RED PINE NURSERY STOCK FUMIGATION IN MICHIGAN CONSERVATION DEPARTMENT NURSERIES

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The European pine shoot moth has become one of the most serious plantation pests of red pine in Michigan. It was introduced into the United States in 1913 and first recorded in Michigan in 1930. Since that time it has been reported in most of the counties in Lower Michigan and in 5 of the 15 counties in the Upper Peninsula. These 5 are Houghton, Schoolcraft, Mackinac, Luce, and Chippewa. Distribution of the shoot moth into and throughout the State has been mainly a result of infested nursery stock. The shoot moth larva overwinters in a bud and can therefore be in the stock during fall and spring shipping seasons.

A threefold action program of hand roguing, fumigation, and spraying was started to control the shoot moth in three Conservation Department nurseries following its discovery in the seedling and transplant beds in the fall of 1957. The infestation was found shortly before the fall shipping season, and fumigation following hand roguing appeared to be the immediate answer to prevent shipping infested trees. A search of the literature and personal communications revealed no commercial scale fumigation of red pine nursery stock. However, Dr. H. A. U. Monro, Science Service Laboratory, Canadian Department of Agriculture, had been conducting research on the effect of methyl bromide fumigation on the shoot moth and on red pine and permitted the use of his unpublished data. The Conservation Department gratefully acknowledges the recommendations and assistance given them by Dr. Monro.

Beginning in early September 1957, all beds 2 years of age and older were carefully checked and the infested trees hand rogued. Most of the infested trees can be found and removed by this method; however, some maybe missed. This was demonstrated by having the same crew rogue the same beds three times. Each time infested trees were found. Hand roguing the 2-2 transplants costs approximately $0.50 per thousand trees examined at a labor cost of $1.86 per hour. This cost varies greatly with the intensity and thoroughness with which the operation is done. Since hand roguing could not be relied on to remove all the infected trees, a fumigation program was set up in the nurseries.

The third phase of the action program is spraying the beds with DDT during the summer to kill the hatching larvae. It is hoped that the spraying in the future will provide complete control and eliminate the need for fumigation and hand roguing.

However, further studies on the techniques and effects of the fumigation will be made so that this information will be available when needed if spraying control is not complete or some other pest is encountered.

FUMIGATION PROGRAM-- All stock from beds inwhich shootmoth larvae were found was fumigated prior to shipping from the nursery. Normal lifting, sorting, and packing procedures were followed, producing open-end bales with the pine tops exposed. After the bales were ready for shipping, they were placed in the fumigation chamber (fig. 1) and exposed to methyl bromide gas. Little extra expense was added to the cost of the trees other than for the additional handling of the bales in loading and unloading the chamber.

A total of 8,542,944 red pine were fumigated during the fall of 1957 and spring of 1958 before leaving the nurseries. This was broken down by age groups as follows: 1,575,000 2-0 seedlings, 5,092,000 3-0 seedlings, and 1,875,944 2-2 transplants.

Fumigant--Methyl bromide is a colorless, odorless liquid boiling at 38.5°F. It is toxic to humans, nonflammable, and as a gas is 3.3 times as heavy as air. When used for most fumigation, chloropicrin is added to methyl bromide as a warning agent. However, chloropicrin is highly phytotoxic to pine and the methyl bromide must be used without the chloropicrin when treating live pine trees. Absence of the warning agent makes the use of methyl bromide more hazardous to humans, and additional safety precautions must be taken. Anyone working with methyl bromide should become familiar with its action and use adequate caution.

The action on insects may be slow, and control results cannot be evaluated for at least 48 hours after treatment.

Chamber- -Detailed plans and list of materials for a fumigation chamber of 600 cubic feet capacity, for use in treating pine nursery stock, are available from the Forestry Division, Michigan Department of Conservation, Lansing 26, Mich.

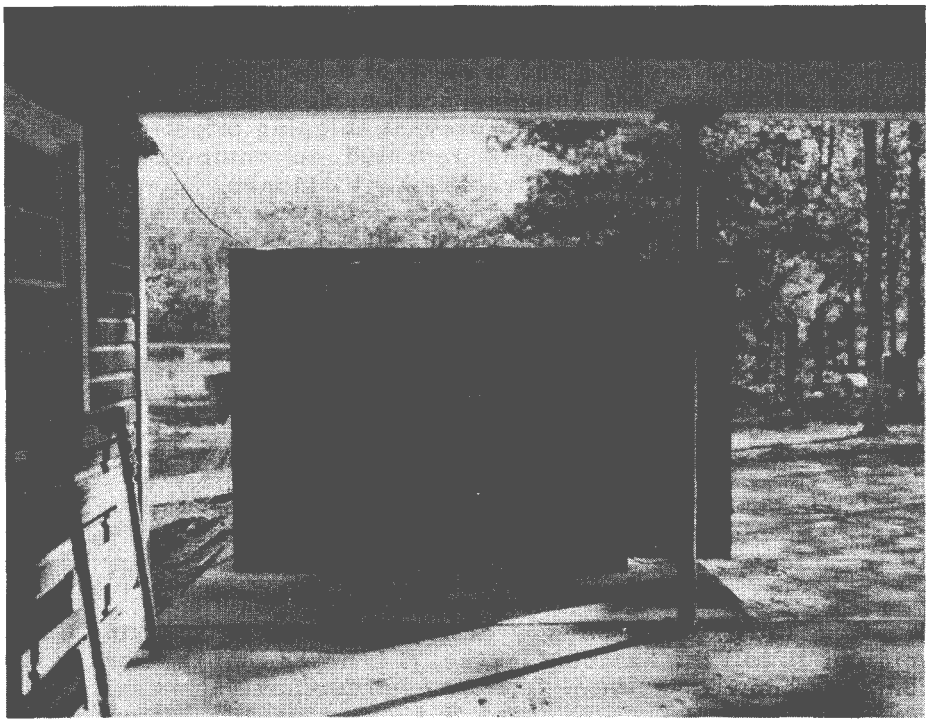

Figure 1.--Front view of chamber used for fumigation of pine nursery stock at Higgins Lake Nursery showing method of loading.

Location: The chamber was located on the loading platform outside the main buildings so that there was a minimum distance to move the trees (fig. 2). After treating, the trees were removed from the chamber, and left on the loading platform for additional aeration prior to truck pickup. An exhaust fan was used to pull fresh air through the chamber after treatment and blow the gas away from the buildings.

Capacity: The following number of trees would approximately fill the chamber:

150,000 2-0 seedlings, or
60,000 3-0 seedlings, or
20,000 2-2 transplants.

These amounts will vary with the size of the nursery stock and the manner in which it is packed.

Loading:--Two rows of bales are placed on 2 by 4 boards in the chamber so that there is some free air space underneath, along the sides, and down the middle. Two separators of 2 by 4 boards are placed on top of each row, and additional layers are added using separators between each layer. Three to five layers, depending on the size of the bales, are used when the chamber is filled to capacity.

An air space around the piles on all sides is essential for good circulation of the gas. The stock is placed no closer than 18 inches from the ends and ceiling of the chamber.

Gas Circulation:--An 18-inch fan is used in the chamber to assure good gas dispersal and is located at the center of the back of the chamber at floor level, with the fan directed along the floor toward the front of the chamber.

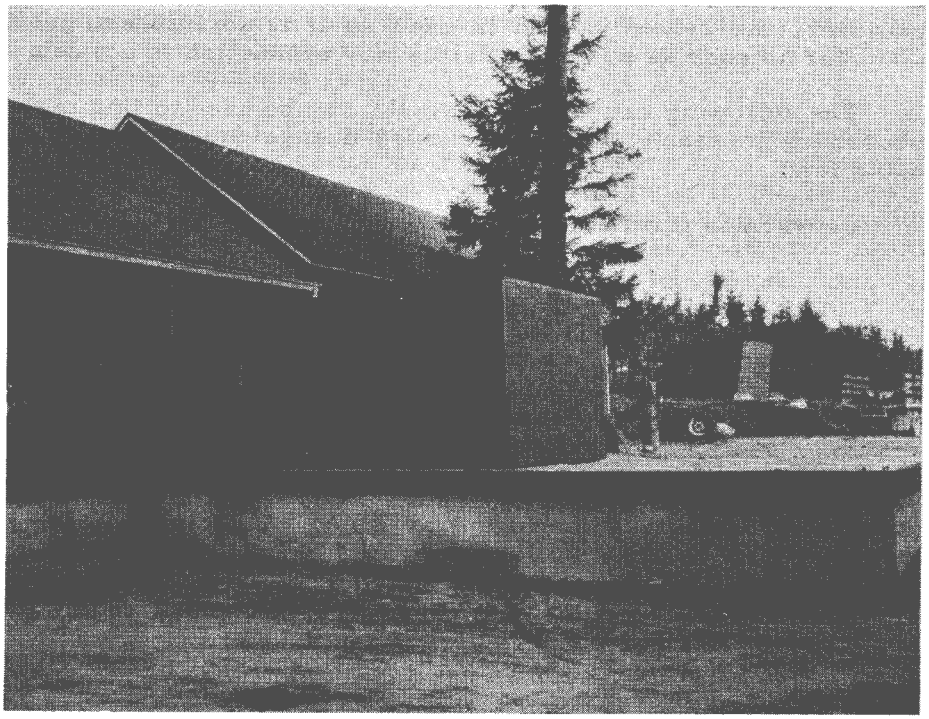

Figure 2.--Rear-side view of chamber showing location on loading dock.

The fan is turned on at the start of the gas introduction and is left on for the first 15 minutes of the fumigation period. Longer circulation is unnecessary and tends to force the methyl bromide out of the chamber if small leaks are present.

Either a reversible fan or a second 18-inch fan is used to clear the chamber of gas after fumigation. Gas is expelled through a small door at the rear of the chamber. The chamber is allowed to clear for 30 minutes before men enter and remove the bundles .

Gas Introduction:--Methyl bromide can be bought in 1-pound cans and larger cylinders. The 1-pound cans are the most conveniently handled when small amounts are used. Special applicators outside the chamber are used to puncture the sealed cans allowing the methyl bromide to enter the chamber through a plastic tube. The discharging

of the gas into the chamber is hastened by immersing the cans and coil of tubing in warm water. Inside, the methyl bromide is caught in a shallow evaporating pan placed near the top of a chamber. A heat lamp placed 6 to 8 inches below the evaporating pan helps to vaporize the methyl bromide, particularly when the air temperature is in the 40's.

Dosage: The following dosage rates for a 2-hour exposure period were used as recommended by Dr. H. A. U. Monro:

Temperature:	Dosage (methyl bromide) per 1,000 cu. ft. *(Pounds)*
40	6
50	5
60	4

Within limits, a smaller amount of gas can be used if the exposure time is lengthened. However, the 2-hour period is used as it is desirable to get the trees in and out of the chamber as soon as possible. In this way production is not delayed.

The following conversion formula can be used to find the amount of methyl bromide necessary to reach the recommended dosage for chambers containing other than 1,000 cubic feet.

Conversion formula:

$$\text{Number of pounds needed} = \frac{\text{Recommended dosage in lbs. x chamber capacity in cu. ft.}}{1{,}000}$$

Example--Number of pounds of methyl bromide necessary to reach the desired concentration of 5 pounds per 1,000 cu. ft. in a 600 cu. ft. chamber.

$$\text{Number of pounds needed} = \frac{5 \times 600}{1{,}000} = 3$$

Methyl bromide costs about $0.70 a pound in 1-pound pressure cans. At 60°F., the approximate cost for the fumigant for treating 2-0 seedlings is 1-1/3 cents per 1,000 trees and 4 cents per 1,000 2-2 transplants.

RESULTS

Effect on Insects--According to the research findings of Dr. Monro (personal communication), a dosage of 4 pounds of methyl bromide per 1,000 cubic feet is necessary to kill the shoot moth larvae at 60°F., with higher concentrations required at lower temperatures. Complete mortality was attained when the temperature was 60° or more.

At lower temperatures some shoot moth survival occurred. Presumably this was due to loss of gas by absorption in the walls and to slow or incomplete vaporization of the methyl bromide. These causes have been corrected by painting the inside of the chamber with a resin base paint and heating the evaporating pan for more rapid vaporization.

Effect on Trees--Many of the treated trees were checked after one growing season in the field. No serious effects could be noted. In addition, during April and May, 1958, sample bundles of 50 trees were exposed for 1, 2, and 3 treatment periods of $1\text{-}2^1$ to 2 hours and then field planted, along with untreated trees. While the trees subjected to 2 and 3 periods were aired between treatments and would not be as severely affected as if the

treatment had been continuous for the total time, nevertheless, some information was obtained. All sample trees were checked inlate August for percent of survival and amount of 1958 terminal growth. The samples do not lend themselves to statistical analysis because of lack of replications, and insufficient variation of treatment temperatures, length of treatment period, and dates of fumigation. However, we believe that the following observations are valid:

1. Jack pine, red pine, and white spruce rank in increasing susceptibility to methyl bromide in the order listed. Jack pine and white spruce were included in the experiment to obtain data useful if fumigation of these species for an insect is necessary in the future.

2. Mortality of red pine was about the same whether receiving one period of recommended treatment or no treatment. Increasing the number of treatment periods caused higher tree mortality. Jack pine and white spruce showed the same reaction.

3. Terminal growth of the living trees averaged almost the same for all treatments and untreated stock. On some trees where new growth had started before fumigation, the growing buds appeared to be injured. However, side buds often took over and grew about the same as the uninjured terminals. There may be growth or mortality differences that will show up after 2 or more years. However, the slight differences in growth present after 1 year may equalize out after additional years.

CONCLUSION--Hand roguing cannot be relied on to eliminate all shoot moth infested trees from the nursery beds. Fumigation of red pine nursery stock with methyl bromide offers an inexpensive, simple method of preventing the spread of the European pine shoot moth on nursery stock. As far as could be determined, little or no fumigation of bundled red pine nursery stock had been done on a commercial scale prior to the treatments by the Michigan Conservation Department.

Examination of fumigated trees planted in the field did not reveal any serious effects from the treatment recommended to kill the shoot moth after one growing season.

Costs for the methyl bromide were less than 4 cents per thousand trees.

It is expected that a thorough spray program during the summer will eliminate the shoot moth from the beds, thereby doing away with the necessity for fumigation and hand roguing. However, fumigation provides a useful and economical control method, and studies will be continued to determine more conclusively its effects on the insects and trees.