Phytotoxicity with Metam Sodium

ROBERT J. BUZZO

Robert J. Buzzo is Olympia Nursery Manager, Lawyer Nursery, Inc, 7515 Meridian Road SE, Olympia, WA 98513; telephone: 360.456.1839; email: lawyernsy@thurston.com

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Abstract

At Lawyer Nursery in Olympia, Washington, we fall-fumigated fallow nursery ground with Vapam® and Telone™ II and Vapam® and Telone™ C-17 from 1998 through 2001. This fumigation provided excellent results when hardwood and conifer seedlings were sown into the treated areas the following spring. Seedling crops were larger and suffered less mortality than crops sown into unfumigated ground. The fall 2001 fumigation, however, resulted in significant damage to established *Pinus* crops growing adjacent to and up to 400 feet (120 m) from the fumigation area as a result of MITC escaping from the soil into the atmosphere.

Key Words

Bareroot nursery, alternatives to methyl bromide

Introduction

Lawyer Nursery Inc, of Plains, Montana, established itself on the West Coast in 1988 when the company purchased a 120-acre nursery site in Olympia, Washington. This property was developed as a forest nursery in 1970 and operated by an industrial forest seedling producer until 1985. In 1991, the company purchased an additional 55 acres (22 hectares) adjacent to the nursery. Lawyer Nursery currently produces an annual crop of 7 to 8 million bareroot seedlings and transplants on the 175-acre (70-hectare) nursery site. Lawyer Nursery in Olympia grows approximately 300 species of seed propagated woody trees and shrubs for a number of markets, including ornamentals, conservation, forestry, Christmas trees, commercial orchards, and so on.

This discussion will document soil fumigation experience at Lawyer Nursery in Olympia and evaluate the effectiveness and phytotoxicity of the chemical fumigant Vapam® HL.

Discussion

When I came to the nursery in 1989, my recent nursery background was in forestry seedling and Christmas tree production. At that time, periodic soil fumigation with methyl bromide/chloropicrin (MBC) was a standard practice in the industry. I utilized this technology in the fall of 1991 through 1993. We achieved typical results with the MBC fumigation in terms of reduced seedbed mortality and excellent weed control, but we struggled with stunted 1+0 conifers, which we attributed to mycorrhizal starvation. In 1994, we sowed a fumigated field with several species of *Acer*. The subsequent poor growth was so dramatic that we discontinued the use of MBC for soil fumigation. This response of *Acer*, thought to be associated with the loss of beneficial mycorrhizae, was reported by Regan in 1996. Many hardwood trees, including *Acer*, associate themselves with endomycorrhizal fungi, which have spores that are only soil borne. This means that re-inoculation can be a slow process if fumigation damages endomycorrhizal fungi (Davey 1994). For the next several years, we utilized crop rotation and post plant fungicide applications to control soilborne pathogens in our seedbeds. We considered soil pathogens to be a much less formidable obstacle to seedling production than the lack of beneficial mycorrhizal fungi.

Interest in alternative chemical fumigants to MBC was studied as early as 1986 (McElroy 1986) because of the relatively high application cost of MBC, the fear of regulatory intervention, and the acute toxicity of MBC. Two chemicals, metam sodium (Soil Prep, Vapam®, Metam ™, Nemasoll) and dazomet (Basamid®) were evaluated in 1985 (Campbell and Kelpsas 1986) and were found to perform as well as MBC in terms of seedling survival and growth. When MBC was listed as a potential ozone depleter in November of 1992 and assigned a phase-out schedule by the EPA, more studies on alternative fumigation chemicals were undertaken in the South (Carey 1994).

In 1998, Lawyer Nursery participated in a small soil fumigation trial comparing Vapam®, Vapam® and Telone™ II, Telone™ C-17, and Telone™ C-35. Telone™ C-17 is a combination of Telone™ (1-3-dichloropropene) and 17% chloropicrin and Telone™ C-35 is a combination of Telone™ and 35% chloropicrin (Dow AgroSciences 1999). This 4-acre trial was done in the fall of the year and the following spring the area was sown with several species of deciduous and conifer crops. The performance of crops sown into fumigated ground in 1999 was quite dramatic in terms of increased seedling size and reduced seedbed mortality in the Vapam®/Telone™ II plot compared to the non-fumigated control. Seedling performance in the Telone™ C-17 and Telone™ C-35 plots was better than the unfumigated control, but not as good as the Vapam® plot. It was my feeling that Vapam® reduced soil pathogens without eliminating beneficial mycorrhizal fungi. Based on results of this trial, we hired a contractor to treat 13 acres (5.3 hectares) with Vapam®/Telone™ II in 1999. The rates were 30 gal/ac (272 l/ha) for Vapam® and 24 gal/ac (224 l/ha) for Telone™ II.

We spring sowed both deciduous and conifer crops into the fall 1999 fumigated soil and the results were again very promising. Seedlings in the fumigated soil sized up better and we noticed less seedbed mortality in fumigated areas compared with seedling crops in non-fumigated areas. In fall 2000, we increased the Vapam® rate to 60 gal/ac (560 l/ha) in an effort to improve weed control. We fumigated 18 acres (7.3 hectares) that year with Vapam® and Telone™; the Telone™ rate remained at 24 gal/ac (224 l/ha). The performance of seedlings planted into fields fumigated in fall 2000 was again very dramatic. We continued to see good size and reduced seedbed mortality. Weed control, however, was erratic. In some fumigated areas, the population of weed seeds was significantly reduced while in others we did not see any significant reduction in the number of weeds. In 2001, we decided to use the combination of Vapam® at 60 gal/ac (560 l/ha) and Telone™ C-17 at 23 gal/ac (215 l/ha) instead of Telone™ II. We fumigated 28 acres (11.3 hectares) in the fall of 2001. Seedbeds in the fumigated areas continued to show the same results we had seen the previous 2 growing seasons in fumigated soil.

In 2002, we sampled soil in deciduous 1+0 seedbeds 10 months after fumigation to see if a soil pathogen assay would confirm what we saw when we visually compared crops in fumigated soil with similar crops sown in non-fumigated soil. These results are summarized in table 1 and they confirm that Vapam® is effective at reducing the levels of *Pithium* and *Fusarium*. It is my feeling that Vapam® reduces pathogen levels without severely impacting mycorrhizal fungi levels and this is what made this material so appealing to Lawyer Nursery. I do not have data other than crop performance to support this hypothesis.

Weed control with Vapam® continued to be erratic; in some areas the chemical had reasonable efficacy on weed seeds while in others we saw little, if any, affect on weed control.

Vapam® HL, or metam sodium (4.26 lb ai/gal [0.5 kg ai/l]) is a dithiocarbamate aqueous sodium salt. The Stauffer Chemical Company first patented Vapam® in 1956 (Herbicide Handbook 2002). Fumigation of soil with metam sodium was discovered in 1950 and

Table 1. Soil pathogen levels detected 10 months after soil fumigation.

	Phytophthora	*Pythium*	*Fusarium*
	- - - - - - - - propagules per gram of soil - - - - - - - - -		
Fumigated soil *Acer rubrum* 1+0	0	80 (vl)	880 (h)
Non-fumigated soil *Acer circinatum* 1+0	0	410 (h)	2000 (vh)

(vl) = very low numbers of propagules of the pathogen isolated per gram of soil sample
(h) = high numbers of propagules isolated
(vh) = very high numbers of propagules isolated

Soil fumigation, 9-27-01, Vapam®/ Telone™ C17
Pathogen assay, 7-27-02, Ribeiro Plant Lab, Inc
Soil samples were taken from 1+0 seedbeds.

it was reported as early as 1962 as a soil fumigant in a forest nursery (Hodges 1962). Metam sodium is considered to be a methylisothiocyanate (MITC) generator because it is quickly broken down in moist soil to MITC. MITC is toxic to nematodes, fungi, bacteria, and insects in the soil (Herbicide Handbook 2002). This chemical gained some notoriety outside of the nursery industry in July of 1991 when a train derailment in northern California resulted in the spill of approximately 13,000 gallons of Vapam® into the upper Sacramento River. This spill killed virtually all of the aquatic life in 40 miles of river; from the site of the spill to where the river empties into the Shasta Reservoir (Fechner-Levy 1991).

No phytotoxicity to crops as a result of Vapam® fumigation was noted at Lawyer Nursery in 1998 or 1999. In spring 2000, a strawberry grower in Olympia treated a portion of his farm that is adjacent to the nursery with Vapam®. The rotovate and roll application is a standard procedure for this grower and several days after the application I noticed some needle burn on approximately 100 *Pinus monticola* 2+1 transplants. This was in early spring prior to bud break and the cause of the needle necrosis was not readily apparent to me. This bed of transplants ran perpendicular to the neighbor's fumigation path and the end of the bed was within 50 feet (15 m) of the Vapam® application. A significant number of trees at this end of the bed were affected and the concentration of affected crop declined in the bed as the distance from the fumigation increased. We sent samples of these affected trees to WSU Puyallup and they noted no pathogens or insects that could be attributed to causing the needle necrosis, so we concluded that *P. monticola* had some degree of sensitivity to Vapam®. The percentage of the crop affected was insignificant and the trees broke bud and looked fine later in the growing season, so we did not give the matter much additional thought.

In fall 2000, I discussed the *Pinus* phytotoxicity incident of the previous spring with the fumigation contractor and, because the areas that had been designated for fumigation were not near *Pinus* crops, we proceeded as we had the previous year. The application method utilized by the contractor was to inject a portion of the Vapam® at a depth of 6 to 9 inches (15 to 23 cm) and spray a portion of the Vapam® on the soil surface. Just behind the surface nozzles was a cultipacker which pushed a berm of soil over the treated surface soil, thus rolling the Vapam® under the soil surface and sealing the surface with the cultipacker. The label suggests that light watering or a tarp after rolling helps prevent gas escape (AMVAC 1997). The Telone™ C-17 was injected at a greater depth with a separate tractor. We did not see any phytotoxicity in the nursery in 2000 following the Vapam® fumigation.

In fall 2001, we did have some *P. monticola* transplants growing in close proximity to the areas we had designated for fumigation. We discussed this with the fumigation contractor and the decision was made to inject all of the Vapam® at depths of 3 and 9 inches (8 and 23 cm). Again, a cultipacker behind the application shanks sealed the soil.

The 2001 fumigation was done on 26, 27, and 29 September. I was away from the nursery during the week following the fumigation application and when I returned to the nursery, I was advised by staff that a number of conifer crops adjacent to the fumigated areas were showing signs of distress. When I inspected the crops on 8 October 2001, I discovered that a significant number of *Pinus* and some *Picea* crops were exhibiting signs of Vapam® injury. These symptoms are discolored needles that appear "bleached out". In some trees, only a portion of the needles showed this affect, and in others, every needle on the tree was affected. In all, 13 species of *Pinus* and 6 species of *Picea* were affected. In some crops, only sporadic individual trees were affected and in other crops, as many as 90% of the population was affected. Of the damaged *Pinus* crops, 6 of 13 affected species suffered damage to over 40% of the population. The damage to *Picea* crops exceeded 4% in only 1 of the 6 species that were affected. Most of the damaged trees were within 50 feet (15 m) of the fumigated areas, but one crop of *Pinus banksiana*, which sustained considerable damage, was over 400 feet (120 m) from the source of the chemical.

Figure 1. 2+2 Pinus strobus *transplant stock (center) shows bleached out needlesfollowing fumigation of fallow field (right) with Vapam®.*

It appeared that the MITC emerged from the soil and was held close to the soil surface either by an inversion or a very still air event. This type of condition is not uncommon during late September and early October in Olympia, as the days are generally warm with cool, calm nights. The unaffected portions of crops that suffered heavy damages were in areas such as the ends of beds, which were slightly elevated from the rest of the crop.

The Washington State Department of Agriculture investigated the incident to determine if the application was within the guidelines of the product label. The Department speculated that, “Some escape of fumigant is almost unpreventable unless the soil is tarped immediately after the application.” The investigator also stated in the report, “I believe in this particular case, the applicator could have followed all the label directions and still caused the damage” (WSDA 2001). The Department concluded that the application was in compliance with the Vapam® label.

Similar damage to *Pinus* crops as a result of metam sodium or dazomet have been reported previously on at least 4 occasions. In fall 1988, *Pinus monticola* seedlings were damaged at the J Herbert Stone Nursery in Central Point, Oregon, as a result of fumigation with dazomet (Basamid®) (Scholtes 1989). Dazomet is also considered a MITC generator, as the immediate breakdown product of dazomet is also methylisothiocyanate (Landis and Campbell 1989). In this case, an untarped application of dazomet coupled with an inversion layer caused damage to non-target crop (*Pinus monticola*) seedlings. Unfortunately I did not read the published report of this incident until after the 2001 fumigation at Lawyer Nursery. More recently, in November 1999, an International Paper Nursery in Texas lost 20 million seedlings after fumigation with a mixture of Sectagon® (metam sodium) and chloropicrin (Peoples 2001). A similar, but less severe incident in terms of numbers of damaged seedlings occurred at the Mississippi State Nursery in fall 1999. Another crop injury incident involving metam sodium damage to *Pinus* seedlings occurred at the Arkansas State Nursery about 10 years ago (Carey 2002).

Conclusion

The reported incidents of phytotoxicity to crop seedlings as a result of metam sodium or dazomet fumigation would indicate that certain conifer trees, particularly those of the genus *Pinus*, are very sensitive to MITC exposure. Based on our experience, *Pinus* foliage is significantly more sensitive to MITC than any of the other 300 species of woody trees that we grow. Of the more than 78,000 trees that were damaged at Lawyer Nursery, over 95% were pines. Had I researched Vapam® prior to using this chemical in the nursery as thoroughly as I did to prepare this paper, I would probably have still used the material and been able to do so without damaging non-target crops.

I think it is safe to speculate that while not all nursery managers read the entire nursery meeting proceedings every year, they do read the product labels for pesticides they use. It is my feeling that the pesticide label is the most efficient place to publicize known risks to crops that may result from the application of a particular pesticide. Certainly there are risks of crop injury associated with many pesticides used by nursery growers. In the case of Vapam®, there are a number of precautions that could be taken to minimize or eliminate the risk of crop injury. These would include not using the chemical within 400 feet (120 m) of *Pinus* seedlings, and sealing the chemical in the soil more effectively with irrigation water or a tarp. It is my feeling that Vapam® offers nursery growers an additional tool to reduce the impact of soil borne pathogens on bareroot nursery crops. If known risk associated with use of this product, such as the documented sensitivity of *Pinus* seedlings, was identified on the product label, the effectiveness of this tool in the nursery would be much improved.

References

AMVAC Agricultural Bulletin. 1997. Vapam® HL soil fumigant. Los Angeles (CA): AMVAC Chemical Corporation.

Campbell SJ, Kelpsas BR. 1988. Comparison of three soil fumigants in a bareroot conifer nursery. Tree Planters’ Notes 39(4):16-22.

Carey WA. 2002. Personal communication. Auburn (AL): Auburn University, Southern Forest Nursery Management Cooperative.

Carey WA. 2000. Fumigation with chloropicrin, metam sodium, and EPTC as replacements for methyl bromide in southern pine nurseries. Southern Journal of Applied Forestry 24(3):135-139.

Carey WA. 1994. Chemical alternatives to methyl bromide. In: Landis TD, Dumroese RK, technical coordinators. Proceedings, Forest and Conservation Nursery Associations; 1994 July 11-14; Williamsburg, VA. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-257. p 4-11.

Davey, CB. 1994. Soil fertility and management for culturing hardwood seedlings. In: Landis TD, Dumroese RK, technical coordinators. Proceedings, Forest and Conservation Nursery Associations; 1994 July 11-14; Williamsburg, VA. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-257. p 48-49.

Dow AgroSciences LLC. 1999. Specimen label for Telone™ C-17 and Telone™C-35. URL: http://www.cdms.net/manuf/manuf.asp (accessed Aug 2002).

Fechner-Levy. 1991. Vapam® Spill – Sacramento River – July 14, 1991. URL: http://www2.latech.edu/~dmg/Fechner_Levy_2-27.pdf (accessed Aug 2002).

Herbicide Handbook. 8th Edition – 2002. Weed Society of America.

Hodges CH. 1962. Diseases in southern forest nurseries and their control. Asheville (NC): USDA Southern Forest Experiment Station. Station Paper 142.

Landis TD, Campbell SJ. 1989. Soil fumigation in bareroot tree nurseries. In: Landis TD, technical coordinator. Proceedings, Intermountain Forest Nursery Association; 1989 August 14-18; Bismark, ND. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-184. p 13-28.

McElroy FD. 1986. Use of metam-sodium and dazomet fumigants. In: Landis TD, technical coordinator. Proceedings: Combined Western Forest Nursery Council and Intermountain Nursery Association Meeting; 1986 August 12-15; Tumwater, WA. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-137. p 139-146.

Peoples B. 2001. Personal communication. Livingston (TX): Nursery Manager, IP Texas Supertree Nursery.

Regan R. 1986. Fumigation practices in Oregon ornamental plant nurseries. In: Landis TD, South DB, technical coordinators. National Proceedings, Forest and Conservation Nursery Associations. Portland (OR): USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GRT-389. p 150-151.

Scholtes JR. 1989. Soil fumigation at J. Herbert Stone Nursery. In: Landis TD, technical coordinator. Proceedings, Intermountain Forest Nursery Association; 1989 August 14-18; Bismark, ND. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-184. p 13-28.

Washington State Department of Agriculture. 2001. Case File T099-2001.