RESEARCH REPORT 10-09

EFFECT OF METHYL BROMIDE ALTERNATIVES ON SEEDLING QUALITY AT THE ARBORGEN SUPERTREE NURSERY, BLENHEIM, SC
2008 – 2009

by
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INTRODUCTION

As part of a long-term, continuing effort on the members of the Southern Forest Nursery Management Cooperative to identify and evaluate soil fumigants as an alternative to methyl bromide (MBr), a 5-year program funded by the USDA – ARS Area-wide Pest Management Project for Methyl Bromide Alternatives – South Atlantic Region, was undertaken in 2006. While 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, concerns from EPA, and the United Nations on the continued reliance of MBr in these production systems has resulted in new soil fumigant chemistries. This large scale study compares seven soil fumigants using operational application techniques and normal nursery management practices over two growing seasons at the Arborgen Supertree Nursery in Blenheim, SC in the production of loblolly pine. Information gathered from these studies should be used by nursery managers in the southern U.S. to choose an MBr alternative that would be useful in the production of forest tree seedlings in their nurseries.

METHODOLOGY

Soil fumigation treatments included two MBr rates and five currently available alternatives (Table 1). These soil fumigants were selected based on results of small plot studies previously conducted by the Nursery Cooperative. The trial occupied 4.5 acres out of a total 77 production acres within the nursery (Table 2). Soil fumigants were shank-injected in April 2008 and covered with 1 mm High Density Polyethylene Tarp (Cadillac Plastics Inc.) as broadcast/flat tarp. The trial was laid out in nursery sections that contained nine seedling beds between irrigation pipelines, with each treatment plot approximately 280' long x 12' wide. The experimental design was a randomized complete block replicated four times over the five nursery sections. Each 9-

bed nursery section contained three soil treatments. The nursery sowed a single family of loblolly pine (*Pinus taeda*) seed in early April 2008 with the seedlings lifted in early December 2008. The second seedling crops' sowing occurred in mid-April 2009 with seedlings lifted in December 2009.

Seedling and soil samples were collected from the middle seedling bed of each 3-bed treatment plot within the section. In 2008 soil samples were collected pre-sowing, post-sowing and just prior to seedling lifting in December. In 2009 soil samples were collected post-sowing, mid-summer and just prior to lifting in December. 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 per 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. At the end of each growing season, twenty-five seedlings per subplot were collected to determine the effect of each soil fumigant on seedling quality. Parameters measured for each seedling included root collar diameter (RCD), shoot height and seedling dry weight (biomass), also root morphology (root length, root surface area, average root diameter and the number of root tips), were measured on ten seedlings per subplot using WinRhizo® software by Regents Instruments Inc. Quebec, Canada.

RESULTS AND DISCUSSION

At the end of the first growing season, there were no significant differences among any of the soil fumigants tested for seedling densities. Thus, MBr alternatives were equally effective in producing similar numbers of seedlings as MBr. Generally, evaluations of MBr alternatives are conducted over two growing seasons because the true test of a soil fumigant is its performance during the second growing season where treatment differences usually begin to appear. Like that of 2008, seedling densities for all soil fumigants in 2009 were at or slightly above the nursery target levels of 22 seedlings/ft^2 (Table 3).

In the 2008 growing season seedlings growing in soils treated with either Chloropicrin or DMDS+Chlor had significantly larger RCD than seedlings from soils treated with 235 lbs/acre of MBr and the MBrC 70/30 (Table 4). It is interesting to note that the two soil treatments with the smallest RCD had the lowest amount of MBr (235 and 280 lb/acre), respectively. These rates were lower than the MBr#1 (400 lbs/acre) treatment. In 2009, seedlings grown in soils fumigated with DMDS+Chlor and Pic+ had larger RCD's than either of the MBr treatments. The proportion of seedlings for each grade in 2008 was variable across all soil treatments examined with none of the soil fumigants standing out. In contrast, Chlor 60 had the highest proportion of seedling culls when compared to the other soil fumigants tested. In 2009, the proportion of Grade 1 seedlings increased for all soil treatments except 100% Chloropicrin which decreased 3%. The average increase in Grade 1 seedlings in 2009 across all treatment was 10% (Figures 1 & 2).

Except for average root diameter, the overall seedling root architecture and root morphology was less during the 2009 growing season than the 2008 growing season (Table 5). Of the soil fumigants tested at this nursery, Pic+ and Chlor 60 consistently resulted in the best root morphology of the MBr alternatives. 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 181 cm to 439 cm, or about 6 - 14 feet of total fine roots per seedling.

At the end of the 2008 growing season, soils treated with Chlor 60 had significantly higher levels of the soil borne fungus *Trichoderma* than fumigation treatments that contained some level of methyl bromide (Table 6). 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 2009 the *Trichoderma* levels within the soil fumigants tested were similar to MBr. The higher rate of MBr (400 lbs/acre) had higher *Trichoderma* levels than MBr at 235 lbs/acre.

Over the course of the 2-yr study nematodes were assayed five times for both the number and nematode species within the soil/seedling interface. Nematode populations within the soil are never uniformly distributed and these studies had relatively low numbers for all soil fumigants used (Table 7). Thus, there is no data to suggest that one soil fumigant is better than another in controlling nematodes as they were equally as effective as MBr. It is interesting to note that Chlor 60 which contains Telone®, a registered nematicide, had more species of nematodes that all other fumigants.

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 a number of different soils and growing conditions throughout the southern US. 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 an MBr alternative 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 most useful in controlling pests at Blenheim, SC and producing high quality seedlings. MBr alternatives that could be considered for Blenheim are Pic+, DMDS+Chlor and Chlor 60. While there have been good seedling results when the soil fumigant DMDS+Chlor (Paladin®) is used, this compound has a significant odor problem that persisted into the summer growing season which will limit its acceptance as an alternative. Chlor 60 had more nematodes (numbers & species) despite having Telone®, and the largest percent of cull seedlings in the first growing season. The large percentage of culls with this soil fumigant during this growing season is unexplainable. Of the alternative soil fumigants tested, Pic+ performed the best for seedling production at Blenheim, SC. 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 useful for nursery managers and researchers to continue to use MBr to grow forest tree seedlings, MBr will eventually be unobtainable and each nursery manager will need to identify the best alternative for their nursery.

REFERENCES

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Table 1. Fumigants and rates used in the 2008 Area-wide demonstration plots.

Fumigant	**Rate**	**Components**
MBr #1	400 lbs/acre	98% MBr & 2% Chloropicrin
MBr #2	235 lbs/acre	98% MBr & 2% Chloropicrin
DMDS+Chloropricrin	70 gal/acre*	79% DMDS & 21% Chloropicrin
MBrC 70/30	400 lbs/acre	70% MBr (98/2) & 30% Solvent A
Pic+	300 lbs/acre	85% Chloropicrin + 15% Solvent A
Chloropicrin	300 lbs/acre	100% Chloropicrin
Chlor 60	400 lbs/acre	60% Chloropicrin & 40% 1,3-D (Telone®)

* Label rate changed after Oct 2007 from 74 gal/acre to the current rate. Compound is now labeled under the name Paladin®.

Table 2. Site information for Blenheim, SC fumigation.

	Blenheim, SC
Fumigation date	3-Apr-08
Fumigation type	Broadcast/flat tarp
Area in trial	4.5 acres
Air temperature range	44° to 48°F
Wind speed	5 – 11 mph
Soil moisture	7%
Soil series	Autryville sand
Plastic in place	7 days
Soil particle size	7.5% clay, 5.5% silt, 87.1% sand (Loamy sand)

Table 3. Seedling density, Blenheim, SC

Treatment	Dec 2008	Dec 2009
MBr #1	22 a	23 a
MBr #2	21 a	23 a
Chloropicrin	23 a	23 a
Chlor 60	23 a	23 a
MBrC 70/30	22 a	22 a
DMDS+Chlor	23 a	24 a
Pic+	22 a	23 a
$lsd_{(0.05)}$	2	2

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 22 seedlings/ft².

Table 4. Loblolly seedling RCD (mm), Blenheim, SC

Treatment	Dec 2008	Dec 2009
MBr #1	4.37 ab	4.38 cd
MBr #2	3.93 c	4.21 d
Chloropicrin	4.46 a	4.43 bcd
Chlor 60	4.22 ab	4.52 bc
MBrC 70/30	4.18 b	4.32 cd
DMDS+Chlor	4.43 a	4.81 a
Pic+	4.32 ab	4.65 ab
$lsd_{(0.05)}$	0.25	0.28

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

Table 5. Loblolly pine seedling root morphology, Blenheim, SC

Treatment	Root Length (cm)		Root Surface Area (cm²)		Avg Root Dia (mm)		No. Root tips	
	2008	2009	2008	2009	2008	2009	2008	2009
MBr #1	420 ab	217 ab	79 a	74 a	0.59 a	1.09 a	826 ab	474 abc
MBr #2	346 b	209 ab	62 a	72 a	0.57 a	1.10 a	724 b	449 abc
Chloropicrin	419 ab	181 b	76 a	58 a	0.58 a	1.05 a	830 ab	400 bc
Chlor 60	416 ab	229 a	77 a	78 a	0.59 a	1.09 a	838 ab	502 ab
MBrC 70/30	408 ab	205 ab	75 a	69 a	0.59 a	1.09 a	832 ab	418 bc
DMDS+Chlor	439 a	198 ab	80 a	70 a	0.58 a	1.14 a	850 a	397 c
Pic+	411 ab	224 ab	75 a	76 a	0.58 a	1.12 a	801 ab	529 a
$lsd_{(0.05)}$	86	45	19	21	0.56	0.11	122	105

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

Table 6. Post-sowing recovery of *Trichoderma* from soil samples (colony forming units/mg soil)

	2008		2009		
Treatment	**7 wks**	**26 wks**	**7 wks**	**15 wks**	**26 wks**
MBr #1	52 a	10 b	47 b	28 ab	114 a
MBr #2	53 a	31 b	20 b	15 b	40 b
Chloropicrin	79 a	58 ab	56 ab	33 ab	65 ab
Chlor 60	80 a	107 a	99 a	55 a	76 ab
MBrC 70/30	83 a	41 b	24 b	18 b	79 ab
DMDS+Chlor	61 a	59 ab	31 b	17 b	62 ab
Pic+	70 a	67 ab	92 a	37 ab	68 ab
$lsd_{(0.05)}$	33	67	48	37	63

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

Table 7. Blenheim, SC average nematode levels/100cc at lifting.

Treatment	Nematode	2008	2009
MBr #1	Ring	0	0.5
MBr #2	Stunt	0.5	0
Chloropicrin	Stubby root	0	0.5
	Lesion	0	0.5
Chlor 60	Stunt	0.5	0
	Ring	0	1.5
	Stubby root	0	0.5
	Lesion	0	0.5
MBrC 70/30	Ring	0	1.5
	Lesion	0	1.5
DMDS+Chlor	Stunt	1.5	0
	Ring	0	1
	Stubby root	0	0.5
Pic+	Ring	0	1.5
	Stubby root	0	0.5

Figure 1. Seedling grade by soil fumigant tested at Blenheim, SC – 2008.

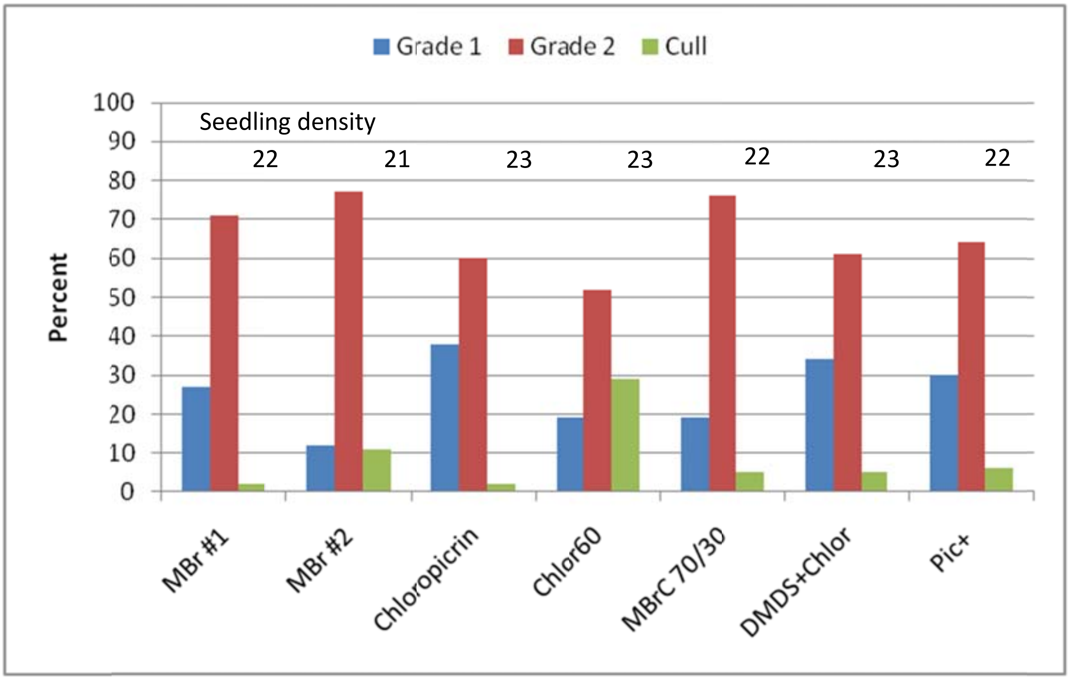

Figure 2. Seedling grade by soil fumigant tested at Blenheim, SC – 2009.