay and expressed as a percentage of the former.

In a subsequent experiment, identical Sitka spruce wafers at initial moisture contents of 6, 40, 75, and 116% were placed in decay chambers that were not inoculated. This permitted an evaluation of changes in moisture content during incubation in the absence of the test fungus.

RESULTS AND DISCUSSION.—Average moisture contents and weight losses due to decay of the wafers are shown in Table 1. Coefficients of variation were consistently less than 10% of their respective means. The data demonstrate the marked decay resistance of Sitka spruce in comparison with sweetgum sapwood; during the 8-week incubation period, average weight loss in sweetgum was 64% as compared to 0.9% for Sitka spruce. The data also show that Sitka spruce remained highly resistant to decay by *P. versicolor* irrespective of the initial moisture content. The observed increases in dry weight after decay are normal for highly resistant woods, and apparently result from growth of mycelium from feeder strips into the test wafers (1).

In an earlier publication (3), the inability of *P. versicolor* to cause significant weight loss due to decay in Sitka spruce was attributed to the relationship between carbohydrates and lignin of wood. The possibility that this apparent resistance might have been an artifact of the test method resulting from a moisture content too low for the fungus to operate effectively has been tested in this experiment and found to be incorrect. The results, therefore, reaffirm the original hypothesis. The large difference in weight loss observed in these two species emphasizes the difference in susceptibility of these representative coniferous and angiospermous woods to decay by *P. versicolor*, a typical white-rot fungus (3).

During the first 4 weeks of incubation, both the spruce and sweetgum test wafers with initial moisture contents of 6-45% increased in moisture content (Table 1). This occurred in both the inoculated and noninoculated spruce wafers. These increases in moisture content indicate that the test wafers absorbed enough water to raise their moisture content well above the fiber saturation point (about 28% moisture content) whether or not the test fungus was present. Between the 4th and 8th weeks of incubation, the inoculated spruce wafers continued to increase in moisture content irrespective of their initial moisture content, but the noninoculated wafers did not do so. This indicates that the mycelium of *P. versicolor* caused movement of an additional amount of water into the test wafers even though it caused no decay in them. This water was not produced as water of metabolism since the slight weight loss due to decay (average 0.9%, Table 1) was too little to account for the increase in moisture

TABLE 1. Influence of initial mositure content of Sitka spruce wood and sweetgum sapwood on average weight loss due to decay (WL)[a] and final moisture content (MC)[b] after decay by *Polyporus versicolor* in the soil-block test

Incubation period (weeks)	Initial moisture content before decay (%)														Avg for all initial moisture contents	
	6 (ASTM controls)		40		45		50		60		75		116 (spruce) 122 (sweetgum)			
	MC	WL	MC	WL	MC	WL	MC	WL	MC	WL	MC	WL	MC	WL	MC	WL
Sitka spruce wood, inoculated																
4	40	+0.7	50	+0.8	52	+1.1	46	+1.2	51	+0.7	54	+1.3	54	+0.9	50	+1.0
8	44	+0.5	62	1.0	65	2.4	65	0.9	60	1.6	64	1.3	68	+0.7	61	0.9
Sitka spruce wood, noninoculated																
4	41		44								72		97			
8	42		42								72		98			
Sweetgum sapwood, inoculated																
4	52	34	59	38	58	41	54	33	54	38	50	36	45	36	53	36
8	94	66	102	62	117	66	93	62	115	66	126	61	108	66	108	64

[a] Weight loss due to decay is expressed as a percentage of initial dry weight.
[b] Moisture content after decay is expressed as a percentage of oven-dry weight after decay.

content observed (50-61%, Table 1). This moisture presumably was moved through the fungus mycelium from the soil (and/or the feeder strip) in the decay chambers into the test wafers.

The inoculated spruce and sweetgum test wafers with initial moisture contents of 60-122% decreased in moisture content during the first 4 weeks of incubation (Table 1). This loss was more pronounced in the inoculated than in the noninoculated spruce wafers. These losses in moisture content indicate (i) that the atmosphere within the decay chambers was not saturated with moisture vapor, as is commonly assumed; and (ii) that the mycelium of *P. versicolor* increased the rate of loss of moisture from the test wafers into the atmosphere within the decay chambers. These conclusions are supported especially by the data for sweetgum wafers (Table 1). In them, a substantial amount of water of metabolism was produced – 0.55 g H_2O for every g of wood substance metabolized. The factor 0.55 can be calculated from the following respiratory equations for the major constituents of wood: $(C_6 H_{10} O_5)_n + 6_n O_2 \rightarrow 6_n CO_2 + 5_n H_2O = \frac{5(18)}{168} = 0.55$ for hexosans; $(C_5 H_8 O_4)_n + 5_n O_2 \rightarrow 5_n CO_2 + 4_n H_2O = \frac{4(18)}{132} = 0.55$ for pentosans; and $(C_{42} H_{50} O_{45})_n + 47_n O_2 \rightarrow 42_n CO_2 + 25_n H_2O = \frac{25(18)}{794} = 0.56$ for lignin.

The amount of moisture calculated from these equations for wafers sustaining an average weight loss of 64% (see Table 1) is ca. 3 times greater than the increase in average moisture content actually observed between the 4th and the 8th week of incubation (53-108% moisture content, Table 1). Thus, both the increase and the decrease in moisture content of the test wafers described above are consistent with the hypothesis that *P. versicolor* can adjust the moisture content of wood by transfer of water through its own mycelium.

LITERATURE CITED

1. AMERICAN SOCIETY FOR TESTING MATERIALS. 1962. Tentative method for accelerated laboratory test of natural decay resistance of woods. ASTM Design. D 2017-62T. Supp. 1962 ASTM Standards. Pt. 6, p. 75-82.
2. AMMER, U. A. 1964. Über den Zusammenhang Zwischen Holzfeuchtigkeit und Holzzerstörung durch Pilze. Holz als Roh- und Werkstoff 22:47-51.
3. PETERSON, C. A., & E. B. COWLING. 1964. Decay resistance of extractive-free coniferous woods to white-rot fungi. Phytopathology 54:542-547.
4. SNELL, W. H. 1929. The relation of the moisture contents of wood to its decay. III. Amer. J. Bot. 16:543-546.
5. SNELL, W. H., N. O. HOWARD, & M. V. LAMB. 1925. The relation of moisture contents of wood to its decay. Science 62:377-379.