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RESEARCH REPORT 04 - 2

INCREASING THE EFFICACY OF FUMIGATION WITH VIRTUALLY IMPERMEABLE FILM (VIF)

By

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INTRODUCTION

Fumigation to control weeds and diseases in forest tree nurseries became economical with the technology for simultaneously injecting methyl bromide (MBr) and tarping it with continuous polyethylene film (Terrell 1962). Before this made fumigation safer and simpler, MBr was sometimes dissolved in carriers to make it liquid at normal fumigation temperatures. One such product, Brozone®, contained MBr dissolved in kerosene which was believed to be safer and to reduce initial rate of gas loss from the soil. Brozone® was tested in forest tree nurseries (Hodges 1960) but never used extensively there. An application to hardwood beds (in the 1990's) resulted in the stunting of sweetgum (*Liquidambar styraciflua*) seedlings apparently from mycorrhizal insufficiency (Carey unpublished). However, pressure to use less MBr while maintaining current efficacy makes it necessary to evaluate new formulations and application techniques.

Weed control was the primary focus of this study, but soil fungi were evaluated and at one site Slash pine (*Pinus elliottii)* seed were sown in the study area. The sites selected were at two forest nurseries in Georgia where the managers expected abundant nutsedge (*Cyperus* spp) in the treated areas.

METHODOLOGY

Study sites were provided at the International Forest Co. nursery near Ashburn, GA and at the Rayonier nursery near Glennville, GA. A riser-line-section was fumigated at each site, and within each the plots were laid out in randomized complete blocks (RCB) with nine fumigation treatments (see Table 1) per block and each treatment plot 13-ft-wide (the width of a single tarp) by 40-ft-long. Ashburn was fumigated April 7, 2003 and Glennville was fumigated the next day by Hendrix and Dail, Inc. using standard application technology to soil, well prepared by nursery management. All materials were shank injected, tarped, and the tarp edges buried in a single pass of the fumigation rig. The need to bury both sides of the VIF tarp left non-treated areas between blocks. Tarps were removed seven days after fumigation.

The species of nutsedge and its assessment varied between nurseries. At Glennville, almost all nutsedge was yellow (*C. esculentus)* and individual plants or the small clumps apparently from a single "mother" plant, were counted individually. At Ashburn, the nutsedge was primarily purple (*C. rotundus*) and abundance was assessed as the percentage of ground cover. The first evaluation at Glennville was on May 12 (35 days post fumigation) and at Ashburn on May 21 (44 days post fumigation). Late season weed abundance was assessed at Glennville and at Ashburn, respectively, on September 10th and 11th. Herbicides were applied by both nurseries' management through the growing season to reduce weed abundance and at Ashburn the study area was disked at least once before the final evaluation.

Soil fungi were assessed from bulked soil samples collected within each treatment plot. Each sample was mixed thoroughly and a 1.0 gm sample transferred to 100 ml of sterile 0.2 % water agar which was mechanically shaken for 15 minutes before 0.5 ml sub-samples were transferred to each of three plates of media selective for *Fusarium* (Nash and Snyder 1961) and three of media selective for *Trichoderma* (Elad *et al.* 1981). Soil for fungal analyses was collected at Ashburn on May 21 (44 days post fumigation) and at Glennville on July 8th (92 days post fumigation).

Slash pine seeds were sown at Glennville on April 21st. Germination was evaluated May 12th and the area re-sown May 15th due to rain damage. Germination for the second sowing was evaluated July 8th and final seedbed density (seedlings/ft^2 of bed) and seedling development was evaluated October 21st (158 days after sowing).

Table 1. Fumigation treatments evaluated at Ashburn and Glennville in 2003.

Treatment Designation	Methyl Bromide	Chloropicrin	Carrier	Tarp
Standard Control (MC67)	235	115	0	HDP
MC67 High	163	87	0	VIF
MC67 Low	100	50	0	VIF
Pic High	0	300	0	VIF
Pic Low	0	200	0	VIF
Pic Plus High	0	300	Paraffin	VIF
Pic Plus Low	0	200	Paraffin	VIF
Pic Plus w/o Tarp	0	300	Paraffin	None
Control	0	0	0	VIF

RESULTS AND DISCUSSION

A deficiency of most alternatives to MBr is weed control. In forest tree nurseries, and many other crops, nutsedge control is usually inferior with lower rates of MBr. Neither chloropicrin (South *et* *al.* 1997) nor other fumigants (Carey 1994) have controlled nutsedge as effective as MBr. Both sites, as predicted by management, produced abundant nutsedge that was fairly well distributed through the study areas.

Early season weed abundance by treatment and nursery is presented in Table 2. Analyzed over treatments, the control differed from all fumigated treatments which did not differ among themselves. Analyzing only fumigated treatments (dropping the control) produced the statistical analyses presented in Table 2. At both nurseries, the Pic-Plus w/o Tarp (300 lbs/ac chloropicrin) had more nutsedge than other fumigated treatments. The efficacy of tarping is demonstrated by less nutsedge among tarped treatment. The increased efficacy for VIF tarp is demonstrated by the lack of difference between plots treated with 350 lbs MC67 under HDP (Standard Control) and those treated at half that rate of fumigant under VIF, and by the comparative effectiveness of all tarped chloropicrin treatments.

At Glennville, mean nutsedge per plot declined from 25 in May to 10 in September, presumably as the result of herbicide application. Treatments ranked similarly at each date and were correlated ($r = 0.71$, $p < 0.01$). At Ashburn, where cultural activities were not limited by seedling production, nutsedge declined (from 22 to 8%) and spring and fall densities did not correlate ($r = 0.21$ $p = 0.22$).

Table 2. Spring nutsedge abundance by fumigant at Ashburn (% cover) at Glennville (plants per plot) and the average for both sites (unitless number) in 2003.

Treatment Designation †	Ashburn *	Glennville	Both Sites
Standard Control (MC67)	0 b	13 bc	7 b
MC67 High	3 b	8 c	5 b
MC67 Low	1 b	15 bc	8 b
Pic High	3 b	9 c	6 b
Pic Low	12 ab	9 c	11 b
Pic Plus High	9 ab	34 ab	21 b
Pic Plus Low	16 ab	6 c	11 b
Pic Plus w/o Tarp	25 a	48 a	37 a
Control	128	84	106
lsd 0.05 (without control)§	*18*	*20*	*14*

† Treatment descriptions are in Table 1.
* Numbers for Ashburn are percentage ground cover, and for Glennville are single plants or small clumps, the average number for both sites is therefore without dimension.
§ Within column means followed by the same letter do not differ at 0.05 (SAS ANOVA Duncan's procedure) for an analysis without the control.

Numbers of colony forming units (cfu's) of *Trichoderma* and of *Fusarium* are presented by treatment and by nursery in Tables 3a and 3b. These genera were assayed due to familiarity with their quantification from soil to evaluate how the parafinic carrier effected the fungicidal activity of chloropicrin. In past studies, cfu's of *Trichoderm*a are usually increased by fumigation with chloropicrin or combinations of chloropicrin and MBr (South *et al.* 1997) and populations of *Fusarium* generally decrease, regardless of fumigant. The fungicidal activity of the Pic-Plus formulations is of concern with respect to potential reductions in mycorrhizae which are negatively effected by fumigation with chloropicrin.

The treatments effected *Fusarium* and *Trichoderma* as expected and without evidence of significant or qualitative differences associated with the paraffin carrier. Quantitative differences among treatments were seldom significant. As usual, chloropicrin enhanced *Trichoderma* a little more than MBr, and both fumigants reduced *Fusarium.* The effects of straight chloropicrin with or without a paraffin carrier needs evaluation for possible reductions of mycorrhizae in different crops and soil types.

Table 3a. Trichoderma by fumigation treatment at Ashburn and at Glennville, GA.

Treatment Designation †	Ashburn *	Glennville	Both
Standard Control (MC67)	2.4 bc	9.7 ab	6.1 bcd
MC67 High	2.1 bc	9.0 ab	5.6 cd
MC67 Low	2.1 bc	11.0 ab	6.5 bcd
Pic High	6.3 abc	13.0 a	9.6 ab
Pic Low	6.4 abc	11.8 ab	9.1 abc
Pic Plus High	8.7 ab	10.6 ab	9.6 ab
Pic Plus Low	9.7 a	12.1 ab	10.9 a
Pic Plus w/o Tarp	4.4 abc	9.7 ab	7.1 bcd
Control	0.7 c	8.0 b	4.3 d
lsd. 0.05 §	*6.5*	*3.6*	*3.5*

Table 3b. Fusarium by fumigation treatment at Ashburn and at Glennville, GA.

Treatment Designation †	Ashburn *	Glennville	Both
Standard Control (MC67)	0.0 ab	0.2 b	0.1 b
MC67 High	0.4 ab	0.5 b	0.4 b
MC67 Low	0.6 ab	0.5 b	0.6 b
Pic High	0.4 b	0.3 b	0.3 b
Pic Low	0.1 b	0.2 b	0.2 b
Pic Plus High	0.1 b	0.1 b	0.1 b
Pic Plus Low	0.0 b	0.2 b	0.1 b
Pic Plus w/o Tarp	0.2 b	0.4 b	0.3 b
Control	1.3 a	2.5 a	1.9 a
Lsd. 0.05	*0.8*	*0.8*	*0.6*

† Treatments are described in Table 1.

* Populations are in colony forming units per 0.005 gms of soil.

§ Within column, means followed by the same letter do not differ at 0.05 (SAS ANOVA Duncan's procedure).

The Glennville study site was sown (April 24th) and resown due to rain damage (for a target density of 22/ft^2) on May 15. However, more heavy rainfall after sowing reduced final seedbed densities (see Table 4) to 33% of the target. Although final densities are not believed to be effected by treatment, the data is presented by treatment in Table 4 for final seedbed density and for mean seedling sizes and masses.

Table 4. Seedling numbers, sizes and masses by fumigant at Glennville, GA in 2003.

Treatment Designation †	Seedlings/ft^2 *	RCD(mm)	Plants/ft^2	Ones/ft^2	Root(gm/ft^2)
Standard Control	5.0 b	4.8	4.7 ab	2.3 ab	4.1 bc
MC67 High	5.7 ab	5.0	5.0 ab	3.0 ab	4.9 abc
MC67 Low	5.0 b	4.7	4.4 b	2.3 ab	4.2 bc
Pic High	5.0 b	5.0	4.8 ab	2.6 ab	5.4 abc
Pic Low	4.0 b	5.3	4.0 b	2.8 ab	4.6 abc
Pic Plus High	3.5 b	5.0	3.3 b	1.5 b	3.5 c
Pic Plus Low	6.5 ab	5.6	6.4 ab	5.2 a	8.3 ab
Pic Plus w/o Tarp	5.7 ab	5.3	5.3 ab	3.6 ab	6.8 abc
Control	8.2 a	4.7	7.7 a	4.2 ab	8.7 a
lsd . 0.05	*2.8*	*0.9*	*2.8*	*2.6*	*3.7*

† Treatments are described in Table 1.
* Seedlings, Plants, and Ones, respectively, are total seedlings, those > 3.2 mm, and > 4.7 mm RCD.

Because Yellow and Purple Nutsedge are difficult to control with the available alternatives to MBr, these weeds were our criteria for evaluations. With 350 lbs of MC67/ac under high density polyethylene (HDP) as the standard for current control, we reduced the amount of MC67 by 200 lbs/ac and maintained nutsedge control by substituting VIF tarp for HDP. In this study VIF tarp significantly increased nutsedge control by chloropicrin compared to non tarped applications and the higher rate of chloropicrin under VIF provided control similar to the standard and the VIF treatments of MC67 at both the Ashburn and the Glennville locations. Applying chloropicrin in solvent (Pic-Plus) had no apparent effect on its efficacy.

MANAGEMENT IMPLICATIONS

Some technical problems remain to be solved before VIF tarps can be used for the continuous tarp applications preferred in forest tree nurseries. Once this problem is overcome the results of this study indicate that the rates of effective fumigants such as MBr and Chloropicrin can be reduced by 50% of those needed under high density polyethylene (HDP) tarps.

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