Auburn University
Southern Forest Nursery
Management Cooperative

# RESEARCH REPORT 10-07

## EFFECT OF METHYL BROMIDE ALTERNATIVES ON SEEDLING QUALITY AT THE SOUTH CAROLINA FORESTRY COMMISSION TAYLOR FOREST TREE NURSERY 2008-2009

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 MBr has been the most commonly used method for producing high quality, pest-free forest tree seedlings in the southeastern United States. This large scale study compares seven soil fumigants and a non-fumigated treatment using operational fumigation methods and standard operating nursery management practices over two growing seasons at the South Carolina Forestry Commission Taylor Forest Tree Nursery in Trenton, SC. Information gathered from this study 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

The soil fumigation trial included two rates of MBr, five currently available alternatives and a non-fumigated control treatment (Table 1). Soil fumigants were selected based on results of studies previously conducted by the Nursery Cooperative. The trial occupied five acres out of a total 31 production acres (Table 2) within the nursery. Fumigants were shank-injected in October 2007 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 consisted of six seedling beds between the irrigation pipelines. Each bed was approximately 400’ long x 4’ wide. The experiment was a randomized complete block design that was replicated five times over 14 nursery sections (areas between irrigation risers). Each 6-bed nursery section included three soil fumigant treatments (2 nursery beds per treatment). After soil fumigation treatments, the nursery sowed a single family of loblolly pine (*Pinus taeda*) seed in early April, 2008. The seedlings were maintained as per standard growing conditions (irrigation, fertilization, etc) at this nursery and were lifted in mid October, 2008. The second growing season was sown to loblolly pine in mid-April, 2009 with second crop of seedlings lifted in October, 2009.

Soil fumigant effectiveness was determined by measuring seedling quality and soil-borne fungi levels during both growing seasons. To ensure treatment integrity, seedling and soil samples were collected from one seedling bed of each 2-bed treatment plot. In 2008, soil samples were collected pre-sowing, post-sowing and just prior to seedling lifting in the fall. In 2009, soil samples were collected post-sowing, mid-summer and just prior to lifting. 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 (1' x 4') subplots per treatment 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 years. At the end of each growing season, 25 seedlings per subplot were removed from the seedling beds to determine seedling quality. Characteristics measured included seedling root collar diameter (RCD), shoot height and seedling dry weight (biomass). In addition, root morphology (root length, root surface area, average root diameter and the number of root tips) on ten seedlings per subplot were measured using WinRhizo® software by Regents Instruments Inc. Quebec, Canada.

## RESULTS AND DISCUSSION

Seedling stand densities for all soil fumigant treatments in 2008 and 2009 were below the nursery target goal of 23 seedlings/ft². Seedling densities were similar for all 7 soil fumigants tested at this nursery (Table 3). One explanation for the low seedling densities observed in these trials is due to the seed used in the trial and the length of time (6 yrs) the study area was out of production. Low germination of the seed and years out of production reduced the number of seedlings that developed. In addition, Trenton had a major rain event in the spring of 2009 that washed a good portion of pine seed from the beds resulting in seedling loss in that area. Generally, because most nurseries are able to produce 2-3 seedling crops per soil fumigation, evaluations of soil fumigants are collected over two growing seasons. The true test of an MBr alternative is its performance during the second growing season when treatment differences usually begin to appear.

In the 2008 growing season the root collar diameter (RCD) of loblolly pine seedlings growing in the non-fumigated treatment was significantly smaller than all other soil fumigants. Of the soil fumigants tested at this nursery, seedlings growing in Pic+ were significantly larger than seedlings growing in MBr, DMDS+Chlor and Chlor 60 treated soils (Table 4). Not unexpected, the effect of soil fumigants in producing larger seedlings was lessened, and in 2009, there was no significant difference in seedling RCD between MBr, Pic+ and the non-fumigated treatments.

The proportion of seedlings produced in 2008 for each grade was similar for all soil fumigants tested: 22% Grade 1, 60% Grade 2 and 20% Cull, except the non-fumigated soil which had the greatest percent of culls with 68% (Figure 1). In 2008, soils treated with Pic+ had a greater proportion of Grade 1 seedlings than all the other soil fumigant treatments examined. In 2009, the proportion of Grade 1 seedlings increased for all soil treatments; with 44% Grade 1, 46% Grade 2 and 9% Cull (Figures 1 & 2). In 2009, the higher proportion Grade 1 and Grade 2 seedlings resulted in a lower proportion of cull seedlings compared to 2008. As expected, the non-fumigated soils produced the highest proportion of cull seedlings. Lower seedling densities typically results in a higher seedling RCD (less seedling to seedling competition), yielding more Grade 1 seedlings per

square foot. Thus, the higher number of Grade 1 seedlings in the second season (2009) is due to the lower seedling densities, 11 trees/sq ft compared to an average of 16 trees/sq ft in 2008.

In general, the overall seedling root architecture and root morphology was less in 2008 than in 2009 (Table 5). The soil fumigants DMDS+Chlor and Chloropicrin consistently resulted in the best root morphology of the MBr alternatives tested at Trenton, SC. One aspect of a fibrous root system is an increase in seedling survival in the field (Hatchell & Muse 1990, Frampton, Isik & Goldfard 2002, Davis & Jacobs 2005). Total seedling root length in these trials ranged from 189 cm to 296 cm, or about 6 - 10 feet of total fine roots per seedling.

At the end of the 2008 growing season, soils treated with MBr had significantly lower levels of *Trichoderma* than treatments that contained Chloropicrin (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, *Trichoderma* levels within the soil fumigants examined were similar to those soils treated with MBr. The non-fumigated soils (6+ yrs) had the highest levels of *Trichoderma* out of all the soil fumigants.

Over the course of the 2-yr study, soils were assayed five times for the number and species of nematodes within the experimental plots. Nematode populations within the soil are generally distributed unevenly throughout the soil and these studies had a range in both, number per 100 cubic centimeters and species for all soil fumigants used (Table 7). Stunt nematode, which can cause problems in seedling nurseries, appeared in all soil fumigant treatments during the second cropping season. Of the fumigants tested, soils treated with Chlor 60 had the fewest nematode numbers overall. Since Chlor 60 contains 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 problems.

## MANAGEMENT IMPLICATIONS

The primary objective of the USDA Area-wide MBr Alternative program is to identify possible alternatives to MBr using large-scale, multi-year trials throughout the southern US. One unique aspect of MBr as a soil fumigant is its ability to consistently control 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 through the Critical Use Exemption or Quarantine and Pre Shipment), those soil fumigants with Chloropicrin appear to be the most useful in controlling pests and producing high quality seedlings in Trenton, SC. DMDS+Chloropicrin resulted in adequate RCD and root morphology characteristics and soil-borne *Trichoderma* levels. However DMDS+Chloropicrin had a significant odor problem that lasted into the summer growing season which will limit its acceptance as an alternative. By far the best MBr alternatives tested were Chloropicrin and Chlor 60, with both soil fumigants controlling nematodes and producing quality seedlings. If buffer zone restrictions limit the use of 100% Chloropicrin, then Chlor 60, with 60% Chloropicrin would be the next best alternative at Trenton, SC. The final decision in selecting an MBr alternative will vary by nursery. Each nursery 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). MBr will eventually be phased out and each nursery needs to identify the best alternative for their nursery in order to continue growing forest tree seedlings.

## 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/a | 98% MBr & 2% Chloropicrin |
| MBr #2 | 235 lbs/a | 98% MBr & 2% Chloropicrin |
| DMDS + Chlor | 74 gal/a (731 lb/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 |
| Chloropicrin | 300 lbs/a | 100% Chloropicrin |
| Chlor 60 | 400 lbs/a | 60% Chloropicrin & 40% 1,3-D (Telone) |

DMDS = dimethyl disulfide Chlor = Chloropicrin

**Table 2.** Site information for Trenton, SC fumigation.

| | Trenton, SC |
|---|---|
| Fumigation | 2-Oct-07 |
| Fumigation type | Broadcast/flat tarp |
| Area in trial | 5 acres |
| Air temperature range | 61° to 82°F |
| Wind speed | 3 – 11 mph |
| Soil moisture | 5% |
| Soil series | Wagram sand |
| Plastic in place | 10 days |
| Soil particle size | 10% clay, 14.7% silt, 75.4% sand (Sandy loam) |

**Table 3.** Seedling density, Trenton, SC

| Treatment | Oct 2008 | Oct 2009 |
|---|---|---|
| MBr #1 | 16.9 a | 11.0 a |
| MBr #2 | 15.7 a | 10.7 a |
| Chloropicrin | 15.8 a | 10.7 a |
| Chlor 60 | 15.0 a | 10.6 a |
| MBrC 70/30 | 16.3 a | 10.9 a |
| DMDS+Chlor | 16.1 a | 10.6 a |
| Pic+ | 16.2 a | 11.3 a |
| Non-fumigated | 16.3 a | 10.8 a |
| | | |
| $lsd_{(0.05)}$ | 2.2 | 2.0 |

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 23 seedlings/ft²

**Table 4.** Loblolly seedling RCD (mm), Trenton, SC

| Treatment | Oct 2008 | Oct 2009 |
|---|---|---|
| MBr #1 | 4.02 b | 4.51 abc |
| MBr #2 | 3.97 b | 4.52 abc |
| Chloropicrin | 4.08 ab | 4.61 ab |
| Chlor 60 | 4.00 b | 4.65 ab |
| MBrC 70/30 | 4.10 ab | 4.79 a |
| DMDS+Chlor | 3.89 b | 4.61 ab |
| Pic+ | 4.34 a | 4.48 bc |
| Non-fumigated | 3.08 c | 4.33 c |
| | | |
| $lsd_{(0.05)}$ | 0.32 | 0.29 |

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, Trenton, SC

| Treatment | Root Length (cm) | | Root Surface Area ($cm^2$) | | Avg Root Dia (mm) | | No. Root tips | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2008 | 2009 | 2008 | 2009 | 2008 | 2009 |
| MBr #1 | 239 bc | 233 a | 48 b | 90 ab | 0.67 ab | 1.25 bc | 518 abc | 547 a |
| MBr #2 | 248 ab | 262 a | 54 ab | 98 ab | 0.69 ab | 1.22 c | 527 abc | 706 a |
| Chloropicrin | 234 bc | 251 a | 54 ab | 106 ab | 0.73 a | 1.36 a | 490 bc | 661 a |
| Chlor 60 | 273 ab | 255 a | 59 ab | 100 ab | 0.69 ab | 1.26 bc | 567 ab | 652 a |
| MBrC 70/30 | 272 ab | 215 a | 58 ab | 83 b | 0.68 ab | 1.25 bc | 599 ab | 553 a |
| DMDS+ Chlor | 258 ab | 267 a | 58 ab | 112 a | 0.72 a | 1.34 ab | 533 abc | 662 a |
| Pic+ | 296 a | 240 a | 64 a | 93 ab | 0.70 a | 1.24 c | 616 a | 629 a |
| Non-fumigated | 189 c | 266 a | 36 c | 106 ab | 0.62 b | 1.27 bc | 446 c | 660 a |
| | | | | | | | | |
| $lsd_{(0.05)}$ | 58 | 56 | 14 | 26 | 0.07 | 0.09 | 121 | 211 |

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 ab | 7 c | 53 a | 69 a | 83 ab |
| MBr #2 | 71 a | 22 bc | 54 a | 74 a | 101 ab |
| Chloropicrin | 31 b | 53 a | 69 a | 76 a | 61 b |
| Chlor 60 | 40 b | 63 a | 57 a | 57 a | 67 ab |
| MBrC 70/30 | 49 ab | 10 bc | 69 a | 71 a | 96 ab |
| DMDS+Chlor | 46 ab | 60 a | 62 a | 74 a | 77 ab |
| Pic+ | 48 ab | 37 ab | 49 a | 54 a | 67 ab |
| Non-fumigated | 44 ab | 14 bc | 69 a | 69 a | 124 a |
| | | | | | |
| $lsd_{(0.05)}$ | 31 | 30 | 39 | 32 | 60 |

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

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

| Treatment | Nematode | 2008 | 2009 |
|---|---|---|---|
| MBr #1 | Stunt | 1.6 | 24.4 |
| | Root knot | 0 | 0.4 |
| | Ring | 0 | 0 |
| | Spiral | 1.2 | 0 |
| MBr #2 | Stunt | 1.2 | 8 |
| | Root knot | 0.4 | 0 |
| | Ring | 0.4 | 0 |
| | Spiral | 0.4 | 0 |
| Chloropicrin | Stunt | 27.2 | 69.6 |
| | Root knot | 0 | 0.4 |
| | Ring | 0 | 0 |
| | Spiral | 204 | 0 |
| Chlor 60 | Stunt | 21.2 | 61.6 |
| | Root knot | 0 | 2.4 |
| | Ring | 0 | 0 |
| | Spiral | 2.4 | 0 |
| MBrC 70/30 | Stunt | 1.6 | 9.2 |
| | Root knot | 0 | 0.4 |
| | Ring | 0 | 0 |
| | Spiral | 0 | 0 |
| DMDS+Chlor | Stunt | 8 | 95.6 |
| | Root knot | 0 | 0 |
| | Ring | 0 | 0 |
| | Spiral | 1.6 | 0 |
| Pic+ | Stunt | 11.6 | 136 |
| | Root knot | 0 | 0 |
| | Ring | 0.8 | 2.4 |
| | Spiral | 0.8 | 0 |
| Non-fumigated | Stunt | 49.2 | 90.8 |
| | Root knot | 0 | 0 |
| | Ring | 11.2 | 0 |
| | Spiral | 4.4 | 0 |

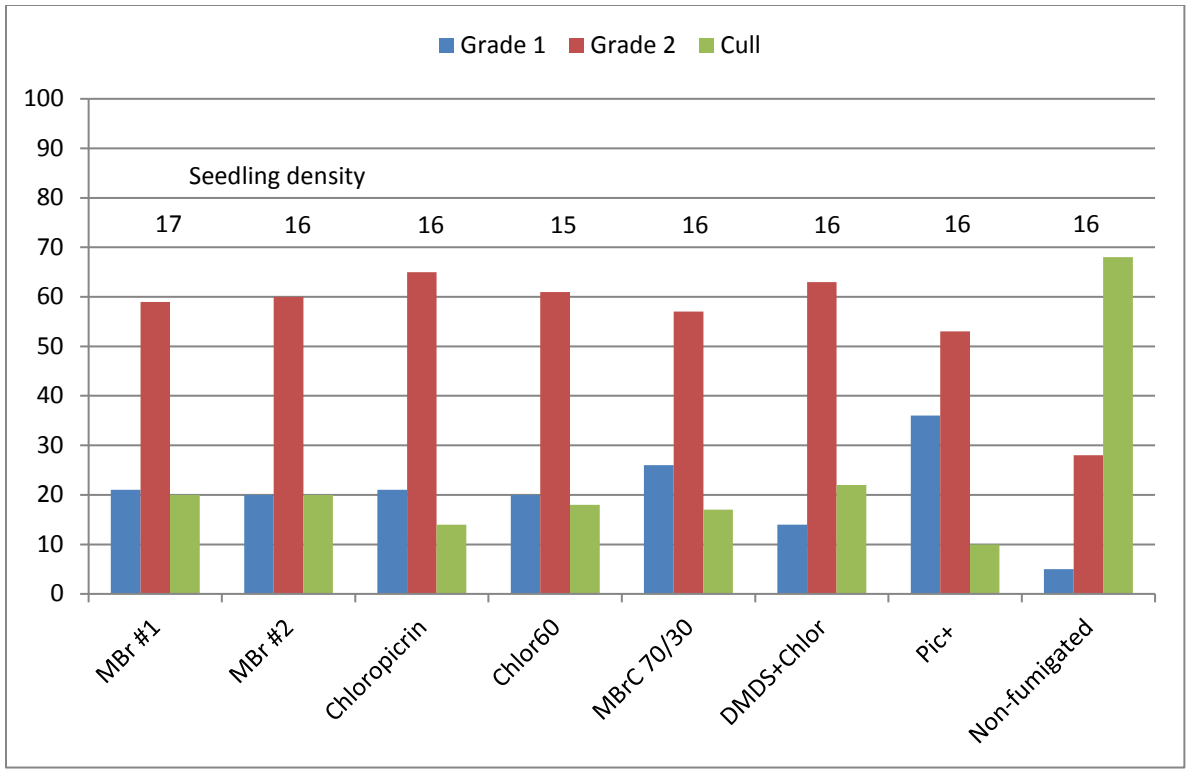


**Figure 1.** Seedling grade by soil fumigant tested at Trenton, SC – 2008.

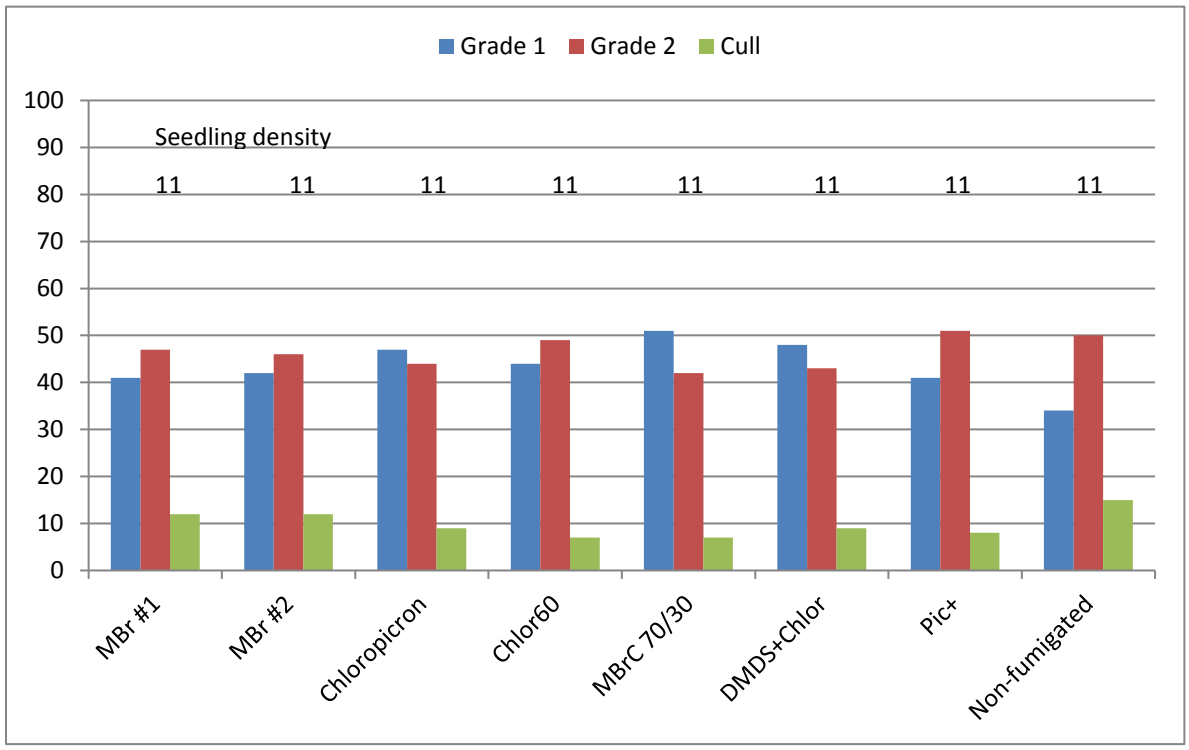


**Figure 2.** Seedling grade by soil fumigant tested at Trenton, SC – 2009.