HEAT-TREATING LOBLOLLY PINE LUMBER TO ERADICATE *BURSAPHELENCHUS XYLOPHILUS*: VERIFICATION TESTS

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The pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is native to North America, and causes pine wilt disease in Japan and other countries where it has been introduced. Species of *Bursaphelenchus* have a phoretic relationship with wood-borers, *Monochamus* spp., and are transmitted during oviposition. As a result, *B. xylophilus* and its *Monochamus* vectors may be found in raw coniferous wood products. Because the PWN has been intercepted in green lumber shipments (Tomminen and Nuorteva 1992), several countries have enacted regulations for imported coniferous sawn wood to protect their forests from exotic pests.

The three experiments in this study verify and expand heat-treatment schedules that ensure eradication of PWN in green sawn wood. In early June 1991, timber-size loblolly pines (*Pinus taeda L.*) were felled, and the stems cut into 2.4-m-long logs. The logs were exposed to attack by pine sawyers (*Monochamus* spp.) and colonization by *B. xylophilus* for three months. The infested-logs were then sawn into dimension lumber.

To sample for nematodes, two 1.6-cm-diameter x 3.2-cm-deep holes were drilled equal distance from the ends in one side of each board. Sampling was done before and after each treatment. The Baermann funnel procedure was used to extract nematodes from the wood borings. Wood samples were dried at 105 C for 24 h. Within boards, the data were pooled. PWN data were expressed as number per gram of dry wood weight.

Experiment 1 simulated kiln-drying of loblolly pine lumber. In this experiment, three 1 by 6's (2.5 cm by 15 cm), three 2 by 6's (5 cm by 15 cm), three 4 by 4's (10 cm by 10 cm), two 2 by 4's (5 cm by 10 cm), and one 6 by 6 (15 cm by 15 cm) boards, each 1.2-m-long, were tested. The lumber was partially dried in a kiln (Moore Dry Kiln Co., Jacksonville, FL) set to operate at 71/66 C (dry-bulb/wet-bulb) temperature schedule for 19 h. The core wood temperature was monitored by a probe placed in the geometric center of one board of each dimension. Before treatment, an average of 91 PWN/g dry weight (dw) was recovered from the lumber; after treatment no PWN were extracted (Table 1).

In Experiment 2, three 1 by 6's (2.5 cm by 15 cm), two 2 by 4's (5 cm by 10 cm), three 2 by 6's (5 cm by 15 cm), three 4 by 4's (10 cm by 10 cm), and one 6 by 6 (15 cm by 15 cm) boards, each 1.2-m-long, were tested. The kiln temperature schedule and probe placement duplicated Experiment 1. Boards were removed from the kiln when the core wood temperature was between 58 and 60 C. The time required to reach the target temperature range was a function of the dimensions of the boards. For example, the 1 by 6's (2.5 cm by 15 cm) and the 6 by 6 (15 cm by 15 cm) reached

target temperature in 1 and 4 h, respectively (Table 2). An average of 87 PWN/g(dw) was extracted from the lumber before treatment; after treatment no PWN were extracted.

In Experiment 3, the time-temperature PWN mortality curve for heat-treated lumber was further defined by placing five stacks of 2 by 6 (5 cm by 15 cm) boards, each 1.2-m-long, in the kiln. Each stack contained four boards. Core wood temperature was monitored by inserting a temperature probe into the geometric center of the top board of each stack. A stack of boards was removed when the core wood temperature of the top board reached 40, 45, 50, 55, and 60 C. This experiment provides further insight into the time-temperature PWN mortality curve. Pinewood nematodes were recovered from the 2 by 6's when the core wood temperature was between 40 and 50 C; however, none were extracted at 55 and 60 C (Table 3). Heat treating green sawn wood to core temperature of 55 C was sufficient for nematode eradication.

In summary, drying pine lumber in a kiln operating at a temperature schedule that exceeds 71 C (dry-bulb) will result in PWN decontamination. These results are agree with Dwinell (1990) and Tomminen and Nuorteva (1992). Dwinell (1990) also reported that heating lumber to a core wood temperature of 60 C was sufficient to eradicate the PWN. Researchers in Canada subsequently concluded that 59 C would eliminate the PWN in sawn wood (Smith 1991). In this study, heat-treating sawn wood to a core wood temperature of 55 C ensured eradication of the PWN. This conclusion is supported by a joint project carried out by researchers from the European Union, Canada, and the United States (EOLAS 1991). The European Union and the Republic of Korea now import coniferous wood certified heat-treated at 56 C for 30 min or kiln dried.

References

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Table 1. Effect of kiln-drying loblolly pine lumber at 71/66 C (dry-bulb/wet-bulb) for 19 h on pinewood nematode density in pine lumber.

Board dimensions (in)	No. of boards tested	PWN/g(dw[a])	
		Before drying	After drying
1 by 6 by 48	3	122	0
2 by 4 by 48	2	58	0
2 by 6 by 48	3	71	0
4 by 4 by 48	3	114	0
6 by 6 by 48	1	91	0

[a] Dry wood weight

Table 2. Effect of heating loblolly pine lumber wood to a core temperature of 58 to 60 C on pinewood nematode density in the wood.

Board dimensions (in)	No. of boards tested	Time to 58-60 C (h)	PWN/g(dw[a])	
			Pre-treatment	Post-treatment
1 by 6 by 48	3	1.0	53	0
2 by 4 by 48	2	2.0	121	0
2 by 6 by 48	3	1.5	178	0
4 by 4 by 48	3	2.5	43	0
6 by 6 by 48	1	4.0	39	0

[a] Dry wood weight

Table 3. Effect of heating loblolly pine lumber to core wood temperatures of 40 to 60 C on pinewood nematode density in the wood.

Core wood temperature[a] (C)	Time (min)	PWN/g(dw[b])	
		Pre-exposure	Post-exposure
40	12	89	86
45	34	78	119
50	48	88	30
55	79	46	0
60	120	50	0

[a] Four 2 by 6 by 48-in boards were removed from the dry kiln (71 C) when the target core wood temperature was reached.
[b] Dry wood weight