Auburn University Southern Forest Nursery Management Cooperative

RESEARCH REPORT 11-02

EVALUATION OF METHYL BROMIDE ALTERNATIVES USING A LOW DISTURBANCE FUMIGATION RIG IN THE PRODUCTION OF LOBLOLLY PINE SEEDLINGS IN A GEORGIA FOREST TREE NURSERY

by
Paul Jackson, Tom Starkey, and Scott Enebak

INTRODUCTION

The USDA – ARS Area-wide Pest Management Project for Methyl Bromide Alternatives – South Atlantic Region is an ongoing research initiative that along with the Southern Forest Nursery Management Cooperative at Auburn University continues to test alternative soil fumigants to methyl bromide (MBr). In the southeastern United States, fumigation with MBr is important for producing high quality forest tree seedlings in an environment that is conducive for soil-borne pathogens, nematodes, and weeds.

Standard broadcast soil fumigation rigs use shanks to inject fumigants into the soil. One problem with shank injection rigs is that they can create chisel traces (openings or chimneys) in the soil that can allow gas to escape into the atmosphere. In an attempt to minimize fumigant loss from the soil and increase fumigant efficacy, the USDA-ARS developed a coulter injection low disturbance fumigation rig. The idea behind the low disturbance rig was to limit the upward movement of soil fumigants and use lower application rates to provide longer soil exposure rates. The bottom line was an attempt to minimize buffer zones under EPA's Re-registration Eligibility Decision (REDs) and still achieve adequate pest (weeds, nematodes, insects, fungi) control and plantable seedlings at the end of the rotation.

In October 2009, a large-scale trial was established at Rayonier's Glennville Regeneration Center in Glennville, GA that compared soil fumigants using the USDA-ARS low disturbance fumigation rig under standard seedling growing practices. The objective of the trial was to identify a soil fumigant that could serve as a replacement for MBr at this particular nursery for the production of loblolly pine (Pinus taeda) seedlings. The ability to reduce soil fumigant rates with the low impact rig would go a long way in working within the new buffer zones and maintaining seedling production at this nursery. Information in this report should be used by nursery managers in the southern US to choose the most viable MBr alternative for forest tree seedling production in their particular nursery.

METHODOLOGY

Six fumigation treatments were tested at Glennville that included three currently available MBr alternatives at two rates that were covered with either virtually impermeable film (VIF) or low density polyethylene (LDPE) (Table 1). The trial was a randomized complete block design replicated four times over a 4.5 acre area of the nursery with treatment beds being 29 x 300 linear ft (Table 2). Each 9-bed nursery section (area between riser lines) included two of the soil fumigation treatments. Fumigants were applied using a USDA-ARS fumigation rig designed to provide minimal soil disturbance, and thus, lessening the chance of fumigant volatility from the soil after injection and increasing the soil retention time. To accomplish this, soils were rolled and compacted, rather than tilled, prior to application, and the fumigants were coulter injected to a depth of 6 inches rather than standard shank injected at 8 inches. Other modifications made included a "beaver tail" to move soil over the injection point and a "soil flap" to cover the coulter trace (Figure 1).

After fumigation in October 2009, a single family of loblolly pine seed was sown in April 2010. Seedlings were maintained throughout the growing season using standard nursery cultural practices (fertilization, irrigation, pest management, etc.) until lifting took place in October 2010. Soil fumigant efficacy was determined by measuring both seedling quality parameters and soil-borne nematodes and fungi. Seedling and soil samples were collected from the center bed of the two treatments in each nursery section (beds 3 and 7). Soil samples were collected pre-sowing and at approximately 7 wks (post-sowing), 15 wks (mid-summer; for nematodes only) and at 30 wks (prior to fall lifting) in the fall. Half of each soil sample was sent to the soils laboratory at Auburn University for an assessment of nematode populations, and the remaining half was plated onto *Trichoderma* selective media (TSM) (Elad et al. 1981) to determine the effects of the soil fumigants on *Trichoderma* levels. Seedling densities were assessed in four (1 x 4 ft) subplots per treatment when soils were sampled at post-sowing, mid-summer, and prior to fall lifting. At the end of the 2010 growing season, all seedlings were lifted from each of the four subplots per fumigation treatment. Seedling quality measurements taken included root collar diameter (RCD), shoot height, and shoot and root dry weight (biomass). Root weight ratios were calculated by dividing the dry root biomass by total seedling biomass (roots + shoots). This number gave an indication of the overall root quality for comparison among treatments. In addition, root morphology (root length, root surface area, root diameter, and the number of new root tips) was measured on ten seedlings per subplot using WinRhizo® computer software and a scanner (Regents Instruments Inc., Quebec, Canada).

RESULTS AND DISCUSSION

At the time of lifting, there was no significant difference in seedling densities (Table 3) or root collar diameter among the six soil fumigants tested (Table 4). As far as seedling quality among the soil fumigants, Chloropicrin had the highest percentage of cull seedlings (RCD < 3.2 mm) regardless of the plastic used (Figure 2). Soils treated with Pic +® under VIF had the least amount of cull seedlings (11%) followed by Chlor 60 under VIF (15%). When comparing across the types of plastics used, using LDPE resulted in 25% culls compared to 17% culls with VIF.

As far as the soil treatments effect on root characteristics, root lengths, root surface areas, and the number of new root tips were similar among the alternative soil fumigation treatments (Table 5).

However, Chlor 60 under VIF and Pic+ under both VIF and LDPE produced larger root diameters than Chloropicrin under LDPE (Table 5). Root weight ratios were smaller for Chlor 60 seedlings compared to Pic+ seedlings when covered with LDPE (Table 6). In contrast to VIF, LDPE is capable of allowing soil fumigants to permeate into the atmosphere through the plastic at a higher rate (Yates et al. 2002). Thus, a rapid loss of gas from the soil under LDPE may explain the lower loblolly pine seedling quality when using LDPE at Glennville.

Trichoderma is a soil-borne fungus that provides a beneficial effect to seedling growth (Cary et al. 2005; Starkey et al. 2006), and can be antagonistic to damping-off pathogens such as *Pythium* (Sun 1996). There was no evidence that the soil fumigants inhibited *Trichoderma* development in the soil as it was detected at similar levels among all soil and plastic treatments at post-sowing and lifting (Table 7). *Trichoderma* levels at Glennville were in line with other soil fumigant trials conducted by the Nursery Cooperative. However, nematode assessments from soils sampled at post-sowing indicated elevated levels of stunt nematodes (*Tylenchorhynchus claytoni*) (Table 8). To confirm the high nematode numbers, soil samples were collected again in early August and unprecedented levels of stunt nematodes were detected (Table 8). Despite the high levels of nematodes within the soil, an aggressive fertilization regime initiated by the nursery manager masked the effects of the nematodes in the fumigation trial. Typically, needle chlorosis is the most common symptom of nematode activity, but chlorosis was not observed. Some possible reasons for the lack of fumigant efficacy may have been caused by:

- A lower rate of fumigant (than normal) was used in a nursery with a history of nematode problems.
- Fumigant injection was not deep enough by the low disturbance coulter injection rig.
- Compacting (rolling) the soil before application may have prevented gas movement through the soil profile.
- The soil moisture may have been too high to allow fumigant (especially Chlor 60) movement throughout the soil profile.

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. This trial featured the USDA-ARS low disturbance fumigation rig developed to minimize soil disturbance by rolling, and thus, compacting soils prior to fumigation. The overall goal was to decrease the amount of soil fumigant used to reduce buffer zone distance and yet increase the area under the curve and dose response. However, by injecting the fumigants at a shallower depth with coulters rather than conventional shank injection, the gas was unable to move as efficiently through the soil. Obviously, the low impact soil fumigation rig is not adaptable for broadcast soil fumigation methods that are currently used in forest tree nurseries. This type of system works well in row crops where the plastic remains in place and the fumigant dispersion needs only to be within the width of the tractor path. The Glennville nursery has had a history of nematode problems, but the levels observed in this trial have never been reported by the Nursery Cooperative in any other

fumigation trial to date. Due to the high levels of nematodes, the trial at Glennville could not be continued into a second growing season. In addition, modifications to the nursery's normal fertilization regime to offset severe nematode damage may have masked any effects from soil fumigation treatments on the seedling characteristics.

Making a determination on a potential alternative to MBr for the Glennville nursery using results from this trial would not be advised. The same soil fumigation treatments would need to be tested at Glennville using a standard shank injected fumigation rig. A previous fumigation trial at Glennville indicated that Pic+ and Chloropicrin under high density polyethylene produced quality loblolly pine seedlings while controlling weeds and nematodes (Enebak et al. 2011). Application issues aside, this trial also indicated Pic+ to have some promise by having fewer culls and producing larger root diameters and root weight ratios than other treatments under the LDPE plastic. However, Chloropicrin had more culls under both plastics and smaller root diameters under LDPE when applied with the low impact USDA-ARS rig. The final decision on selecting an MBr alternative will vary by nursery, and each manager needs to consider the alternative soil fumigant's ability to work in their soils and the impact of the EPA's Re-registration Eligibility Decision in order to continue growing quality forest tree seedlings.

REFERENCES

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Table 1. Plastic type, soil fumigant, and treatment rates used in the Area-wide demonstration trial at Glennville, GA.

Plastic	Fumigant	Rate	Component
VIF	Chlor 60	100 lbs/a	60% Chloropicrin + 40% 1,3-dichloropropene
LDPE		200 lbs/a	
VIF	Chloropicrin	100 lbs/a	100% Chloropicrin
LDPE		200 lbs/a	
VIF	Pic +	100 lbs/a	85% Chloropicrin + 15% solvent
LDPE		200 lbs/a	

Table 2. Site information for the Area-wide demonstration trial at Glennville, GA.

	Glennville, GA
Fumigation Date	October 22, 2009
Fumigation Type	No till/coulter injected; broadcast/flat tarp
Experimental Area	4.6 acres
Air Temperature	62-81°F
Wind Speed	0-9 mph
Soil Moisture	7.8%
Soil Series	Tifton loamy sand
Pastic Type	VIF & LDPE
Plastic in Place	10 Days

Table 3. Seedling density after sowing, mid-summer, and at lifting for the Area-wide trial at Glennville, GA.

		Seedling Density (ft^2)
Plastic	**Fumigant**	**Oct 2010**
VIF	Chlor 60	21 a
LDPE	Chlor 60	22 a
VIF	Chloropicrin	20 a
LDPE	Chloropicrin	20 a
VIF	Pic +	21 a
LDPE	Pic +	22 a
	LSD (0.05)	*(3.5)*

* Least significant difference is italicized.

Table 4. Loblolly pine seedling root collar diameter at lifting (Oct 2010) in the Area-wide trial at Glennville, GA.

Plastic	Fumigant	Root Collar Diameter (mm)
VIF	Chlor 60	4.14 a
LDPE	Chlor 60	3.95 a
VIF	Chloropicrin	3.89 a
LDPE	Chloropicrin	3.61 a
VIF	Pic +	4.29 a
LDPE	Pic +	4.17 a
	LSD $_{(0.05)}$ *	*(0.66)*

* Least significant difference is italicized.

Table 6. Loblolly pine seedling root morphology measurements at lifting (Oct 2010) in the Area-wide trial at Glennville, GA.

		Root Morphology			
Plastic	Fumigant	Root Length (cm)	Root Surface Area (cm^2)	Root Diameter (mm)	Root Tips (#)
VIF	Chlor 60	118.8 a	47.1 a	1.27 ab	275.0 a
LDPE	Chlor 60	122.0 a	43.3 a	1.15 bc	323.3 a
VIF	Chloropicrin	133.5 a	47.5 a	1.15 bc	329.0 a
LDPE	Chloropicrin	135.0 a	44.9 a	1.05 c	332.0 a
VIF	Pic +	138.5 a	52.1 a	1.20 ab	324.3 a
LDPE	Pic +	127.0 a	50.2 a	1.28 a	302.0 a
	LSD $_{(0.05)}$ *	*(22.5)*	*(8.0)*	*(0.12)*	*(72.7)*

* Least significant differences are italicized.

Table 5. Loblolly pine seedling dry weights and root weight ratios at lifting (Oct 2010) in the Area-wide trial at Glennville, GA.

Plastic	Fumigant	Root Weight Ratio (%)
VIF	Chlor 60	14.3 ab
LDPE	Chlor 60	12.2 b
VIF	Chloropicrin	13.1 ab
LDPE	Chloropicrin	12.8 ab
VIF	Pic +	14.6 ab
LDPE	Pic +	15.0 a
	lsd $_{(0.05)}$	*(2.3)*

* Least significant difference is italicized.

Table 7. Number of *Trichoderma* colony forming units (CFUs) from soils collected after sowing and at lifting in the Area-wide trial at Glennville, GA.

		***Trichoderma* (CFUs/mg soil)**	
Plastic	**Fumigant**	**May 2010**	**Oct 2010**
VIF	Chlor 60	155 a	61 a
LDPE	Chlor 60	159 a	35 a
VIF	Chloropicrin	173 a	57 a
LDPE	Chloropicrin	193 a	49 a
VIF	Pic +	158 a	38 a
LDPE	Pic +	185 a	64 a
	LSD $_{(0.05)}$ *	*(50)*	*(42)*

* Least significant differences are italicized.

Table 8. Average number of stunt nematodes from soils collected after sowing, mid-summer, and at lifting in the Area-wide trial at Glennville, GA.

		Stunt Nematodes (#/100 cc of soil)		
Plastic	**Fumigant**	**May 2010**	**Aug 2010**	**Oct 2010**
VIF	Chlor 60	165 (66-334)*	548 (274-894)	303 (118-534)
LDPE	Chlor 60	189 (24-434)	1,223 (620-1,626)	386 (142-614)
VIF	Chloropicrin	106 (0-174)	374 (0-830)	269 (112-620)
LDPE	Chloropicrin	45 (0-118)	470 (8-1,122)	275 (34-672)
VIF	Pic +	99 (4-152)	838 (182-1,454)	389 (198-580)
LDPE	Pic +	181 (4-394)	492 (142-1,060)	345 (128-914)

* Range (lowest to highest) of stunt nematodes detected between the four repetitions in each soil treatment.

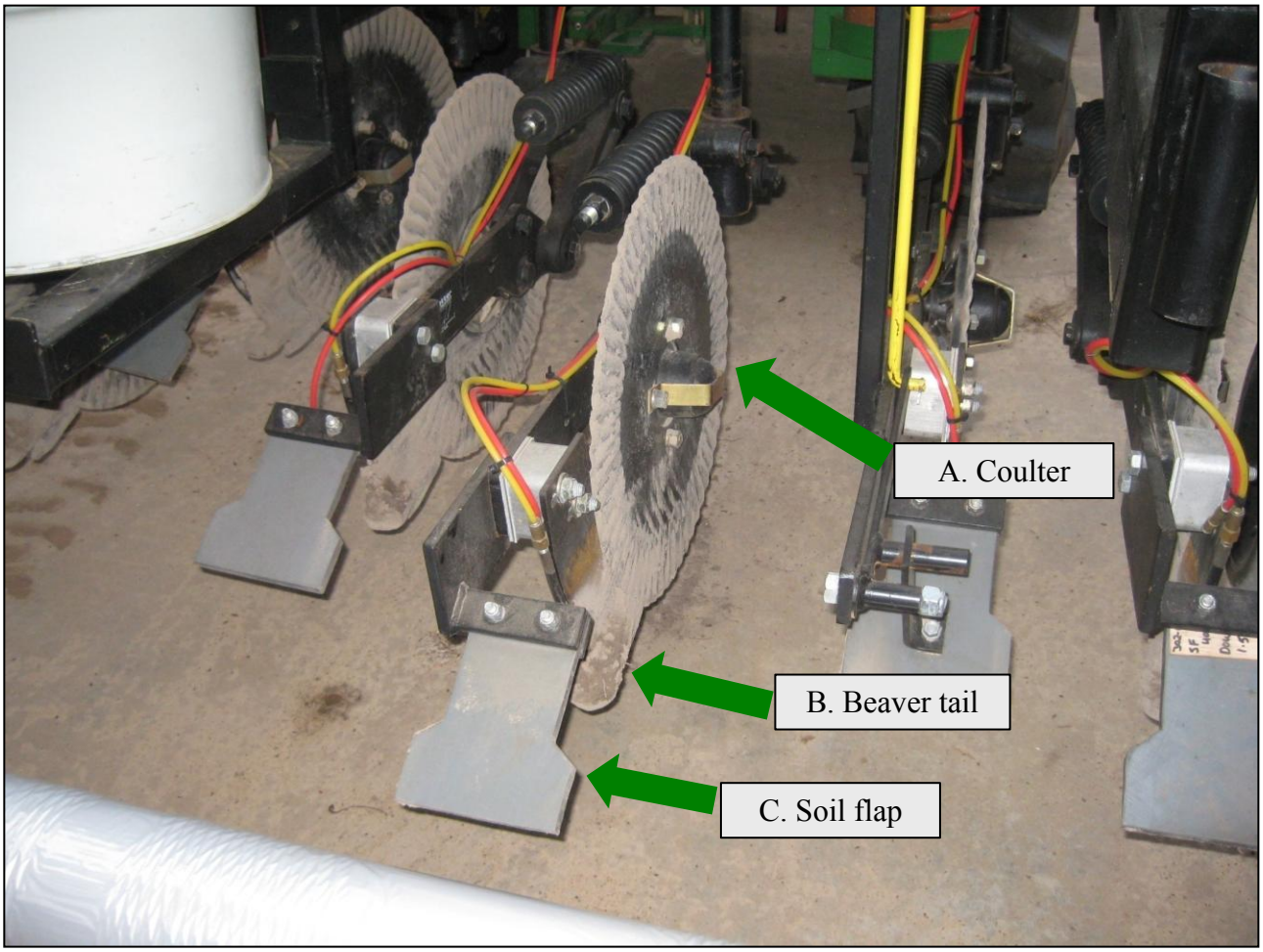

Figure 1. The USDA fumigation rig showing the (A) coulter, (B) the beaver tail that follows the injection point, and (C) the soil flap that covers the coulter trace.

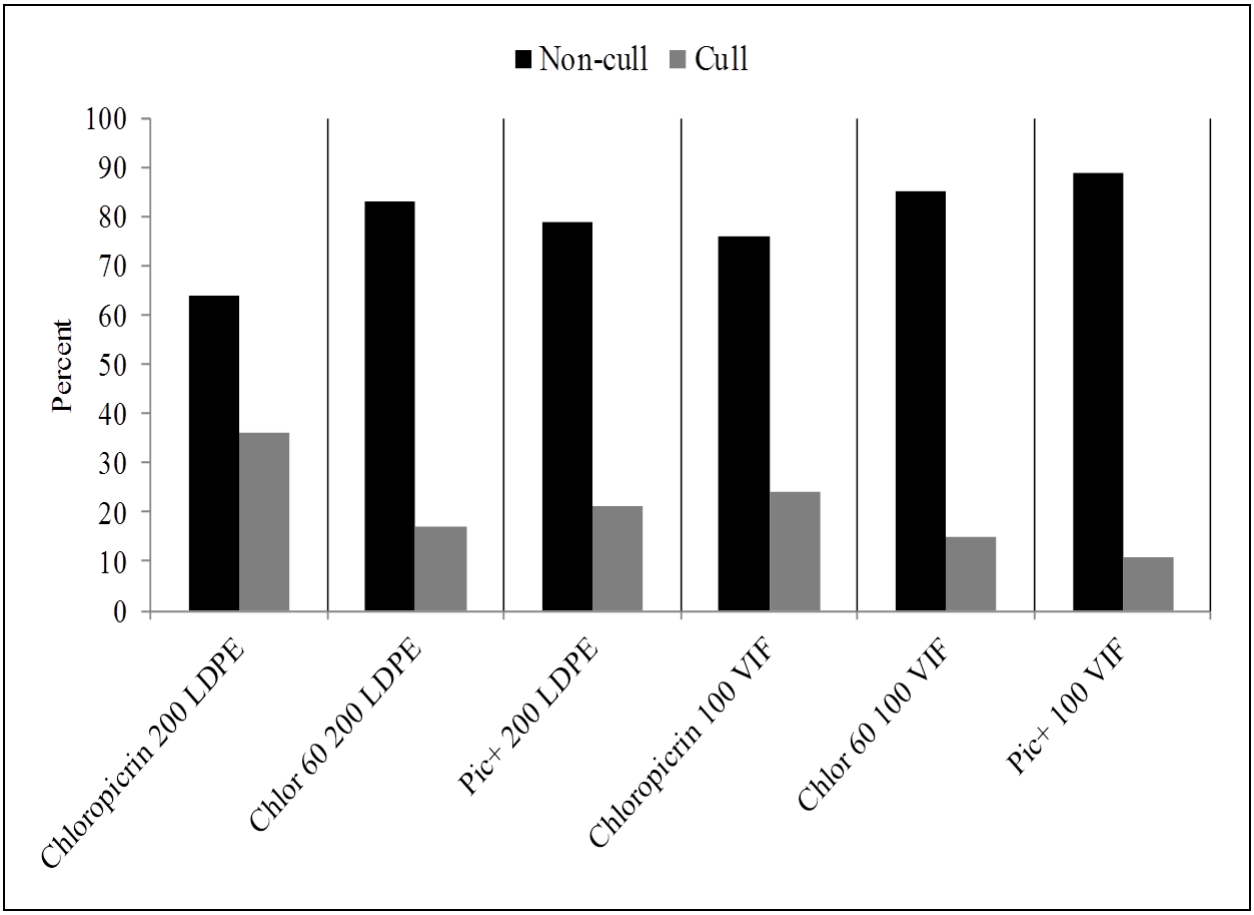

Figure 2. Percentage of non-cull vs. cull seedlings between soil fumigation treatments at Glennville, GA in the 2010 growing season.