Auburn University
Southern Forest Nursery Management Cooperative

RESEARCH REPORT 08-07

INDIAN MOUND NURSERY, TEXAS:
METHYL BROMIDE ALTERNATIVE STUDY 2005 - 2007

by
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INTRODUCTION

These studies are part of a long-term effort by the Auburn University Southern Forest Nursery Management Cooperative to identify and evaluate soil fumigant alternatives to methyl bromide. Fumigation with methyl bromide has been the most commonly used method for producing high quality, pest-free forest nursery seedlings in the southeastern United States. The data discussed in this report covers two growing seasons.

METHODOLOGY

Two fumigation trials were established at the Indian Mound Nursery in Alto, TX in 2005 with the objective to examine alternative soil fumigants for the production of seedlings over a typical two-year rotation. In **Study I**, Basamid (Bas - 450 lbs/ac) was applied in October, 2005, tilled and water applied via irrigation pipes as per the manufacturer's recommendations. In November, 2005, methyl bromide (98/2, 350 lbs/ac) was shank injected and covered with high density plastic in this same nursery section. Four replications of each fumigant, each 100' long were placed in 3 bed rows of one nursery section. Also in November, 2005, in the adjoining nursery section, the following fumigants were shank injected and covered with high density plastic:

1. Chloropicrin 60 (C-60) (60% Chloropicrin & 40% Telone) @ 300 lbs/acre
2. Telone C35 (TC35) (65% Chloropicrin 35% Telone) @ 330 lbs/.acre
3. PIC + (85% Chloropicrin and 25% solvent) @ 300 lbs/acre
4. MBC 70/30 (70% 98/2 Mbr/Chl & 30% solvent) @ 350 lbs/acre

Each treatment (120' of bed-row) was replicated three times in three bed rows. Non-fumigated control plots were established in the same nursery section as the Basamid and methyl bromide.

Study II, located in another area of the nursery, was established in November 2005 using the following soil fumigation treatments:

1. Chloropicrin (Ch150) @ 150 lbs/acre
2. Chloropicrin (Ch300) @ 300 lbs/acre
3. MBr 98/2 (MBr) @ 350 lbs/acre
4. Non-fumigated Control (CTRL)

Each treatment (120' of bed-row) was replicated three times across three bed rows. All plots were maintained under normal nursery management practices by the Indian Mound nursery staff.

RESULTS & DISCUSSION

Season 1: At the 2006 Contact Meeting in Tyler, Texas, a field tour of these 2 fumigation trials was conducted. Prior to the actual tour, we noticed that one treatment appeared taller and seemed to have higher seedling density than the other treatments. At that time we opted to collect mid-season seedling quality data including heights, RCD, seedling counts and dry weights (Table 1 and 2).

The soil fumigant that stood out (visually) from the other soil fumigants during the mid-summer visit was PIC+ and this was confirmed numerically for each seedling quality parameter (Table 1). In contrast, Basamid had the lowest seedling quality parameters of all soil fumigants tested (Table 1).

On January 2, 2007 we returned to the Indian Mound Nursery to collect the final seedling data for the first growing season. At the time of our seedling sampling in January, the seedlings within the test plots had been neither lateral pruned nor undercut. Therefore, we did not include root biomass in our examination because we believed we left far too many roots in the nursery soil.

The seedling quality characteristics for the soil fumigants tested in Study I are shown in Table 3. Unlike the mid-season results, no single treatment stood out with respect to increasing seedling quality as did PIC+ in the mid-summer collection (Table 1). The seedling numbers by seedling grade are shown in Figure 1. All soil fumigants tested at the Indian Mound Nursery had similar (statistically) numbers of Grade 1 (> 4.7 mm) and Grade 2 (> 3.2 mm) seedlings. There were relatively few culls in the seedlings collected for all soil fumigants examined. The seedling densities in soils treated with PIC+ had the least amount of variation both within the plots and between the replications and is indicated by the low standard error term for PIC + (0.26) as compared to the other soil fumigants tested (Table 3).

The effect of soil fumigants on soil fungi, especially the beneficial fungus, *Trichoderma* is shown in Table 4. As has been shown in numerous other fumigation studies, Basamid significantly inhibits the recovery of *Trichoderma* (Cary 1996, Fraedrich & Dwinell 1997, Starkey et al 2006). Fumigants containing chloropicrin had significantly more total fungi and *Trichoderma* than the methyl bromide treatment.

In Study II, (different chloropicrin rates) there were no significant differences in seedling quality or quantity among the soil fumigants tested and the non-fumigated control (Table 5). The seedling densities in this study were lower than the nursery target of 24 seedlings per square foot and were lower than seedling densities in Study I. The effect of these low seedling densities (lower densities = bigger seedlings) can be seen in Figure 2. There was a much higher percentage of Grade 1 (> 4.7 mm) seedlings in Study II than in Study I and few culls in Study II.

Methyl bromide had significantly fewer total fungi than the other fumigants (Table 6). *Trichoderma* spp. levels were higher in the chloropicrin treatments than the methyl bromide treatments in both Study I and Study II.

At the end the first year, the results with PIC+ were encouraging. As with all fumigation studies, the seedling quality and quantity data after the second growing season post fumigation are important in making methyl bromide alternative recommendations. The first year results of the Basamid treatments again confirm that this soil fumigant is not an acceptable alternative to methyl bromide.

Season 2: Due to reductions in nursery seedling production, the area in Study II was not sown, thus 2-yr seedling production data is unavailable for that study. However, the area in Study I was sown to loblolly pine in April 2007 and seedlings were maintained using the standard operating procedures of the Indian Mound Nursery. In January 2008, we returned to the nursery and collected second crop seedling data from Study I. Like the previous season's seedling crop, we were still able to visually pick out the PIC+ treatments due to both seedling size and uniform stand density.

PIC+ and MBC 70/30 had numerically greater RCD, height and dry weight than the other treatment (Table 7). At the end of the second season PIC+ had more Grade 1 seedlings and less culls than any of the other treatments. Basamid had less Grade 1 seedlings and more culls than any of the other treatments (Figure 3).

At the Advisory meeting in 2007, there was some concern about the effects of these new soil fumigants on seedling root architecture. When the roots systems of seedlings grown in these soil fumigants were examined with the WinRhizo root scanning software, there were no statistically significant differences among soil fumigant treatments for the root parameters measured (Table 8). However, the PIC+ treatment had numerically larger root length, surface area, and root tips than the other soil fumigants tested. At the end of the second growing season, the soil fungi count and *Trichoderma* spp. levels ranged from 174 to 218 colony forming units and did not differ by treatment (Table 9). There were no trends with respect to seedling quality or negative effects on root morphology and soil fumigation in the data collected.

The second season seedling quality data indicates the PIC+ and MBC 70/30 soil fumigant treatments would be at the top of any list for MBr alternatives. If one was only interested in alternatives without methyl bromide, then PIC+ is the best alternative in this study. The seedling density variation in the PIC+ was small at the end of the first growing season. At the end of the second year, the minimal seedling variation between replications of PIC+ was apparent and statistically significant as indicated by the standard error of 0.26. Basamid, as previous Nursery Cooperative studies have confirmed, is at the bottom of the list of alternatives with respect to seedling densities and quality.

MANAGEMENT IMPLICATIONS

There are many factors that can affect soil fumigant efficacy. The three factors that have the greatest effect are soil preparation, soil moisture and soil texture. Soil preparation and soil moisture can, to a large extent, be manipulated and controlled by the nursery manager, whereas the soil texture was determined when the nursery site was chosen. When these factors are similar for two nurseries, yet fumigation results (seed quality) differ between the nurseries, the difference may be due to soil texture. This is why it is important for all nurseries to be testing some of these alternatives to methyl bromide as one alternative, effective at one nursery, may not be effective at another nursery. Of the 6 different soil fumigants tested at the Indian Mound Nursery, PIC + was a methyl bromide alternative that showed favorable results over the 2 year study. This treatment gave comparable seedling densities and quality to that of MBr and would be a good choice to try at other nursery sites. The site of this fumigation study in Texas is an Attoyac Fine Sandy Loam with 61% sand, 28% silt and 11% clay.

Cross contamination of fumigated and non-fumigated land

IPM Sidebar

Many times when we see problems in the second growing season after fumigation, the problems can be traced back to contaminated soil from non-fumigated areas or second year land being brought into newly fumigated land. It goes without saying that tractors should never be allowed to transect old and newly fumigated land. Note the tractor paths running through the different soil fumigant treatments.

REFERENCES

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Starkey, T., Enebak, S. and McCraw, D. 2007. Seedling quality and weed control with dazomet, methyl bromide and methyl iodide at the Glennville regeneration center 2005-2006. Research Report 06-05. Auburn University Southern Forest Nursery Management Cooperative, Auburn AL., 6 pp.

Table 1: Seedling height, RCD, dry biomass and densities sown in soils treated with different soil fumigants: Study I - mid-summer collection.

Trmt	*Height (in)*	*RCD (mm)*	*Total Dry Wt (gms)*	*Seedling Counts (per sq ft)*
Bas	5.7 c	2.4 c	0.89 c	18.7 a
MBr	6.2 c	2.5 abc	0.92 bc	20.7 a
TC35	6.3 c	2.5 abc	1.00 abc	18.8 a
CTRL	6.3 bc	2.4 bc	0.87 c	13.0 b
MBC70/30	6.5 bc	2.6 abc	1.02 abc	17.9 a
C-60	6.8 ab	2.7 ab	1.23 ab	18.4 a
PIC+	7.5 a	2.8 a	1.28 a	22.4 a
lsd	*1.0*	*0.3*	*0.30*	*3.2*

Means followed by same letter within columns are not significantly different at the 0.05 level.

Table 2. Seedling height, RCD, dry biomass and densities sown in soils treated with different soil fumigants: Study II - mid-summer collection.

Trmt	*Seedling Height (in)*	*RCD (mm)*	*Total Dry Wt (gms)*	*Seedling Counts (per sq ft)*
CTRL	5.0 b	2.4 a	0.73 c	16.4 a
Ch150	5.9 ab	2.4 a	1.05 b	15.9 a
MBr	6.7 a	2.6 a	1.29 ab	19.6 a
Ch300	7.2 a	2.7 a	1.37 a	15.1 a
lsd	*1.6*	*0.4*	*0.25*	*3.3*

Means followed by same letter within columns are not significantly different at the 0.05 level.

Table 3: Seedling shoot height, RCD, dry biomass and densities sown in soils treated with different soil fumigants: Study I - end of first growing season.

Trmt	*Seedling Height (in)*	*RCD (mm)*	*Shoot Dry Wt (gms)*	*Seedling Counts (per sq ft) & (Std Error)*	*Shoot Wt (gram per sq ft)*
Bas	10.4 ab	5.0 a	4.1 a	18.9 b (1.20)	75.0 b
Mbr	11.2 ab	5.3 a	4.5 a	21.1 ab (0.74)	92.5 a
TC35	10.5 ab	5.1 a	4.1 a	20.7 ab (0.95)	85.0 ab
CTRL	10.2 b	5.1 a	4.2 a	20.9 ab (0.86)	85.0 ab
MBC70/30	11.3 a	5.4 a	4.6 a	19.5 ab (1.09)	90.0 ab
C-60	11.1 ab	5.2 a	4.2 a	22.7 a (1.63)	95.0 a
PIC+	10.8 ab	5.0 a	4.0 a	22.0 ab (0.26)	87.5 ab
lsd	*1.2*	*0.5*	*0.8*	*3.8*	*19.5*

Means followed by the same letter with a column are not significantly different at 0.05 level.

Table 4: Total soil fungi and *Trichoderma* spp. from fumigated soils: Study I - end of first growing season.

Trmt	*Total Fungal Counts*	*Trichoderma spp (%)*
Bas	64.3 c	15.5 e
MBr	66.2 c	23.6 d
TC35	160.5 a	49.5 b
CTRL	68.3 c	24.8 d
MBC70/30	78.4 c	46.1 bc
C-60	127.8 b	64.3 a
PIC+	180.7 a	40.6 c
lsd	*44.5*	*11.6*

Means followed by same letter within a column are not significantly different at 0.05 level.

Table 5: Seedling shoot height, RCD, dry biomass and densities sown in soils treated with different soil fumigants: Study II - end of first growing season.

Trmt	*Height (in)*	*RCD (mm)*	*Shoot Dry Wt (gms)*	*Seedling Counts (per sq ft)*	*Shoot Wt (per sq ft)*
CTRL	10.4 a	5.2 a	4.3 a	18.0 a	77.5 a
Ch150	10.7 a	5.5 a	4.7 a	16.0 a	72.5 a
MBr	10.7 a	5.2 a	4.4 a	18.0 a	80.0 a
Ch300	11.0 a	5.5 a	5.3 a	15.9 a	82.5 a
lsd	2.1	1.0	1.8	5.4	30.9

Means followed by same letter within a column are not significantly different at 0.05 level.

Table 6: Total soil fungi and percent *Trichoderma* spp. from fumigated soils: Study II - end of first growing season.

Trmt	*Total Fungal Counts*	*Trichoderma spp. (%)*
CTRL	143.6 a	12.0 d
Ch150	162.9 a	50.9 b
MBr	113.3 b	29.9 c
Ch300	149.3 a	60.2 a
lsd	*55.5*	*12.9*

Means followed by same letter within a column are not significantly different at 0.05 level.
Total Fungal Counts are the number of colony forming units per gram soil.
Percent *Trichoderma* is percentage of total colony forming units that contained *Trichoderma*.

Table 7: Seedling RCD, shoot height dry biomass and densities sown in soils treated with different soil fumigants: Study I - end of second growing season.

Trmt	RCD (mm)	Height (cm)	Dry Weight (gm)		Seed Density (ft^2) and Std Error
			Shoot	Root	
Bas	3.97 c	18.8 c	2.5 c	1.1 a	13.8 a (0.65)
MBr	4.22 bc	20.1 bc	2.7 bc	1.2 a	13.8 a (0.42)
TC35	4.30 bc	20.8 bc	2.8 bc	1.1 a	13.3 ab (0.56)
CTRL	4.37 bc	20.3 bc	3.0 bc	1.3 a	14.4 a (0.78)
C-60	4.41 bc	20.9 bc	3.0 bc	1.2 a	13.4 ab (1.0)
MBC 70/30	4.48 ab	22.6 ab	3.2 ab	1.2 a	11.5 b (0.90)
PIC+	4.91 a	24.0 a	3.7 a	1.4 a	12.8 ab (0.26)
lsd	*0.41*	*1.87*	*0.60*	*0.29*	*1.87*

Table 8. Seedling root morphology and characteristic: Study I - end of second growing season.

Trmt	Total Seedling Root Length (cm)	Surface area (cm^2)	Avg Root Diameter (mm)	# Root tips
Bas	236	101	1.37	670
MBr	228	100	1.40	655
TC35	217	98	1.44	694
CTRL	214	99	1.44	665
C-60	222	98	1.39	703
MBC 70/30	233	96	1.31	662
PIC+	250	102	1.30	755
lsd	*46*	*21*	*0.14*	*122*

Table 9: Total soil fungi and *Trichoderma* spp. from fumigated soils: Study I - end of second growing season

Trmt	*Total Fungal Counts*	*Percent Trichoderma spp.*
Bas	202.3 a	22.0 a
MBr	218.5 a	48.0 a
TC35	225.0 a	7.3 a
CTRL	279.5 a	33.2 a
MBC70/30	174.3 a	11.7 a
C-60	208.7 a	33.8 a
PIC+	190.0 a	10.5 a
lsd	*155*	*38.2*

Means followed by same letter within columns are not significantly different at 0.05 level.
Total Fungal Counts are the number of colony forming units per gram of soil.
Percent *Trichoderma* spp. is percentage of total colonies that contained *Trichoderma*.

Figure 1: Grade 1, grade 2 and cull seedlings from Study I - end of first season

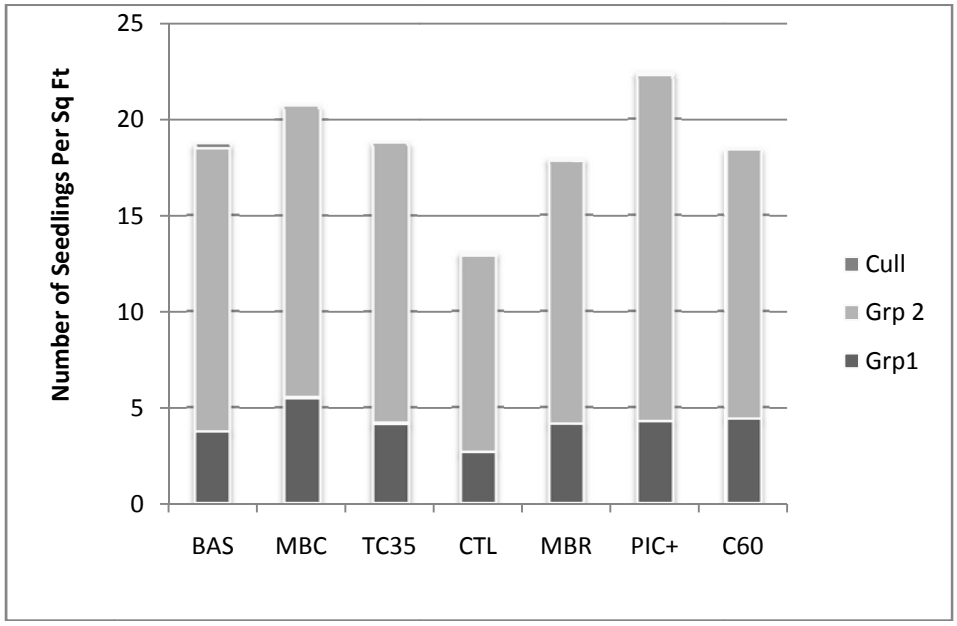

Figure 2: Seedling grade by treatment: Study II - end of first growing season

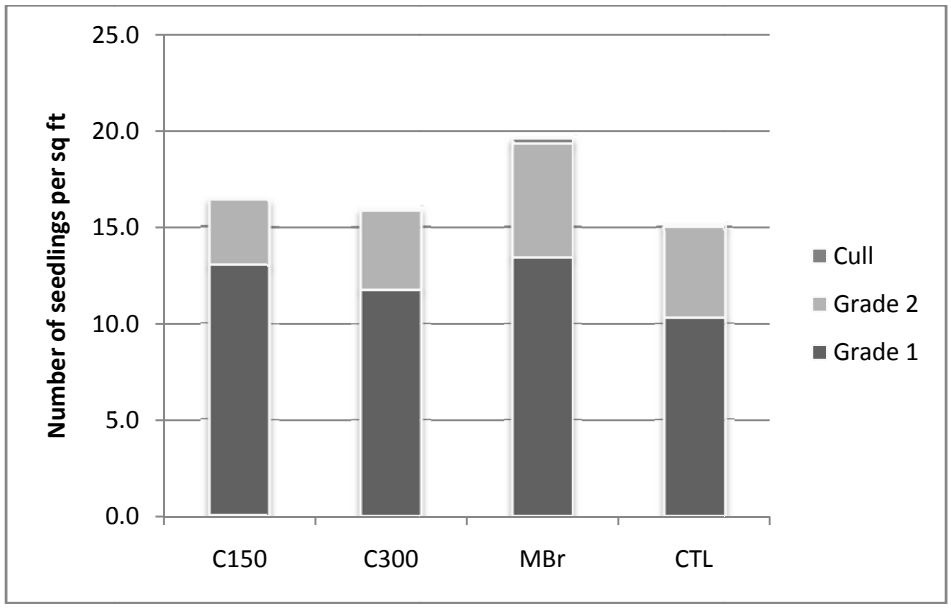

Figure 3: Seedling grade by treatment: Study I - end of second growing season