ALTERNATIVES TO METHYL BROMIDE IN FOREST TREE NURSERIES[1]

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INTRODUCTION

Methyl bromide (MBr) was listed for withdrawal under the Clean Air Act in 1993. Since then much research has focused on evaluating treatments to replace its use in forest nurseries and other crops. Almost all the techniques were tested before 1960 and then neglected in favor of MBr. Therefore, the real problem was to determine which now fit most effectively into a production scheme that has changed radically since MBr was widely accepted in the late 1960's. With few exceptions good estimates of the effectiveness of available alternatives was possible using published studies. To date, after regulatory losses of pesticides are considered, the most promising alternatives could have been predicted from a review of literature. Considering the probable costs and benefits associated with some retested alternatives, many efforts (money) might be difficult to justify.

Records of disease losses in forest nurseries before MBr may hardly seem credible to us today. Henery (1951), stated that "when the number of seedlings produced per unit area has been calculated, it has not been unusual to find a 40-50 percent reduction resulting from root rot". Problems were similar in Virginia (Morris 1960) where, "the usual loss of from 20 to 30 percent of the germinated seedlings" occurred annually. Root rot "destroyed at least 20 million (20 percent) of Florida's nursery-grown pine seedlings" in 1976 (Seymour 1978). It may seem more surprising to realize that these losses are not far off what seems to have been the average impact of disease in non-fumigated nurseries. Among 157 published comparisons from forest nurseries, there was a 50 percent increase in numbers of seedlings for beds fumigated with MC2 or MC33 compared to controls (Carey 1994).

The following alternatives to methyl bromide are presented in what I consider the reverse order of desirability to the forest nursery industry. That is, Alternative (Move) is least likely to be cost effective based on probable costs and historical benefits. However, each of these alternatives has been used in the past. Most nursery managers would be surprised by what is "reasonable" to those who consider anything but pesticides reasonable.

ALTERNATIVES

Move

Nurseries have been abandoned due to pest problems. Before effective fumigants made eliminating soil borne disease possible moving nurseries was common. 'Reasonable commercial control has often been secured in Wisconsin by planting on newly cleared forest soil (Riker and others 1947)." Also, diseases caused the Virginia Division of Forestry's nursery production to be moved to newly cleared land at the New Kent nursery in 1959 (Morris 1960). More recently, referring to MBr fumigation in the northwest, Sutherland (1984) recommended, "sites requiring this level of maintenance might best be abandoned or paved for a container nursery!" Expensive pest avoidance! When two pine crops are grown per fumigation, the cost of pest control is about 4 percent or 0.2 cents of a 3.5 cent bareroot loblolly or slash pine seedling. Similar container-grown seedlings cost about 13.5 cents and although they have other advantages, 10 cents a seedling (75 percent) is expensive pest control. If pest control at bareroot nurseries cost 10 cents per seedling it would be the equivalent of $70,000 per acre. With nursery establishment costs of perhaps $3,000,000 for a bareroot capacity of 50,000,000 seedlings, moving must be put off for about 40 years if it is to be an alternative to fumigation. That is not likely to be cost effective, and within a few years the new nursery could have similar problems.

Sow More Seed

Howe and Clifford (1982) wrote that "the standard nursery practice when sowing conifer seeds is to over-plant in order to compensate for losses from damping-off and other factors that affect germination and survival of seedlings." Over sowing could be a logical consideration if soil-borne diseases were normally distributed. Both the efficacy of fumigation and problems associated with over sowing can be appreciated from an early fumigation study (Hill 1955) where MBr increased bed densities from the expected $48/ft^2$ to the unmanageable $229/ft^2$ which itself would suppress seedling development.

The economic threshold for an effective treatment is relatively easy to calculate. For example, if a seed cost 0.5 cents ($60/lb), then to sow 25 $/ft^2$ the economic threshold for a $1,000 treatment is an expected 28 percent loss. It is difficult or impossible to calculate the economic threshold for non-effective treatments, such as over sowing. If seedling quality is considered, production might be worse in years where too many seedlings survive. In addition, costs associated with morphological or genetic improvement, such as more expensive seed and more space per seedling, are magnified by the risks associated with production. For example, if a seed cost 1 .O cent (control pollination) not only is the extra 28 percent sown to replace disease twice as expensive so are the culls in areas without disease.

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[1]Carey. W.A. 1999. Alternatives to methyl bromide in forest tree nurseries. In: Landis, T.D.; Barnett, J.P., tech. coord. National proceedings: forest and conservation nursery associations-1998. Gen. Tech. Rep. SRS-25. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 69-70.
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Disease Suppressive Soils-Biological Control

Since at least the turn of the century the importance of soil characteristics to root disease has been recognized and since mid-century it has been known that the fungi responsible for damping-off were relatively rare in natural forests (Riker and others 1947). This has been observed with soils and plants moved from nurseries to forests and from forests to nurseries (Smith 1967). This was part of the reason for moving seedling production as cited in Alternatives. If pathogens do not survive in forest soils then perhaps nursery soils can be made suppressive. The suppressive factor appears to be related to soil organic matter, pH, or biological control agents. These factors were considered as early as 1921 (Taylor) and an extensive review was made 35 years ago (Vaartaja 1964). Unfortunately, it has been a difficult research area and optimal conditions remain unknown. Till recently, "because of frustrations, discouragement, and failures, many scientists have not continued their investigations with amendments. The lack of papers on the subject during the past several years has made this attitude apparent" (Papavizas 1974). Given the extensive history and slow progress of trials with organic amendments and pH modification, the optimism emerging after 1993 may be difficult to understand (at least in terms of the probabilities associated with grower costs).

Physical Suppression

Physical suppression can overlap with techniques to create suppressive soils. For example, if 300 gallons of H_2SO_4 is pH modification then 1,000 (or more) gallons could be thought of as an attempt to directly destroy fungi. Recently, physical suppression has usually involved heat, either by solarization or inputs of hot water or steam. Solarization has the advantage of being relatively cheap. However, it fits poorly into the production cycle and it has not been reliable in forest nurseries.

Unlike most other techniques reevaluated since 1993, the ability to heat soil on a scale to treat fields is new. Advances in mechanical technology make it possible but problems remain. First, lethal temperature must be dispersed through 2,000,000 lbs of soil per acre furrow slice and we would like to treat more than just the top six inches. Even though treatment was effective (Carey 1997) and the technology is getting better, hot water applicators are, at present, too slow. Steam applicators are slower still. The potential to physically change the soil structure and the amount of water (35,000 gal/ac) and fuel needed may make these technologies impractical in some nurseries.

Pesticides

By paying close attention to the literature we could have made our task between 1993 and 1998 easier. A 1994 search of information on fumigation in forest nurseries produced 354 comparisons that included data on seedling numbers for both treatments and controls (Carey 1994). Here are the nine most frequently tested fumigants before 1993 with the percent increase compared to controls in parentheses: MC2 (49), MC33 (49), metham-sodium (37), ethylene dibromide or EDB (28), allyl alcohol (27), MITC generators such as dazomet (18), formaldehyde (16), chloropicrin, (16) and DD (6). Although there were many fewer comparisons with data for seedling size, chloropicrin most enhanced seedling growth. The only available fumigant not extensively covered in the surveyed literature was dichloropropene (1,3-D) which is one of the components of the old DD formulation. Although 1,3-D had good efficacy in our trials, it appears likely to have regulatory problems with air quality. After removing from consideration those compounds which now have regulatory restrictions or are likely to be restricted (that is EDB, formaldehyde, DD, some MITC generators such as Vorlex, and 1,3-D) we could probably have restricted our evaluations to combinations of chloropicrin and metham-sodium along with herbicides to increase nutsedge control. Is it surprising that no new, magic, techniques were developed for forest nurseries from all the money and effort expended? Expected reward for activities as diverse as purchasing lottery tickets or research on methyl bromide alternatives is a function of the cost times the probability of success. More can be done by concentrating on the most likely alternatives. In my opinion, the probability of success was sometimes ignored in favor of options without pesticides. Attempts to mulch, compost, acidify and employ beneficial microorganisms may seem more reasonable to those who don't have to produce seedlings on a budget, but whose money is spent?

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