

Survey of Southern Forest Nurseries: Fumigation Practices and Pest Management Concerns

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Abstract-The proposed ban on methyl bromide by the Environmental Protection Agency in 2001 is anticipated to have an adverse impact on forest tree nurseries in the southern region. Surveys in the past have indicated that methyl bromide was the fumigant of choice for southern nurseries. A recent survey of southern nursery managers was conducted to determine what type of alternatives to methyl bromide fumigation are in use or have been attempted, and what pest problems have occurred as a result of these other methods of pest control.

The majority of nursery managers routinely use MBC (methyl bromide with chloropicrin) fumigation for control of pest problems (89%). The most important pest problems that currently concern nursery managers are nutsedge followed by post-emergence damping-off. Forty-two percent of nursery managers have used fumigants other than MBC. Dazomet was the most common fumigant tested by nurseries, and only 5 out of 17 nurseries reported that dazomet had the same effectiveness as MBC. Inability to control weeds was cited as the most common problem with the use of dazomet.

Twenty out of 45 nursery managers have attempted to manage a portion of their nursery without the benefit of fumigants. Six of these nurseries were just in the process of establishing studies, while 14 nurseries have been managed for 2 years to more than 10 years without fumigation. Again, weeds were the most frequently listed problem (9 out of 14), followed by diseases (5 out of 14) in unfumigated beds. Only two nurseries continue to manage their entire nursery without the use of fumigation.

If fumigants were not available, 67% of nursery managers responded that weeds would be a problem and 62% cited pathogens would be a problem in their nursery. When managers were asked what the greatest needs were for management of pest problems, they rated the development of herbicides for control of specific weed problems (80%), and better information on prevention and control of specific disease problems (60%) as high priority needs.

INTRODUCTION

Southern nursery managers are faced with many challenges in their efforts to provide the South with quality seedlings for reforestation. Pests that cause damage to their crops are of great concern. These agents can include diseases, nematodes, insects, competing weeds, chemicals, environmental conditions, and animals. Management of damaging agents is an important part of any nursery's program. The soil fumigant MBC (methyl bromide with chloropicrin) is a broad spectrum fumigant that is used to control soilborne pests. In the South, methyl bromide is an integral part of nursery pest management (Boyer and South 1984; Fraedrich 1994). The Environmental Protection Agency has planned to phase out production and use of methyl bromide by the year 2001, which could have an adverse effect on the production of seedlings for reforestation.

A survey of southern nursery managers was initiated by the USDA Forest Service. Forest

Health Unit (R-8), in cooperation with the Southern Research Station to provide specific information on nursery fumigation practices, current pest problems, alternative fumigants, and anticipated pest problems if no fumigant were available. The survey was also designed to gain information on pest problems that nurseries may have had when they managed seedbeds without fumigation.

METHODS

In January 1995, a survey was mailed to 87 managers of state, forest industry, and other private nurseries that produce tree seedlings in the South. The source of the nursery addresses was obtained from the October 1992 issue of *Forest Farmer* (Anonymous 1992). The survey consisted of a series of questions that required respondents to check the appropriate response or provided a short answer.

Survey responses were summarized and responses to questions were reported as a percentage of respondents. Short answer responses were grouped into major categories and then divided by the total number of respondents.

RESULTS

A total of 45 (52%) of the nursery managers responded to the survey. The percentage of state, industry and private nurseries that answered the survey was 94%, 66%, and 12% respectively. The 45 responses consisted of 25 (56%) from forest industry, 16 (36%) from state agencies, and 4 (9%) from private nurseries.

All of the nursery managers reported that they produce conifers, while only 28% of the respondents grow hardwoods. The species most commonly produced was loblolly pine (Table 1). The second most common species grown was slash pine. Hardwoods were often grouped by genus due to the great variety of hardwood species grown by nurseries. Oaks were listed most frequently as a crop produced at nurseries, followed by ash species.

Table 1. The percentage of nurseries that are producing a particular pine species or hardwood genus

<u>Types of trees produced</u>	<u>Percentage of nurseries (n=45)</u>
Loblolly pine	87
Slash pine	58
Longleaf pine	33
Virginia pine	20
White pine	16
Sand pine	9
Oak	35
Ash	16
Sweetgum	11
Walnut	9
Sycamore	9

Nursery managers were asked to provide information regarding the pest problems that occur in their nurseries under their current nursery pest management practices. They were also asked to rate the severity of these problems, and indicate whether these problems occurred on a yearly or periodic basis (table 2). The most severe pest problem reported was nutsedge with 18% of managers listing it as a severe-yearly problem, and 33% listing it as a moderate-yearly problem. Some managers also added prostrate spurge under "other" pest problems (9% severe-yearly, 9% moderate yearly). Pre-emergence and post-emergence damping-off were primarily considered as slight-periodic problems, but 18% of managers listed post-emergence damping-off as a moderate-yearly problem.

Table 2-Percentage of southern nurseries reporting a pest problem in their nurseries as severe, moderate, or slight on a yearly or periodic basis under current nursery practices (n=45)

Pest	<u>Severe</u>		<u>Moderate</u>		<u>Slight</u>		<u>Unsure</u>	<u>None</u>	<u>N/R</u> ²
	<u>Y</u> ¹	<u>P</u> ¹	<u>Y</u> ¹	<u>P</u> ¹	<u>Y</u> ¹	<u>P</u> ¹			
Pre-damping-off	--	2	7	4	20	38	9	11	9
Post-damping-off	--	2	18	2	18	53	--	2	4
Charcoal root rot	2	--	2	4	--	24	13	47	7
<i>Cylindrocladium</i>	9	--	--	--	2	13	20	49	7
<i>Rhizoctonia</i>	2	--	7	4	7	27	13	27	13
Pitch canker	4	--	*	--	2	20	7	51	13

Fusiform Rust	2	--	--	2	11*	20	--	47	16
Seedborne fungi	--	--	--	--	4	13	40	33	9
Cutworms	--	--	7	4	13*	29	2	24	16
White grubs	--	4	4	--	9*	38	2	29	9
Nematodes	--	--	--	--	11*	22	24	29	11
Nutsedge	18	2	33	4	20	7	2	11	2
Other: Spurge	9	--	9	--	--	--	--	--	--
Other: lygus bug	--	4	--	--	--	7	--	--	--

¹Y=a yearly problem in the nursery; P=a periodic problem

²N/R=no response

*2-4 % of nursery managers in this severity rating failed to indicate whether the pest was a yearly or periodic problem

Insect pest problems, such as cutworms (Family: *Noctuidae*) and white grubs (*Phyllophaga* spp.), were reported most frequently as a slight-periodic problem. In the "other" category, 4% of nursery managers indicated that lygus bugs cause a severe-periodic problem, and 7% indicated it was a slight-periodic problem. Specific disease problems such as *Rhizoctonia* blight and *Cylindrocladium* root rot were reported primarily as slight-periodic pest problems by a small percentage of managers. Most managers did not regard these diseases as problems, or were unsure if they were a problem in their nursery. It is noteworthy that 40% of managers were unsure whether they had a problem with seedborne fungi, and 24% of managers were unsure if nematodes were a problem in their nursery.

Eighty-nine percent of nursery managers reported that they routinely use MBC in their nursery (Figure 1). Three managers indicated they rely upon other fumigants and two indicated that they did not routinely fumigate their nursery beds. Forty-five percent of nurseries that applied MBC use the formulation with 2% chloropicrin (18 out of 40). MBC with 33% chloropicrin was applied by 30% of the nursery managers. Both formulations were utilized by 25% of those nurseries that use MBC.

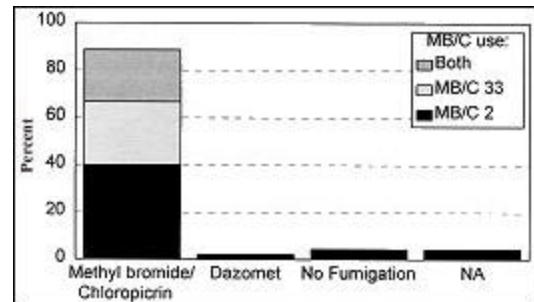


Figure 1. The percentage of southern nurseries that utilize a particular fumigant operationally (n=45).

Fumigation after every other crop was conducted by 58% of nurseries that rely on MBC. Fumigation with MBC before every crop was reported by 25% of nurseries. Another 8% of the nursery managers reported fumigation before every other crop of pines and before every crop of hardwoods. Only 5% of nursery managers reported fumigation before every third to fifth crop, and another 5% were not fumigating their nursery.

Fumigants other than MBC were used or tested by 19 of the 45 nursery managers (42%); most of these (17 of 45) use or had tested dazomet (Basimid[®]). Dazomet was reported to be less effective than MBC by 11 of the 17 managers. Only 5 managers that applied dazomet reported that its effectiveness was the same as MBC. Chloropicrin is currently being tested by 2 of the responding nurseries; no rating was reported by these managers. Metam-sodium (Busan 1020[®]) was the only other fumigant listed by a manager to have the same effectiveness as MBC. One nursery manager had tested vorlex (discontinued 1991 by NOR-AM) and reported it to be less effective than MBC. A new fumigant, consisting of 70% dichloropropene and 30% chloropicrin (Triform[®]), was tested by one manager and he reported it to be less effective than MBC. When managers were asked what were the problems with other fumigants, all answers but one were aimed at dazomet. Poor weed control was the most common problem cited by 7 out of 17 nursery managers who used dazomet. Other problems reported by managers were poor seedling growth, poor mixing with soil, and no benefit (2 out of 17, each category). One manager had difficulty finding a contractor to apply the fumigant and another manager reported the fumigant remained in the soil after it should have dissipated.

Forty-four percent of nursery managers indicated that they have managed areas of their nursery without the benefit of fumigants. Seventy percent of these nurseries (14 out of 20) have had unfumigated areas ranging from 1 acre for 2 years, up to the entire nursery for more than 10 years. The primary pest problem identified by managers that had unfumigated beds were weeds (9 out of 14). Nutsedge was mentioned as a severe to moderate problem in these unfumigated areas by 6 out of 8 nursery managers. Diseases caused by fungi were the second category of pests cited by 5 out of 14 managers as problems in non-fumigated beds. The two disease problems cited were damping-off (3 out of 5) and root rots (2 out of 5). Managers rated these disease problems as moderate to severe. Only one nursery mentioned nematode damage as a problem in non-fumigated beds. Although 44% of managers have managed some portion of their nurseries without fumigation, only 16% of nurseries routinely leave small areas in their nursery unfumigated to determine the effectiveness of fumigation for the prevention of pest problems.

A profile of 6 nurseries that have managed unfumigated areas for 5 years or more is outlined in table 3. The most common pest problems reported by these nurseries were weeds and damping-off. The current fumigation practice at 4 of the 6 nurseries is the use of MBC before every crop, or every other crop. Only 2 nurseries are continuing to manage their seedling crops without fumigation. In both cases the soil texture of these nurseries was sandy clay loam, and tile soil was managed for an average of 3% organic matter.

Table 3. Profile of nurseries that have managed areas without fumigation for 5 years or greater

<u>Area</u>	<u>Years</u>	<u>Species</u>	<u>Soil texture</u>	<u>Pest problems</u>	<u>Current fumigation</u>
1/10th acre	5	Loblolly pine	Loam	moderate-slight damping-off	MBC 33 before every other crop.
18 beds	5	Slash pine	Sand	severe nutsedge	MBC 33 before every other crop
Entire nursery	7	Loblolly pine	Sand	poor crop quality; nematodes & root rots were major concerns	MBC 33 before every other crop - if they had problems in an area since the last fumigation
Entire nursery	10	White pine, oaks, poplar, alder	Sandy loam	severe weeds and damping-off	MBC 2 before every crop
Entire nursery	8+	Loblolly pine, Virginia pine	Sandy clay loam	moderate nutsedge & sicklepod; slight-periodic damping-off & cutworms	no fumigation - organic matter 2.6-3.9%
Entire nursery	10+	Loblolly pine	Sandy clay loam	severe prostrate spurge; periodically other pests; moderate charcoal root rot; slight damping-off, Rhizoctonia, cutworms, and nematodes	no fumigation; plants longleaf and hardwoods in the fall; organic matter 3%.

Both managers believed that maintaining a high level of organic matter has helped reduce soilborne diseases. One of these nursery managers believed that planting longleaf pine and hardwoods in the fall also helped to reduce seedling losses. Both nurseries have had slight periodic problems with damping-off and cutworm damage. One nursery has a severe problem with prostrate spurge, and the other has moderate problems with nutsedge and sicklepod.

Managers were asked which pests they anticipated to be a problem in their nursery if all fumigants were withdrawn from the market. Sixty-seven percent of the nursery managers responded that weeds would be a problem in their nursery (30 out of 45). Nutsedge was the most common weed listed (15 out of 45), followed by spurge (5 out of 45). Sixty-two percent of managers listed diseases as potential problems (28 out of 45). The disease problems listed most often were root rots (14 out of 45), damping-off (7 out of 45), and nematodes (7 out of 45). Specific disease problems reported by nursery managers were charcoal root rot (3 out of 45). Rhizoctoma blight (3 out of 45). and Fusarium diseases (3 out of 45). Other soilborne

organisms listed were white grubs (5 out of 45) and cutworms (2 out of 45)

In view of the decision by the Environmental Protection Agency to ban the use of methyl bromide by the year 2001, nursery managers were asked what they considered to be their greatest needs for the management of pest problems. Managers identified the development of herbicides for control of specific weed problems as their greatest need (Table 4). The second greatest need identified was better information on the prevention and control of specific diseases. Development of systems to forecast insect and disease problems was third in importance.

Table 4. The greatest needs of nursery managers for management of pest problems in view of the expected ban of methyl bromide in 2001.

<u>Needs for the future</u>	<i>Priorities</i>			<u>NR¹</u>
	<u>high</u>	<u>medium</u>	<u>low</u>	
Development of herbicides for control of specific weeds	80	18	0	2
Information on prevention and control of specific diseases	60	33	2	4
Development of systems to forecast pest problems	44	36	16	4
Information on prevention and control of specific insects	27	60	11	2
Better information on control of seedborne diseases	29	27	40	4
Better practices for the production of high quality seedlots	29	24	40	7

DISCUSSION

Currently the majority of nursery managers (89%) routinely use MBC formulations to manage pest problems. The number of southern nurseries that use MBC has not significantly changed since Boyer and South (1984) surveyed southern nursery managers in 1981. However, the frequency of fumigation use has dropped from 60% (Boyer and South 1984) to 25% of nurseries fumigating before every crop. The drop in frequency of fumigation was probably due in part to the development of herbicides that provide adequate control of many weeds in pine seedbeds at one tenth the cost of fumigation (South 1980; South and Gjerstad 1980). Also, there is evidence that fumigation can provide good control of root diseases for up to 3-4 years after fumigation (Hodges 1962).

The use of fumigants by nursery managers for weed control has been well documented throughout the United States (Boyer and South 1984; Fraedrich 1994; South 1980; South and Gjerstad 1980). In 1980, South and Gjerstad reported that the use of MBC fumigation in pine seedbeds for weed control was justified when the incidence of perennial weeds was severe; otherwise herbicides could provide effective control of weeds. They stated further that nursery managers could reduce their fumigation costs by as much as two-thirds, if they used fumigation as needed for nutsedge and disease control. Only in hardwood seedbeds was routine fumigation economically justified for weed control (South and Gjerstad 1980).

Why did nursery managers report that weed control was still the primary reason for application of MBC? In a 1993 survey, over half of southern nursery managers indicated that herbicides were not an effective alternative to soil fumigation for weed control (Fraedrich 1994). The lack of selective herbicides for control of weeds in hardwood seedbeds, and the ineffective control of nutsedge and sparges in conifer beds, were the primary reasons for the belief that herbicides would not be an adequate substitute for fumigation (Fraedrich 1994). Dazomet, the most common alternative fumigant currently used, has been reported to be less effective than MBC in controlling weeds such as nutsedge or prostrate spurge (Alspach 1989; Carey 1995; Chapman 1992; Hildebrand 1991; Hildebrand and Dinkel 1989). In this survey, nutsedge was reported to be the greatest problem in nurseries and is expected to be the greatest future problem if fumigants were not available. This expectation was realized at 6 of 14 nurseries that found nutsedge to be a severe to moderate problem when fumigation was not used for more than two consecutive crops. The lack of effective weed control by available herbicides and alternate fumigants helps to explain the emphasis that managers place on technology development of herbicides for control of specific weeds.

In addition to controlling weeds, fumigation with MBC has been used by nursery managers to prevent soilborne diseases (Boyer and South 1984). Southern nursery managers rated fumigation for disease control as moderate to high in importance in a 1993 survey (Fraedrich 1994). This perception may be due to the view that fungicides are not an effective control of diseases when compared to fumigation (Fraedrich 1994). The results from this survey, compared to the 1981 survey by Boyer and South (1984), showed an increase in the nurseries who reported pre- and post-emergence damping-off, however, the severity of the problem was classified as slight in both surveys. The reduction in the use of MBC from 1981 to 1994 may account for the reported increase in the occurrence of damping-off. One reason that many managers maintained a reduced fumigation schedule may be because the expense of fumigation was not warranted if the damage was slight (Hodges 1962).

Only a few nurseries listed specific root diseases as the cause of severe-yearly problems. The majority of nursery managers who reported root disease problems rated the severity as slight, as did nursery managers in 1981 (Boyer and South 1984). Results of the present survey indicated that many managers were unsure of whether they had root disease, seedborne disease, or nematodes in their nursery. The regular use of fumigation by the majority of nurseries would reduce the potential for a severe outbreak of any soilborne pathogen. If no fumigants were available, two-thirds of managers believed that soilborne pathogens would become a problem. Comparatively, only a third of the managers who left part of their nursery without fumigation, reported moderate to severe losses from damping-off and root rot.

Seventeen nursery managers have used dazomet and none indicated that damping-off or root rot was a problem when this fumigant was used. The results of several studies in the western United States have shown that dazomet was as effective as MBC at controlling damping-off and root disease on conifers (Alspach 1989; Campbell and Kelpsas 1988; Hildebrand 1991; McElory 1986; Tanaka et al. 1986). Other studies have shown that areas treated with dazomet had higher populations of potential pathogen in the sod, however, seedling survival and size surpassed or equaled those treated with MBC (Campbell and Kelpsas 1988; Tanaka et al.

1986). These survey results, coupled with past research, indicate that dazomet is a possible alternative fumigant for controlling damping-off and root diseases in pine nurseries.

Parasitic nematodes were reported to be a slight problem in about a third of the nurseries. However, almost as many managers were not sure if nematodes were a problem in their nursery. Only a few managers believed nematodes would be a problem if fumigants were not available. These results correspond to a 1993 survey that found over half of managers surveyed considered the use of fumigation for nematodes as low or not important (Fraedrich 1994). The low concern of managers towards nematode control is perhaps justified considering that effective nematicides are available.

Insect pests, such as cutworms and white grubs, were considered a slight problem in nurseries. In fact, none of the nurseries that managed without fumigation listed insects as a problem. In 1935, Wakeley stated that white grubs were a persistent and destructive nursery pest, and that even a light infestation of grubs could reduce stocking by 10-20%. Wakeley (1935) also reported that cutworms were considered less serious, except when populations were high. The present routine use of fumigation has probably helped to maintain low populations of grubs and cutworms. Insecticides can also provide effective control when fumigation is not used (Bacon and South 1989), therefore, few nursery managers have anticipated that cutworms or grubs to be a problem if all fumigants were withdrawn from the market.

Alternate fumigants are being tested in many nurseries in the South (Carey 1995). Whether any of these fumigants will replace MBC in effectiveness as a biocide is unknown at this time. Nursery managers may have to use a more comprehensive IPM program to control soilborne pests when methyl bromide is no longer available. The primary problem with alternate fumigants is the poor control of nutsedge and spurge. Until more selective herbicides are developed, nurseries that do not have access to selective herbicides will have to be more aggressive in their sanitation efforts.

The use of alternative fumigants and other pesticides to replace MBC may be short-term solutions (Civerolo et al. 1993; Fraedrich 1994; Kannwischer-Mitchell et al. 1995). Public concern over environmental quality, and human health and safety, has continued to increase over time, therefore, alternative fumigants to MBC may be challenged by environmental regulations in the future (Civerolo et al. 1993). Long-term research priorities, outlined at the USDA Workshop on Alternatives to Methyl Bromide, were to develop new cultural/ crop production systems, and - integrate existing cultural practices that are appropriate (Civerolo et al. 1993). Nationwide studies are being conducted in public and private nurseries to evaluate alternative soil and crop management systems and their effect on soilborne diseases (James et al. 1994; Littke 1994). Initial results are promising (Barnard et al. 1996; Hildebrand 1996; Stone et al. 1996), however, this may be due to a lack of disease pressure. Significant disease pressure may not occur in the first couple of years for many nurseries that have been using fumigation for decades.

The future management of southern nurseries depends on exploration of various methods to manage nursery pest problems including alternate fumigants, selective herbicides, and cultural practices. Nurseries may be able to maintain quality seedling production with the

integration of these alternate methods into their current pest management. The more information and management options that a nursery has available, the more readily a nursery can adjust to changes in pesticide availability.

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