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EFFECT OF METHYL BROMIDE ALTERNATIVES ON SEEDLING QUALITY AND PATHOGENIC SOIL FUNGI AT THE GLENNVILLE REGENERATION CENTER

2007 – 2008

STUDY 1: SEEDLING QUALITY

by
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INTRODUCTION

The study reported herein is a portion of the USDA – ARS Area-wide Pest Management Project for Methyl Bromide Alternatives – South Atlantic Region, and part of a long-term continuing effort by the Auburn University Southern Forest Nursery Management Cooperative to identify and evaluate soil fumigants as an alternative to methyl bromide (MBr). Fumigation with methyl bromide has been the most commonly used method for producing high quality, pest-free forest tree seedlings in the southeastern United States. This is large scale study compares seven soil fumigants using operational application techniques and normal nursery management practices over two growing seasons at the Rayonier Regeneration Center in Glennville, GA. Information gathered from these studies should be used by nursery managers in the southern US to choose a MBr alternative that would be useful in the production of forest tree seedlings in their nurseries

METHODOLOGY

A soil fumigation trial was established in the forest seedling nursery at the Rayonier Regeneration Center in Glennville, GA to look at alternative fumigants for the production of forest tree seedlings over a two-year rotation. Soil fumigation treatments included MBr and six alternatives that are currently available for large-scale use (Table 1). With the exception of New Pic+, soil fumigants were selected based on results of small plot studies previously conducted by the Nursery Cooperative. New Pic+ is a reformulation of Pic+ which was tested previously in Texas at the Indian Mound Nursery (Research Report 08-07).

The soil fumigation trial occupied 10 acres out of a total 45 production acres (Tables 2 & 3) within the nursery. Fumigants were shank-injected in March 2007 and covered with 1 mm High Density Polyethylene Tarp (Cadillac Plastics Inc.) as broadcast/flat tarp. The trail was laid out in nursery sections consisting of nine seedling beds between irrigation pipelines, with each bed approximately 600' long. The experimental design was a randomized complete block which was replicated five times over the 12 nursery sections which had three fumigant plots per nursery section. The nursery sowed a single family of loblolly pine (*Pinus taeda*) seed in early April 2007 that were eventually lifted in mid October 2007. The second seedling crops' sowing occurred in mid-April 2008 with seedlings lifted in late October 2008.

Seedling and soil samples were collected from the middle seedling bed of each 3-bed treatment plot. In 2007 and 2008 soil samples were collected pre-sowing, post-sowing, mid-summer and just prior to seedling lifting in October. Half of each soil sample was plated onto *Trichoderma*-selective media (TSM) (Elad, Chet and Henis 1981) and the remaining half was sent to the Soils Laboratory at Auburn University for a quantitative assessment of nematode populations. Seedling densities and growth characteristics were assessed in four subplots (4' x 1') per each treatment plot at 7 wks post sowing, mid-summer (15 wks post sowing) and just prior to lifting in the fall (26 wks post sowing) in both production years. Twenty-five seedlings per subplot were collected in mid-summer and fall of the first year (2007) and only in fall of the second year (2008) to determine seedling quality and characteristics. Seedling root collar diameter (RCD), shoot height and seedling dry weight (biomass) was determined for each soil fumigant tested. To determine if the soil fumigant tested had any effect on root morphology (root length, root surface area, average root diameter and the number of root tips) ten seedlings per subplot were examined using WinRhizo® software by Regents Instruments Inc. Quebec, Canada.

RESULTS AND DISCUSSION

Seedling densities for 2007 were below target levels due to wind damage that occurred in April 2007 shortly after sowing. Taking this seedling reduction into account, there were no significant differences between seedling densities for any of the soil fumigants tested in 2007. While, seedling densities for the 2008 seedling crop were generally higher than 2007, they were still below target levels for all soil fumigants tested (Table 4). The true test of an MBr alternative is its' performance during the second growing season where treatment differences usually begin to appear. Unlike the 2007 growing season, where all soil fumigants were similar to MBr in producing seedlings, in 2008, soils treated with MBrC 70/30 and DMDS+Chloropicrin had significantly lower seedling densities when compared to the standard MBr treatment.

In the 2007 growing season there were no differences in seedling root collar diameters (RCD) among any of the soil fumigant tested as all were similar to MBr (Table 5). In 2008, soils treated with the various soil fumigants resulted in seedlings treated with Chloropicrin and Chlor 60 having significantly smaller RCD's than the other treatments used (Table 5). When considering seedling grades; Grade 1 = seedlings > 4.69 mm, Grade 2 = seedlings 3.2 - 4.69 mm and Cull = seedlings < 3.2 mm, the proportion of seedlings grown in 2007 for each grade was similar across all soil treatments tested: 77% Grade 1, 22% Grade 2 and 1% Cull. Not, surprising, in 2008 the proportion of Grade 1 seedlings declined for all soil treatments; with 56% Grade 1, 41% Grade 2 and 3% Cull (Figures 1 & 2). One possible explanation for the lower number of Grade 1 seedlings in the second cropping season (2008) could be the higher seedling densities that year. Higher seedling densities typically results in a lower mean RCD yielding fewer Grade 1 seedlings per sq ft. When comparing seedling densities and proportion of Grade 1 seedlings in 2008, two soil fumigants stand out. MBr has a high percentage of Grade 1 seedlings even though it has high seedling density. Soils fumigated with Chlor 60 had relatively low percentage Grade 1 seedlings even though those plots had a low seedling density (Figure 2). In contrast, soils fumigated with Chloropicrin had relatively low percentage Grade 1 seedlings from those plots, but had the highest seedling density.

Generally, seedling root architecture and root morphology indicated smaller seedlings in 2008 when compared to seedlings grown in 2007 (Table 6). As far as an MBr alternative, DMDS+Chlor performed best across all the root morphology measurements at Glennville. For root length and number of root tips Pic+ was significantly better than the other non-MBr fumigants. One of the aspects of determining the affects of MBr on root architecture is that a fibrous root system increases the chance of seedling survival in the field (Hatchell & Muse 1990, Frampton, Isik & Goldfard 2002, Davis & Jacobs 2005). An interesting point in quantifying root systems is that total seedling root length in these trials ranged from 142 cm to 304 cm, or about 5 - 10 feet of total fine roots per seedling.

The effects of soil fumigants on soilborne fungi in the 2007 growing season indicated that soils treated with MBr had significantly lower levels of *Trichoderma* than soil fumigants that used high levels of Chloropicrin (Table 7). Previous Nursery Cooperative research has shown that *Trichoderma* is an important soil borne fungus necessary for proper pine seedling growth (Cary, McCraw & Enebak 2005, Starkey, Enebak & McGraw 2006, Starkey & Enebak 2008). By the end of the second growing season in 2008 the *Trichoderma* levels within the various soil fumigants tested were similar to MBr. The DMDS+Chlor treated soils had more rapid *Trichoderma* growth compared to the other treatments.

Over the course of the 2-yr study each treatment was examined five times for the number and species of nematodes within the soil/seedling interface. Nematode populations within the soil are never uniformly distributed and these studies had a wide range in numbers and species for all soil fumigants used (Table 8). One of the more troublesome species on seedling production is the Stunt nematode which appeared during the second cropping season in all soil fumigants tested. Of the 7 soil fumigants, soils treated with Chlor 60 had the fewest nematode numbers. With Chlor 60 containing 40% 1, 3-dichorolpropene (Telone) one would expect this compound (labeled for nematodes) to have fewer nematodes and may be an option for nurseries that have nematode issues in the second growing season.

MANAGEMENT IMPLICATIONS

The primary objective of the USDA Areawide MBr Alternative program is to identify possible alternatives to MBr using large-scale, multi-year trials in soils and conditions throughout the southern U.S. One of the unique aspects of MBr as a soil fumigant is its ability to consistently control weeds, insects, nematodes and fungi across many different growing conditions. We have yet to find a MBr alternative (Magic Bullet) that fits those characteristics and these studies bear that out. When MBr is no longer available (either by CUE or QPS), those soil fumigants with Chloropicrin appear to be the most useful in controlling pests in Glennville, GA and producing high quality seedlings. The difference between Pic+ and New Pic+ is the solvent used in the application/injection process. When used as a soil fumigant, both treatments resulted in similar seedling characteristics (RCD, seedling densities, seedling root morphology, etc) and had similar affects on the levels of the important soil born fungi, *Trichoderma*. However, it was observed that the New Pic+ formulation did not control annual sedge (*Cyperus compressus*) when used and later, annual sedge became a problem in those plots. So much so, that we have dropped the use of this particular soil fumigant from further trials. DMDS+Chloropicrin resulted in adequate RCD and root morphology characteristics and soilborne *Trichoderma* levels, but had a significant odor problem that lasted into summer growing season. While DMDS + Chloropicrin resulted in adequate seedling characteristics, the lingering odor when this particular soil fumigant is used could limit its acceptance as an alternative to MBr. Of the other soil fumigants tested, Chlor 60 performed poorly in RCD, root length, root surface area characteristics. By far the best MBr alternative tested was Chloropicrin and Pic+, with both soil fumigants controlling weeds, nematodes and producing high quality seedlings. One of the potential pitfalls with using 100% Chloropicrin at 300 lbs/acre is the buffer zone restrictions. If these restrictions limit the use of 100% Chloropicrin, then Pic+, with 85% Chloropicrin would be the next best alternative at Glennville. The final decision when selecting a MBr alternative needs to take into consideration the ability of the soil fumigant to work under individual nursery soil conditions and the impact of the new EPA Reregistration Eligibility Decision (REDs) on each individual nursery. While it would be wonderful for nursery managers and researchers to continue to use MBr in perpetuity to grow forest tree seedlings, MBr is going to go away and each nursery manager will need to identify the best alternative for their nursery.

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Table 1. Fumigants and rates used in the 2007 Area-wide demonstration plots.

Fumigant	**Rate**	**Components**
MBr	350 lbs/a	67% MBr & 33% Chloropicrin
DMDS + Chloropricrin	74 gal/a (731 lb/a)	79% DMDS & 21% Chloropicrin
MBrC 70/30	400 lbs/a	70% MBr (98/2) & 30% Solvent A
New Pic+	300 lbs/a	85% Chloropicrin + 15% Solvent B
Pic+	300 lbs/a	85% Chloropicrin + 15% Solvent A
Chloropicrin	300 lbs/a	100% Chloropicrin
Chlor 60	400 lbs/a	60% Chloropicrin & 40% 1,3-D (Telone)

Table 2. Site information for Glennville fumigation.

	Glennville, GA
Fumigation	20-Mar-07
Fumigation type	Broadcast/flat tarp
Area in trial	10 acres
Air temperature range	50° to 78°F
Wind speed	3 – 13 mph
Soil moisture	5.5%
Soil series	Tifton loamy sand
Plastic in place	7 days

Table 3. Soil particle size analysis for Glennville, GA Trial.

Nursery	**% clay**	**% silt**	**% sand**	**Texture class**
Glennville, GA	10	5.9	84.1	Loamy sand

Table 4. Seedling density, Glennville, GA

Treatment	Oct 2007	Oct 2008
MBr	13.4 a	15.4 a
Chloropicrin	13.7 a	15.6 a
Chlor 60	13.2 a	14.5 ab
MBrC 70/30	12.5 a	12.9 b
DMDS+Chlor	13.7 a	12.9 b
Pic+	13.1 a	14.2 ab
New Pic+	13.9 a	14.4 ab
$lsd_{(0.05)}$	3.6	2.1

Within column means followed by the same letter do not differ at 0.05 level using Duncan's Multiple Range Test
Target seedling density is 18 seedlings/ft²

Table 5. Loblolly seedling RCD (mm), Glennville, GA

Treatment	Oct 2007	Oct 2008
MBr	5.34 a	4.93 ab
Chloropicrin	5.33 a	4.62 b
Chlor 60	5.41 a	4.58 b
MBrC 70/30	5.66 a	4.88 ab
DMDS+Chlor	5.49 a	5.14 a
Pic+	5.69 a	4.95 ab
New Pic+	5.55 a	4.91 ab
$lsd_{(0.05)}$	0.68	0.44

Within column means followed by the same letter do not differ at 0.05 level using Duncan's Multiple Range Test

Table 6. Loblolly pine seedling root morphology, Glennville, GA

Treatment	Root Length (cm)		Root Surface Area (cm²)		Avg Root Dia (mm)		No. Root tips	
	2007	2008	2007	2008	2007	2008	2007	2008
MBr	292 a	167 a	83 ab	45 ab	0.92 b	0.86 a	715 ab	366 a
Chloropicrin	218 b	152 ab	68 b	40 b	1.02 a	0.85 a	515 c	328 a
Chlor 60	289 a	148 ab	86 a	39 b	0.95 ab	0.87 a	738 ab	303 a
MBrC 70/30	304 a	157 ab	91 a	45 ab	0.98 ab	0.93 a	820 a	325 a
DMDS + Chlor	266 a	170 a	78 ab	48 a	0.95 ab	0.90 a	633 bc	342 a
Pic+	302 a	165 ab	88 a	48 a	0.93 b	0.93 a	735 ab	344 a
New Pic+	264 a	142 b	81 ab	41 ab	0.99 ab	0.94 a	680 b	310 a
$lsd_{(0.05)}$	49	25	17	7	0.08	0.12	137	86

Within column means followed by the same letter do not differ at 0.05 level using Duncan's Multiple Range Test

Table 7. Post-sowing recovery of *Trichoderma* from soil samples (colony fungal units/mg soil)

	2007			2008		
Treatment	**7 wks**	**15 wks**	**26 wks**	**7 wks**	**15 wks**	**26 wks**
MBr	137 a	75 bc	90 b	110 ab	110 ab	69 a
Chloropicrin	56 b	91 b	118 ab	114 ab	133 ab	60 a
Chlor 60	44 b	71 bc	90 b	83 b	69 b	49 a
MBrC 70/30	94 ab	54 c	98 b	98 ab	100 ab	60 a
DMDS+Chlor	84 ab	146 a	168 a	140 a	146 a	47 a
Pic+	63 b	94 b	108 b	82 b	114 ab	39 a
New Pic+	78 ab	68 bc	119 ab	96 ab	79 b	43 a
$lsd_{(0.05)}$	67	38	57	48	66	40

Within column means followed by the same letter do not differ at 0.05 level using Duncan's Multiple Range Test

Table 8. Glennville, GA nematode levels at lifting.

		2007 nematodes/100cc					2008 nematodes/100cc				
Trt	**Nematode**	**R1**	**R2**	**R3**	**R4**	**R5**	**R1**	**R2**	**R3**	**R4**	**R5**
MBr	Stunt	0	0	4	0	0	46	2	116	22	6
	Stubby root	6	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0
Chloropicrin	Stunt	0	0	0	0	8	38	10	76	0	2
	Stubby root	0	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0
Chlor 60	Stunt	0	0	0	0	0	10	2	16	4	0
	Stubby root	0	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0
MBrC 70/30	Stunt	0	0	22	0	0	98	82	138	48	4
	Stubby root	8	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0
DMDS+Chlor	Stunt	0	0	0	18	0	32	12	46	0	0
	Stubby root	0	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0
Pic+	Stunt	0	22	6	0	0	14	0	58	8	2
	Stubby root	0	0	0	4	0	0	0	0	0	0
	Ring	0	2	0	0	0	0	0	0	0	0
New Pic+	Stunt	26	42	0	6	0	6	154	98	424	18
	Stubby root	0	0	0	0	0	0	0	0	0	0
	Ring	0	0	0	0	0	0	0	0	0	0

Figure 1. Seedling grade by soil fumigant tested at Glennville, GA – 2007.

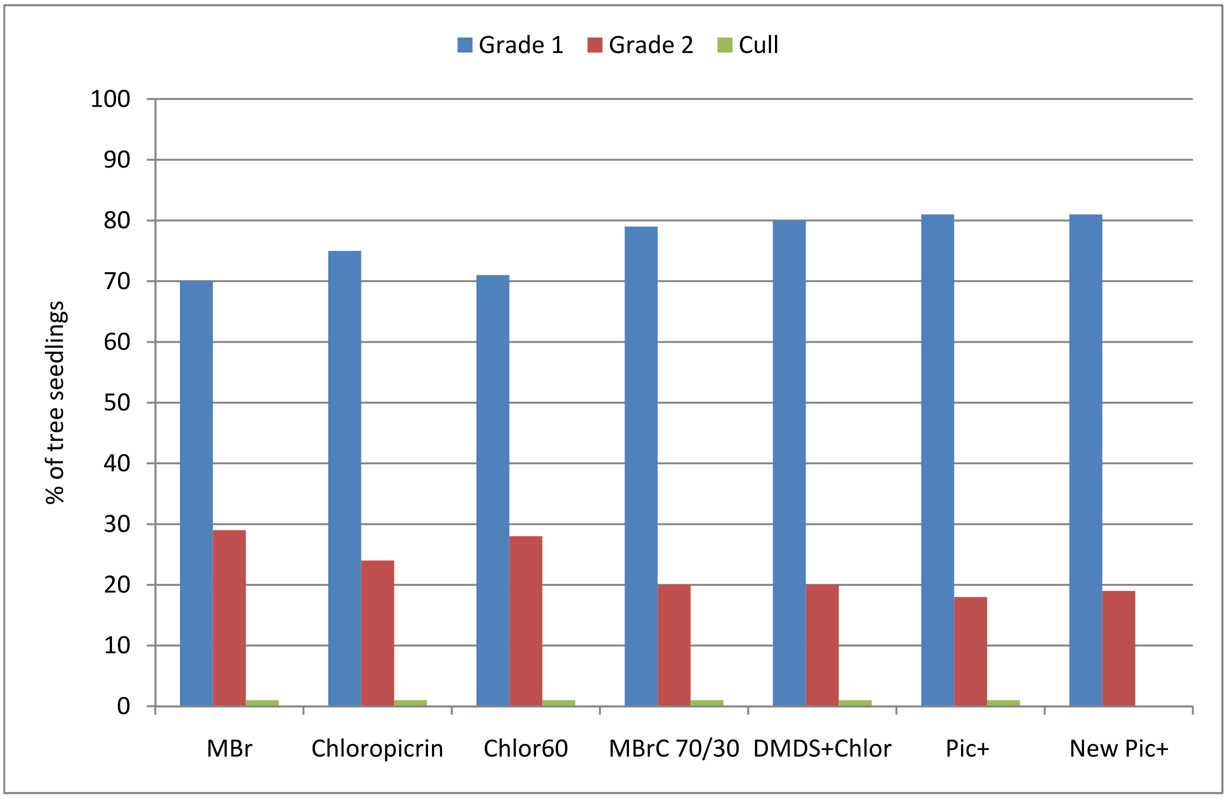
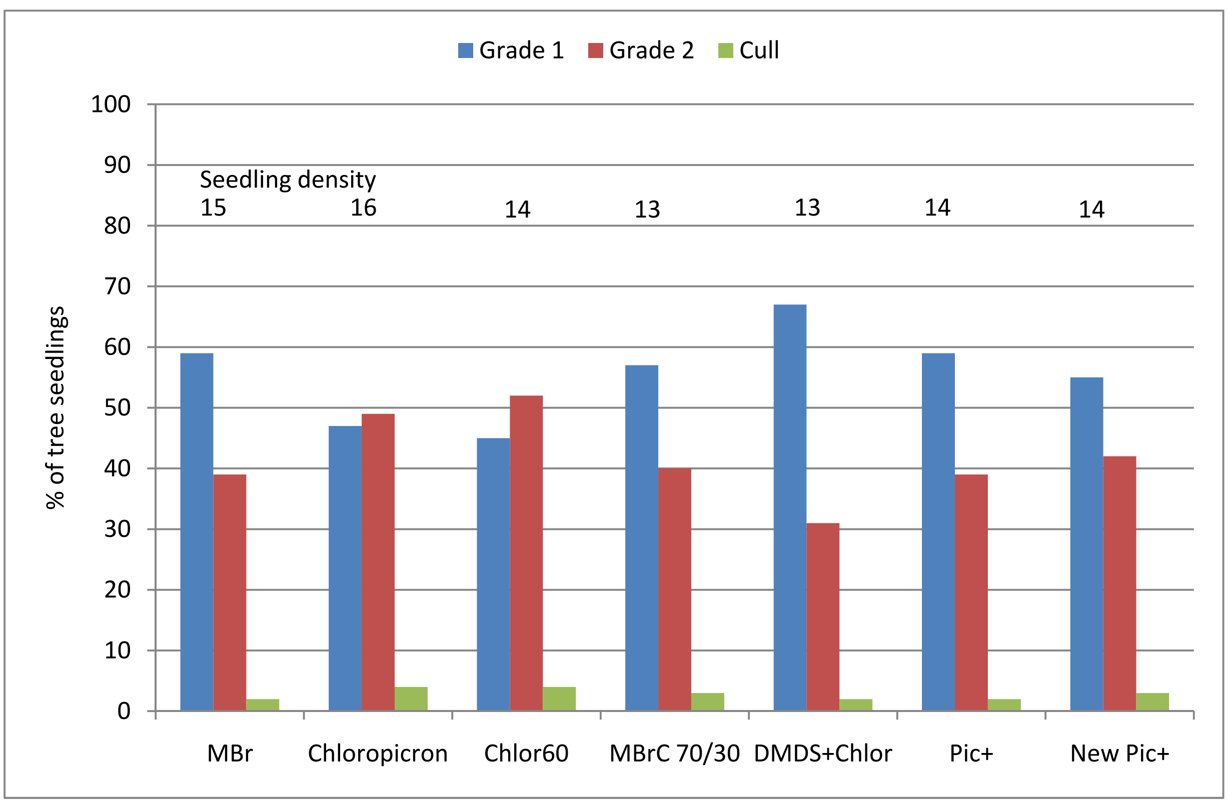


Figure 2. Seedling grade by soil fumigant tested at Glennville, GA – 2008.



EFFECT OF METHYL BROMIDE ALTERNATIVES ON SEEDLING QUALITY AND PATHOGENIC SOIL FUNGI AT THE GLENNVILLE REGENERATION CENTER

2007 – 2008

STUDY 2: SOIL PATHOGENIC FUNGI

INTRODUCTION

Forest nurseries in the United States have relied for many years on MBr soil fumigation to control weeds, pathogenic fungi, insects and nematodes. In the southern United States, there are three fungal genera that are of primary concern in the production of pine seedlings. These genera are: *Fusarium*, *Pythium* and *Rhizoctonia* which are associated with seedling root and foliage diseases.

For many years, nursery managers have recognized the importance of MBr to control these soil borne pathogens in the production of forest tree seedlings (Henry 1953). However, due to the concern over ozone depletion in the stratosphere, the use of MBr has begun a phase-out program as dictated by the 1987 Montreal Protocol. Finding alternatives for MBr has been a priority for the forest nursery industry and the Southern Forest Nursery Management Cooperative since 1991. Although it will be difficult to find a soil fumigant alternative that is as broad-spectrum as MBr, the nursery industry realizes the importance of testing new compounds, rates and application techniques.

The purpose of this study is to look at the efficacy of MBr and a number of fumigant alternatives against the soil borne fungi *Fusarium*, *Pythium* and *Rhizoctonia* that cause root and foliage diseases on forest tree seedlings in the southern United States.

METHODOLGY

A 12 section (9 bed rows each) soil fumigation trial was established at the forest tree nursery at Rayonier Regeneration Center, Glennville, GA, to look at alternative fumigants for the production of forest tree seedlings over a typical two-year rotation. The soil fumigants included in this study were determined from previous results of small plot studies conducted by the Nursery Cooperative. Methyl bromide and alternatives were applied during the spring 2007 fumigation (Table 9) and covered with 1 mm High Density Polyethylene Tarp (Cadillac Plastics Inc.) as broadcast/flat tarp. A single family of loblolly pine (*Pinus taeda*) was sown in soil fumigant alternative treatments.

The experimental design used a randomized complete block design replicated five times with each treatment 600 linear bed feet. The 600 linear bed feet of chloropicrin treatment in each replication was further subdivided as follows (Table 10). The same sequence of chloropicrin treatments was repeated in each replication:

In 2007 *Pythium, Rhizoctonia and Fusarium,* all known pathogenic soil borne fungi, were cultured in the laboratory on Potato Dextrose Agar. Approximately eight weeks prior to soil fumigation, agar plates of each fungi was used to inoculate bags containing moistened, sterilized oatmeal. The oatmeal bags were mixed on a regular basis to encourage fungal growth throughout the oatmeal. Two days prior to soil fumigation in Glennville, a 300 ml beaker of the oatmeal/fungus mixture was placed into a Hubco® Soil Sample Bags (5" x 7") whose top was folded over, stapled shut, and labeled as to the fungus.

As the soil fumigation was occurring, three Hubco bags, containing one species of each soilborne fungus were placed into each treatment listed in Table 9. Due to the shortage of Hubco bags, nursery soils that were to be fumigated with New Pic+ were not evaluated. For the soil fumigants placed under plastic, an 18" slit was cut and the three bags (one of each soilborne pathogenic fungus) were buried approximately 4 inches deep and 18" from the plastic edge. The slit was then sealed with fumigation tape. The bags in the sections without plastic were buried at the same depth in the fumigated area.

Six days after soil fumigation, the Hubco soil bags containing fungal inoculated oatmeal were removed from each of the soil fumigation plots, placed in a cooler and returned to the laboratory at Auburn University. In the laboratory, each Hubco soil bag was thoroughly mixed and then opened. From each fungal species, nine oatmeal pieces were placed in groups of three on the following selective media: 1) PARP media for *Pythium, 2)* Komada's media for *Fusarium* and 3) Ko and Hora's media for *Rhizoctonia* There were three agar plates for each replication and for each treatment.

One week after plating the inoculated, then fumigated oatmeal onto selective agar media, each plate was examined for fungal growth that would indicate the target soilborne pathogens. Of the three fungi tested, *Pythium* plates grew slower than the other two fungi. In addition to the soilborne pathogens, the numbers of oatmeal groups with nontarget fungi were also counted. As a control, bags of each soilborne pathogenic fungus not fumigated were also plated out on selective media as described above.

RESULTS AND DISCUSSION

The number of pathogenic (target) and nonpathogenic fungi (non target) recovered from bags fumigated is shown in Table 10. When non-fumigated control bags were plated onto their selective media, the individual soilborne fungus was recovered from 100% of all oatmeal groups on each plate. The following observations were made:

1. In general, fewer soilborne pathogenic fungi inoculated onto oatmeal were recovered than non-target fungi. The non-target fungi were primarily saprophytic fungi either *Penicillium* or *Aspergillus*.
2. Soil fumigation with either MBr or the other soil fumigant alternatives does not completely eliminate all soilborne fungi. This is important since growth of pine seedlings has been correlated with the occurrence of the beneficial genus of *Trichoderma* (Bailey and Lumsden 1998; Dong, et. al. 1987; Papavizas 1985; Mousseaux et.al. 1998; Samuels 1996).
3. All soil fumigants tested at the Glennville nursery were equally effective in eliminating the soilborne target fungi placed into the Hubco bags. However, a small amount (2%) of *Fusarium* in the Chlor 60 treatment and *Rhizoctonia* in the MBr treatment was recovered on agar plates.
4. When comparing Chloropicrin at 150 lbs/a under tarp with Chloropicrin at 150 lbs/a with no tarp the amount of non-target fungi recovered was not significantly different for *Pythium* and *Fusarium*. The amount of non-target fungi recovered in the *Rhizoctonia* was more than double for the no tarp as compared to under tarp and this difference was significant.
5. When comparing Chloropicrin at 300 lbs/a under tarp with Chloropicrin at 300 lbs/a with no tarp the amount of non-target fungi recovered was not significantly different for *Pythium, Fusarium or Rhizoctonia*.
6. When comparing Chloropicrin at 300 lbs/a under tarp with Chloropicrin at 150 lbs/a with no tarp the amount of non-target fungi recovered was not significantly different for *Pythium, Fusarium or Rhizoctonia*.

7. DMDS plus chloropicrin had the lowest recovery of non-target soilborne fungi compared to the other soil fumigants used. The difference in fungal recovery on the agar plates was apparent visually as after even seven days, many agar plates were void of any fungal growth.

MANAGEMENT IMPLICATIONS

Soil fumigation is an effective way to reduce pathogenic soilborne fungi that infect forest tree seedlings. All soil fumigants tested at the Glennville Regeneration Center were found to be effective in controlling *Pythium*, *Rhizoctonia* and, *Fusarium* when inoculated onto oatmeal. The wide spread use of MBr has minimized widespread seedling losses due to soilborne pathogenic fungi. Of the fungi tested, *Pythium* still can cause damping-off problems in the early spring and are often limited to areas of poor drainage and standing water. *Rhizoctonia* can appear in nurseries both as root decay and as foliage blight. Typically, the foliage blight is more severe in second year crops as the fungus increases in numbers over the first growing season.

The soil fumigants currently being tested in southern forest nurseries do not completely eliminate beneficial fungi which are needed for seedling growth. In these trials, the population levels of non target soilborne fungi rebounded quickly. In contrast, dazomet, a soil fumigant tested by the Nursery Cooperative for several years significantly reduced the levels of beneficial fungi which remained after two growing seasons (Starkey et. al. 2006).

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Table 9. Fumigants and rates used in 2007 Areawide demonstration plots.

Fumigant	Rate	Components
MBr	350 lbs/a	67% MBr & 33% Chloropicrin
DMDS+Chlor	731 lbs/a	79% DMDS & 21% Chloropicrin
MBrC 70/30	400 lbs/a	70% MBr (98/2) & 30% Solvent A
Pic+	300 lbs/a	85% Chloropicrin + 15% Solvent A
New Pic+	300 lbs/a	85% Chloropicrin + 15% Solvent B
Chloropicrin	300 lbs/a Under Tarp	100% Chloropicrin
Chloropicrin	300 lbs/a No Tarp	100% Chloropicrin
Chloropicrin	150 lbs/a Under Tarp	100% Chloropicrin
Chloropicrin	150 lbs/a No Tarp	100% Chloropicrin
Chlor 60	400 lbs/a	60% Chloropicrin & 40% 1,3-D

Table 10. Rate of chloropicrin and plastic used for each treatment.

Chloropicrin Rate	Plastic/None	Linear Bed Feet
300 lbs/a	Under plastic	450’
300 lbs/a	No plastic	50’
150 lbs/a	No plastic	50’
150 lbs/a	Under plastic	50’

Table 11. Proportion of pathogenic soilborne (target) and nonpathogenic fungi (non target) recovered from sample plates at Glennville, GA.

Glennville, GA		**Pythium**		**Fusarium**		**Rhizoctonia**	
Fumigant	**Rate**	**Target**	**NonTarget**	**Target**	**NonTarget**	**Target**	**NonTarget**
MBr	350 lbs/a	0.00 a	0.33 ab	0.00 a	0.42 a	0.02 a	0.27 bc
DMDS + Chlor	731 lbs/a	0.00 a	0.11 ab	0.00 a	0.18 a	0.00 a	0.00 c
MBrC 70/30	400 lbs/a	0.00 a	0.53 ab	0.00 a	0.60 a	0.00 a	0.51 ab
Pic+	300 lbs/a	0.00 a	0.13 ab	0.00 a	0.33 a	0.00 a	0.00 c
Chloropicrin	300 lbs/a plastic	0.00 a	0.04 b	0.00 a	0.26 a	0.00 a	0.11 bc
Chloropicrin	300 lbs/a no plastic	0.00 a	0.44 ab	0.00 a	0.22 a	0.00 a	0.48 ab
Chloropicrin	150 lbs/a plastic	0.00 a	0.41 ab	0.00 a	0.41 a	0.00 a	0.41 bc
Chloropicrin	150 lbs/a no plastic	0.00 a	0.56 a	0.00 a	0.52 a	0.00 a	0.85 a
Chlor 60	400 lbs/a	0.00 a	0.09 ab	0.02 a	0.13 a	0.00 a	0.04 c
	lsd	*0.00*	*0.44*	*0.03*	*0.44*	*0.03*	*0.34*

Within column means followed by the same letter do not differ at 0.05 level using Duncan's Multiple Range Test