METHYL BROMIDE ALTERNATIVES FOR DECONTAMINATING SOFTWOOD CHIPS, LUMBER, AND LOGS

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International trade in unprocessed wood can introduce exotic pests into new habitats. The global transport of wood fiber without causing environmental harm or ecological disaster requires that the wood be free of pests. USDA Forest Service research on decontaminating coniferous chips, green lumber, and logs has concentrated on the pinewood nematode (PWN), *Bursaphelenchus xylophilus,* and its pine sawyer, *Monochamus*, vectors. The emphasis of the research has been on alternatives to methyl bromide. Mitigation procedures that have been investigated over the past decade include fumigation, irradiation, chemical dips, and elevated temperature.

A native of North America, the PWN has become a destructive introduced pest in the forests of Japan and other Asian countries. *Bursaphelenchus xylophilus has* a phoretic relationship with pine sawyers and are transmitted to recently felled logs or dead or dying conifers, particularly pines, during oviposition. As a result of secondary transmission, these pests may be found in chips, green lumber, and logs. The PWN has been intercepted in chips, green lumber, and packing case wood exported from North America. As a result of these and other interceptions, and the pine wilt disease in Asia, the European Union and other countries regulate all coniferous imports to protect their forests from the PWN and other exotic pests. The United States also regulates wood imports to protect our trees from introduced pests.

USDA scientists from the Southern Research Station of the Forest Service and the Stored-Product Insects Research and Development Laboratory of the Agricultural Research Service determined that metam-sodium and aluminum phosphide were effective in eradicating the PWN in southern pine chips. To demonstrate the practicality of in-transit fumigation, they applied phosphine to a shipload of woodchips exported from Georgia to Sweden. The holds were treated with aluminum phosphide at a rate of 4gmPH_3/m^3. The experiment was successful and awaits broader application.

The irradiation of pine chips was considered to be an alternative to fumigation. Southern Research Station and Georgia Institute of Technology scientists treated PWN-infested wood samples in a cesium-137 irradiator and found 0.9 MRAD to be the lethal dosage. Subsequently, Canadian scientists reported that 0.7 MRAD dosage (cobalt 60 gammacell 220 irradiator) will

eliminate the PWN in aqueous solution. These data support the contention that a higher dosage is necessary to eliminate the PWN *in vivo* than *in vitro*. The scientists concluded that 0.9 MRAD was too high to make this an attractive means of disinfestation for commercial wood. The lethal dosages for xylem-inhabiting nematodes, however, appears to be considerably lower than that required for bacteria and fungi. In general, a lethal dosage of 2.5 MRAD is necessary to kill bacteria and fungi in wood.

The Southern Research Station studied the efficacy of dip-diffusion sodium borate treatments for eradicating the PWN in chips and for eradicating the PWN and pine sawyers in debarked pine logs. Neither the liquid nor the powder formulations were effective in controlling PWN or pine sawyers. However, in a companion treatment, PWN and sawyers were not recovered from pine logs fumigated with methyl bromide at the rate of 240g/m^3.

The use of elevated temperatures to eradicate mesophilic organisms in wood shows the most promise. Mortality of the PWN and its vectors in wood is primarily a function of temperature, time, heat source, and moisture content. For example, conventional heat, live steam, and hot water can raise wood temperatures to levels that are lethal to the PWN (greater than 45°C). Research by scientists from the Georgia Institute of Technology and the Southern Research Station determined that the mortality of the PWN in pine chips exposed to radio frequency (RF) waves was a function of temperature. Furthermore, in a RF unit with parallel electrodes operating at a frequency of 27.1 MHz, it took only 90 seconds to heat pine chips to 98°C. In a subsequent study, they evaluated the effectiveness of radio waves and steam, alone or in combination, on PWN-infested chips. High temperatures are possible in less time by combining steam and radio waves, suggesting that the relationship between these two heat sources may be synergistic. Cooperative research between Southern Research Station and Canadian scientists found that a radio-frequency/vacuum kiln equipped with parallel electrodes operating at a frequency of 13.56 MHz was effective in eliminating the PWN and its vectors in sawn wood. They also reported that wood moisture content was a factor in nematode mortality when RF waves were used as the heat source. The greatest efficiency, in terms of nematode eradication, was to heat the wood to a lethal temperature prior to drying.

Elevated temperature can pasteurize or sterilize softwood chips, sawn wood, or logs. Heating southern pine chips, green lumber, and logs to a corewood temperature of 60°C for 30 minutes is sufficient to eliminate such mesophilic pests as PWN, pine sawyers, and pathogenic fungi. Scientists from the Southern Research Station and South Korea found that a corewood temperature of 55°C for 30 minutes will eradicate the PWN in green loblolly pine lumber. A team of scientists from the Southern Research Station,

European Union, and Canada concluded that heating coniferous wood to a corewood temperature of 56°C for 30 minutes will eradicate the PWN and its vectors. Shorter exposure times can be achieved with thermal treatments, such as live steam and radio waves, that rapidly heat the wood to high temperatures.

Drying coniferous wood at conventional kiln schedules is essentially a wood sterilization process. The time-temperature schedules required to dry sawn wood to commercial standards are much higher than those required to eradicate pests in the wood. This has been confirmed by Southern Research Station, Finnish, Canadian, and South Korean scientists.

Europe now accepts coniferous chips, sawn wood, and logs that are certified to have been kiln-dried or heat- treated to a corewood temperature of 56°C for 30 minutes. South Korea now allows the importation of kiln-dried pine sawn wood. The research on elevated temperatures as well as other mitigation procedures for decontaminating transported wood has required the cooperative efforts of scientists in North America, Europe, and Asia. The value of these wood exports to the United States has been estimated at $355 million per year.

Similar control principles are appropriate for export or import of chips, green lumber, or logs. Pest control begins in the forest and requires a thorough knowledge of the life histories of the target pests. Efficient logging management practices, quality control, and inspections can minimize pest problems. The wood management system should include appropriate mitigation procedures to ensure that transported wood does not harbor pests.
