RADIO WAVES AND STEAM, ALONE OR IN COMBINATION, FOR THE ERADICATION OF *BURSAPHELENCHUS XYLOPHILUS* IN SOUTHERN PINE CHIPS

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Infestations of North American pine chip exports by the pinewood nematode (PWN), Bursaphelenchus xylophilus, were first reported in 1984. Because of the ban by the European Union and several individual countries of softwood products, unless kiln-dried, from countries known to have B. xylophilus, the last shipment of pine chips from North America to Europe was in 1986. Resumption of trade depends on finding a cost effective technique to eliminate the PWN in large volumes pine chips. The use of steam (Dwinell 1994) and radio waves (Dwinell and Carr 1991) to heat-treat pine chips has shown promise, as has radio-frequency/vacuum dryers to decontaminate green pine lumber (Dwinell et. al. 1994).

Since steam and radio waves heat wood differently, their combined effect could result in a highly efficient procedure for heat-treating large volumes of pine chips. Therefore, the authors conducted a study to further define the efficacy of steam heat and radio waves, alone or in combination, for the eradication the PWN in pine chips.

The study used a radio frequency (RF) drying oven (Georgia Power Technology Applications Center, Atlanta) with parallel electrodes that operate at a frequency of 27.1 MHz. A steam line (100°C at 210 g/cm^2) was attached to the radio frequency unit. For each run of an experiment, two 1.0-kg lots of PWN-infested chips were placed in polyethylene containers beneath the electrodes. Each container was 25.4-cm high x 18.9-cm wide x 12.7-cm deep with an input hole for steam on one side near the top, two holes for temperature probes, and 81 outlet holes at the bottom. The containers were transparent to radio waves. Temperature was monitored by two fluoroptic thermometry probes inserted into each lot of chips. All process data were saved in a personal computer through a data-acquisition system. The probes were scanned at 1.4-sec intervals.

There were nine treatments. Exposure durations were 5, 10, and 20 sec for the three live-steam treatments; 10, 20, and 25 sec for the three RF treatments; and the following schedule for the three treatments that combined steam and RF heating: 5 sec steam plus 25 sec RF, 10 sec steam plus 20 sec RF, and 20 sec steam plus 10 sec RF. The temperature of the steam and RF treatments was monitored for 60 sec. The temperature of the combination treatments was monitored for 90 sec. Each treatment combination was replicated three times. Three subsamples served as untreated controls. Data for each lot within each run were pooled.

Nematodes were extracted from 25-g subsamples with the Baermann funnel procedure. The wood moisture content was determined by drying subsamples at 105°C for 24 hours.

An average of 40 PWN/g (dry weight) were recovered from pine chip samples that were not treated. They were also recovered from pine chips exposed to steam heat for 5 and 10 sec, and to RF for 10 sec. No PWN, however, were recovered from samples exposed to 20 sec steam, 20 or 25 sec of RF, or any combinations of steam and RF (Table 1). None of the treatments altered wood moisture content.

Table 1 summarizes the mean and maximum temperatures for the monitoring periods. For steam and RF alone, the maximum temperature of the air-

space between the chips reached 60.6°C with 20 sec steam and 25 sec RF after 18 and 36 sec, respectively. When steam and RF were combined, mean temperatures ranged from 66.5 to 80.5°C, and the maximum temperature range was 81.0 to 94.7°C. Maximum temperatures were reached in 30-36 sec in treatments that employed a combination of steam and RF heating. Figures 1, 2 and 3 show the temperature curves for the nine treatments.

In summary, the data confirm that live steam and radio waves are effective in eradicating the pinewood nematode in pine chips when temperatures exceed 57°C. This agrees with previous studies that examined conditions necessary to eradicate mesophilic organisms in wood and other substrates. Higher temperatures can be reached in less time by combining live steam with radio waves, suggesting that the relationship between steam and RF may be synergistic. Using steam and radio waves, alone or in combination, is a viable alternative to fumigating with methyl bromide.

References

Dwinell, L.D. 1994. Using heat to decontaminate pine chips infested with the pinewood nematode. In: Ann. Intl. Res. Conf. on Methyl Bromide Alternatives and Emissions Reduction, Kissammee, FL, Nov. 13-16, 1994.

Dwinell, L.D. and W.W. Carr. 1991. Using radio waves to eradicate Bursaphelenchus xylophilus in southern pine chips. [Abstract]. J. Nematology 23:257.

Dwinell, L.D., S. Avramidis, and J.E. Clark. 1994. Evaluation of a radio-frequency/vacuum dryer for eradicating the pine wood nematode in green sawn wood. Forest Prod. J. 44:19-24.

Table 1. Recovery of pinewood nematodes after exposure of infested southern pine chips to steam and radio waves (RF), alone or in combination.

Treatment	Temperature (°C)		Average time to maximum temp. (sec)	PWN/g(dw[a]) (Mean)
	Mean[b]	Maximum		
Control	--	--	--	40
5 sec Steam	32.5	37.7	36	13
10 sec Steam	46.3	55.5	12	9
20 sec Steam	50.8	60.6	18	0
10 sec RF	38.9	42.3	12	25
20 sec RF	50.8	57.0	24	0
25 sec RF	53.9	60.6	36	0
5 sec Steam + 25 sec RF	66.5	81.0	36	0
10 sec Steam + 20 sec RF	76.9	91.8	36	0
20 sec Steam + 10 sec RF	80.5	94.7	30	0

[a] Dry wood weight

[b] Mean of temperature for 60 sec monitor period for steam and RF alone and 90 sec for steam + RF treatments.

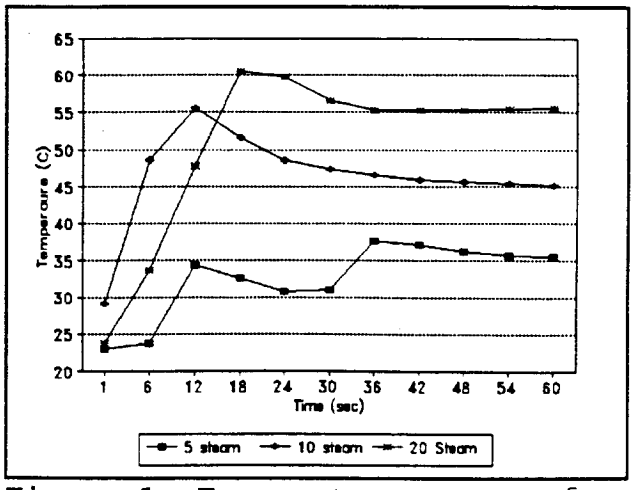

Figure 1, Temperature curves for steam treatments.

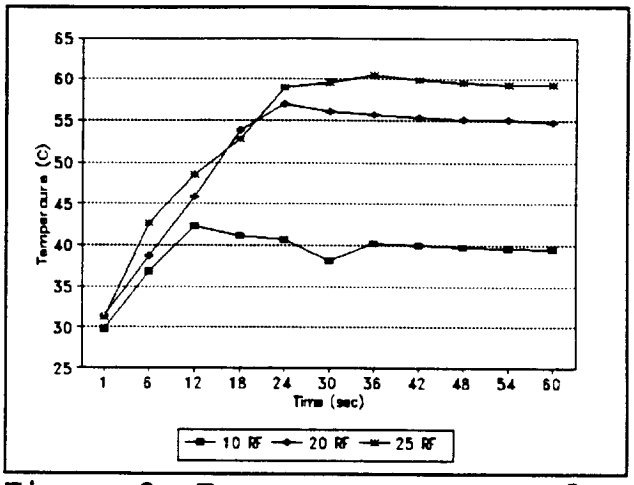

Figure 2, Temperature curves for radio frequency treatments.

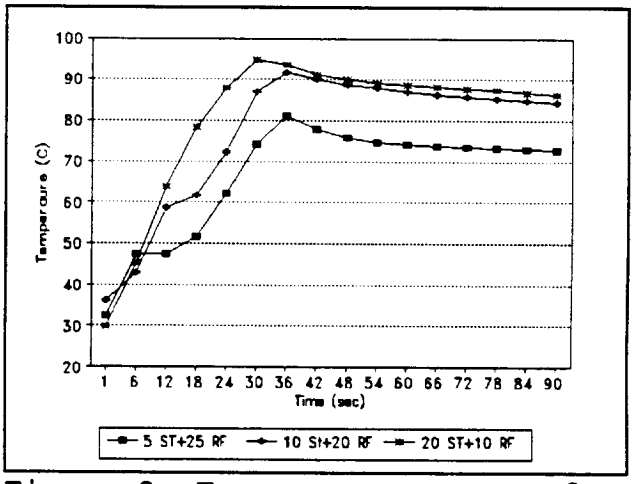

Figure 3. Temperature curves for the combined effect of steam and radio frequency treatments.