RESEARCH REPORT 97 - 7

A SINGLE NURSERY TEST OF HOT WATER, 1,3-D, AND METHAM-SODIUM AS ALTERNATIVES TO METHYL BROMIDE

by
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INTRODUCTION

Fumigants containing methyl bromide (MBr) are widely used to insure seedling quality and production in southern forest tree nurseries. Because MBr will probably not be available in the near future, alternative treatments should be evaluated within the framework of current cultural practices both to acquaint nursery management with necessary techniques and provide estimates for possible changes in seedling growth. One proposed alternative is the use of hot water as a soil treatment. The injection of super-heated water into the top soil horizons may control disease, weed, and insect pests much the same way as MBr. Other alternative substitutes for MBr are the already known fumigation chemicals 1,3-dichloropropene (1,3-D) and Metam-sodium with chloropicrin. The objective of this study was to test hot water and these two chemical fumigants as possible substitutes for MBr and to compare their efficacy against the standard Methyl-bromide/chloropicrin fumigation.

METHODOLOGY

The chemical fumigants and the hot water treatment (HWT) were installed during the Spring of 1994 at the MacMillan Bloedel nursery near Camben, Alabama. The field design compromised total randomization for cost-efficient and safe application of the commercial (MC2) treatment to a contiguous area and the need of current application technology with respect to the HWT (Figure 1). The following treatments were applied:

1) Methyl bromide plus 2% chloropicrin (MC2) at a rate of 350 lbs/ac, injected and covered with continuous plastic tarps on March 28.
2) Triform® at 350 lbs/ac (1,3-dichloropropene (1,3-D) at 235 lbs/ac plus chloropicrin at 115 lbs/ac, injected and tarped on April 17.
3) Metham-sodium mechanically incorporated at 400 lbs/ac, followed by shank injected chloropicrin at 125 lbs/ac and soil surface compaction using a drum-roller.
4) Hot water at 110° C (230°F), shank-injected and mechanically mixed by vertical

shaft cultivators to a depth of 6 inches. Approximately 1,700 gal of water were applied to 400 linear feet of nursery bed for the equivalent rate of 37,000 gallons per acre. The boiler unit traveled approximately 44 ft/minute (0.5 mph).

Soil temperatures were recorded for several hours for nursery Blocks 9 and 10 using continuous recording thermometers (Thermographs). Temperatures were recorded in the other four blocks during the 15 minutes after application using hand-held probes that were relocated within a 10-foot section of nursery bed between readings.

Loblolly pine (Pinus taeda) was sown the first week of May, 1995. Seedlings per square foot (seedbed density) were determined on June 6 and Nov. 11 using either 3 or 4 samples taken with a 4 ft^2 counting frame. Seedlings were lifted from these same frames on Nov. 11 to measure size and mass.

Soil samples were collected within each nursery block before treatment (March 21, 1995) and within each treatment block when seedbed densities were determined (June 6 and November 11). Samples were collected across transects within each treatment block using a 3/4" diameter soil probe, bulked and mixed thoroughly. These samples were used to determine soil texture, pH, soil fungi, and nematodes.

RESULTS:

Seedling Development

The large area covered by this study (more than 40 acres) increased block differences more than was anticipated. Soil textures ranged from 65-75% sand, 12-17% silt, and 10-22% clay across the 6 blocks (45.6 acres total area). The average was 73, 14, and 13% sand, silt, and clay, respectively. Soil pH averaged 5.45 with a range of 5.1 to 5.8. In addition, the time of sowing and number of seedlots contributed to variability of germination and seedling development.

Fewer seedlings among the normally reliable "standard-practice-control" MC2 treatment (Table 1) is puzzling and removes an anticipated benchmark for variability among blocks. In June, the MC2 treatment contained fewer seedlings/ft^2 than any treatment but the control. With 2.5 fewer seedlings/ft^2, the MC2 treatment was unusually poor compared to its relative performance in other studies. Areas of stunted seedlings within MC2 treatments were determined (based on root morphology and foliage phosphorus) to have insufficient mycorrhizal colonization. Although not believed to affect seedbed density directly, insufficient mycorrhizae unusually indicates "effective" fumigation which could have affected other non-monitored soil microorganisms.

The 1,3-D/chloropicrin and the metham-sodium/chloropicrin treatments ranked among the best for both numbers and sizes. The hot-water treatment improved seedling production compared to the control. Other treatment combinations did not rank consistently for numbers or sizes of seedlings. Bed densities differed between treatments only for the comparison limited to the three treatments included in all six blocks (ANOVA $P = 0.01$). Seedbed densities were negatively correlated with average rcd ® = -0.54, $P = 0.02$) and the number of grade-one seedlings/ft^2 ® = -0.56 $P = 0.02$). However, seedling weight per unit area of bed did not differ between treatments.

Seedling weights were analyzed by square-foot of nursery bed to compensate for the tendency for individual size to vary inversely with bed density. Lower bed densities among MC2 treatments compared to controls should and did correlate with larger mean rcd's and more grade-one seedlings. However, within the range of seedbed densities assessed here, per area biomass is reported to decrease with decreases in bed density. Therefore, although the significant increase in individual biomass (mean rcd's and numbers of grade-one seedlings) in MC2 treatments is expected, greater per area biomass is not, and indicates growth enhancement by treatment.

Fungi

Treatment means and lsd's for the three selected groups of soil fungi are presented in Figure 2. Among June samples, cfu's of all three fungi differed between treatments but not between blocks. In November, only numbers of cfu's of Fusarium differed between treatments ($P < 0.05$). The significant correlation between November and June seedbed densities ($r=0.95$ $P = 0.0001$) indicates that little or no post-damping-off mortality occurred in any treatment.

Nematodes

Treatment effects on nematode populations are presented in Table 2. No treatment contained more than 2 pathogenic nematodes per 100 cc of soil in June and treatments did not differ ($P = 0.34$). Pathogenic nematodes increased by November except among MC2 treatments where none were extracted but treatments still did not differ ($P = 0.08$). Numbers of saprophytic nematodes differed between treatments in June ($P = 0.02$) and in November ($P=0.006$). By November, saprophytic nematodes were more abundant among metham-sodium/chloropicrin treatments ($\alpha = 0.05$).

Hot Water Treatment

It was hoped the HWT would raise soil temperatures in the top six inches to approximately 50° C for 15 to 30 minutes. On the large scale, the thermograph data indicated this occurred (Figure 3). The small scale or movable probe data, however, indicate that despite mechanical mixing, temperatures varied about 10° C between "pockets" of soil for five to ten minutes after treatment. The effect of this on soil pathogens within these parts of treated beds is not known. Certainly, the HWC resulted in a larger average seedling size and higher seedbed densities when compared to the control, although this difference did not separate statistically (Table 1).

MANAGEMENT IMPLICATIONS

Using 1994 technology and a treatment rate of 3 to 4 acres per hour, the speed of hot water treatment is not practical to the scale of forest tree nurseries. However, planned modifications for continuous water supply and the ability to treat more than one bed width, could reduce the time required significantly.

The two chemicals tested in this study proved to be suitable substitutes to MC2 as measured by seedling density and development. Metham sodium did not provide the same level of nematode control as the other two chemical treatments.

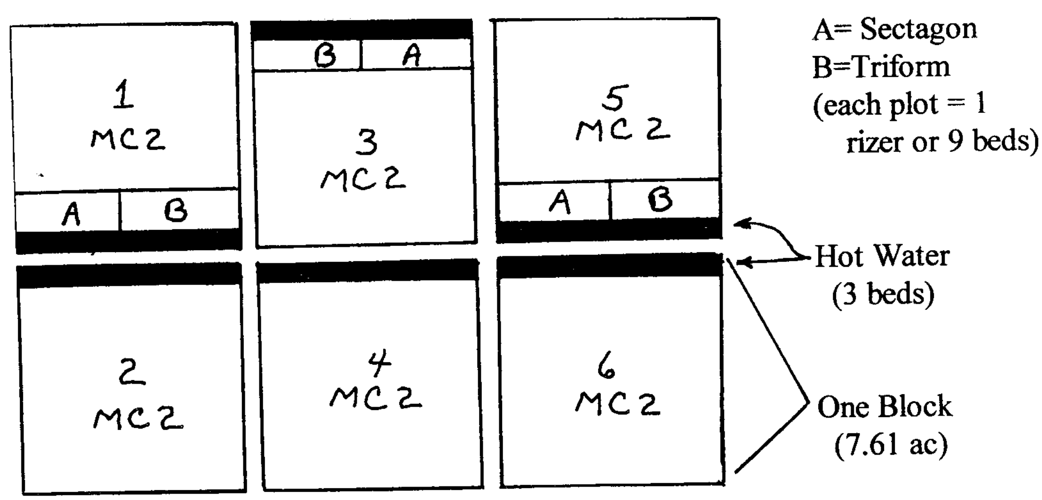
Table 1. Treatment means for pine seedling production by soil treatment at the MacMillan Bloedel nursery near Camden, AL.

			Values per ft^2 of nursery bed					
		Average	Bed Density		Grade 1	Oven Dry Weights		
N	Treatment	rcd	Spring	Fall	Seedlings	Shoot	Root	Total
6	Control	4.0 c	22.8 ab	22.7 ab	2.2 c	45.3	14.5	60.0
6	Hot Water	4.1 bc	24.1 a	24.4 a	4.7 bc	53.6	16.9	70.5
6	MC2	4.5 a	20.3 b	20.3 b	7.1 ab	55.8	16.7	72.6
3	Triform	4.5 a	24.0 a	22.6 ab	8.2 a	57.4	18.0	75.5
3	Sec/Chl	4.3 ab	24.1 a	22.9 ab	5.2 abc	54.7	15.3	70.1
	lsd	0.24	3.4	3.6	4.7	14.9	4.3	18.1

Table 2. Nematodes (per 100 cc of soil) by treatment at the MacMillan Bloedel nursery.

		Pathogens		Saprophytes	
N	Treatment	June	November	June	November
6	Control	0.5	52.3	108.3 a	164.2 a
6	Hot Water	1.8	46.0	85.7 ab	204.0 a
6	MC2	0.7	0.0	41.3 b	141.0 a
3	Triform	0.0	3.7	41.7 b	253.0 a
3	Sec/Chl	0.0	16.0	68.0 ab	404.7 b

Figure 1. Plot layout at the MacMillan Bloedel nursery.



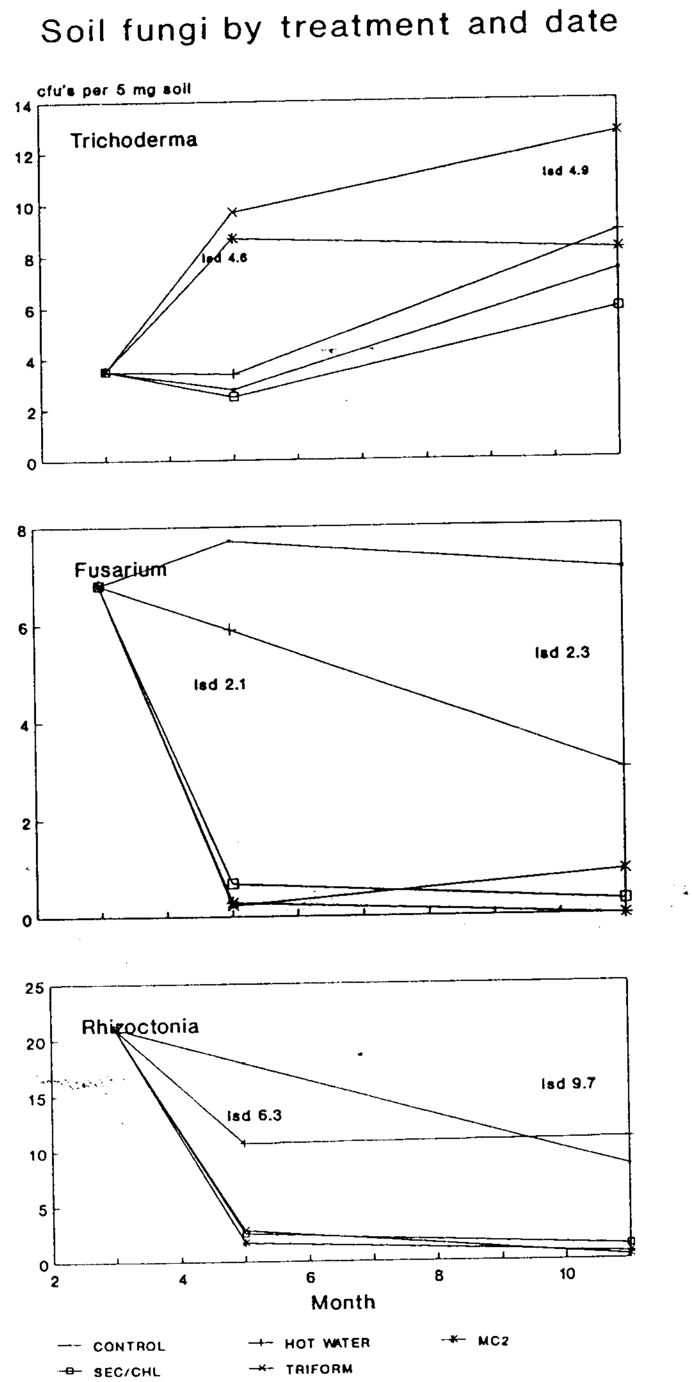


Figure 2. Colony forming units of Trichoderma, Fusarium, and Rhizoctonia by soil treatment and date at a forest tree nursery.

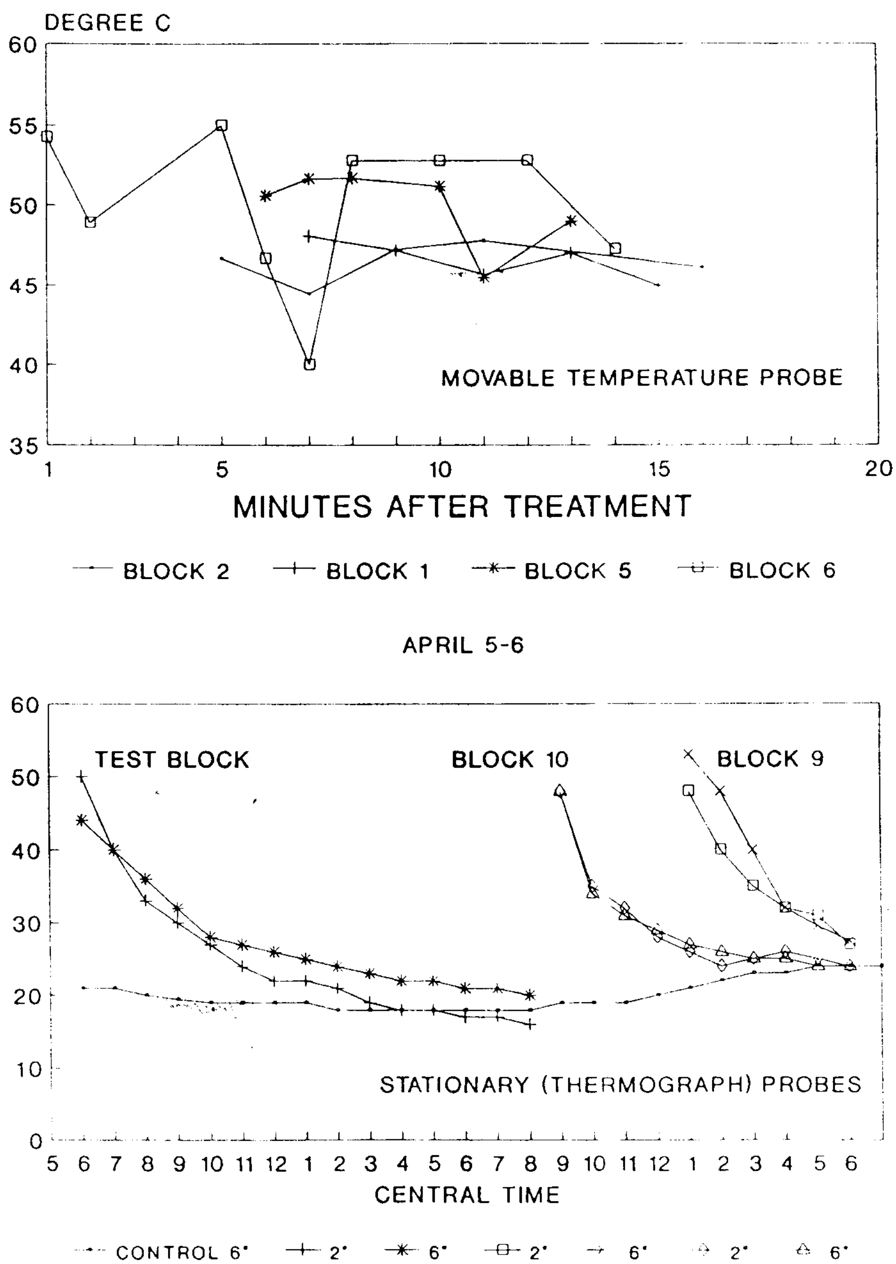


Figure 3. Soil temperatures after shank injecting and mechanically mixing (to a 6 inch depth) 110° C water at a rate of approximately 37,000 gallons per acre.