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Alternatives to Methyl Bromide: Assessment of Research Needs and Priorities for Forestry, Nursery, and Ornamental Crops

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This report summarizes the findings of a session at the USDA workshop "Alternatives to Methyl Bromide" held in Arlington, Virginia, in June 1993. The report is published in full in the 1993 USDA publication, Alternatives to Methyl Bromide: Assessment of Research Needs and Priorities. Tree Planters' Notes 45(2):43-47; 1994.

The specific objectives of the USDA workshop "Alternatives to Methyl Bromide" were to

- Evaluate the existing and potential alternatives to methyl bromide uses as a postharvest commodity and quarantine treatment and as a soil fumigant to control agricultural pests.
- Identify research needs and priorities to develop effective alternative pest management strategies that do not rely on the use of methyl bromide.

The workshop was attended by over 250 individuals, many of whom were pest management specialists and scientists from various industries, universities, and State and Federal agencies. The workshop was divided into nine sessions. One of these sessions (session VIII) was devoted to the impact of the loss of methyl bromide on nursery production of forest tree seedlings and ornamental trees and shrubs. The evaluation process for each discussion group included the identification of the pests that would become a problem without methyl bromide, assessment of the scope of the problem (that is, national or regional), and a determination of the existing and potential alternative pest management practices available. As a final step, the group prioritized the research needs of the commodity group it represented. The nursery session was chaired by Robert Linderman, Wayne Dixon, Stephen Fraedrich, and Richard S. Smith, Jr., and comprised the following participants: Larry Abrahamson, William Carey, Everett Hansen, Harvey Holt, Robert James, Jennifer Juzwik, Robin Rose, and David Schisler.

The production of forestry and ornamental crops includes a wide diversity of plant species. The plants themselves are the product, and they are grown in many different types of production systems, from bareroot in ground beds and fields to production in containers and greenhouses. These plants are produced in every part of the United States and shipped from their site of production to their site of use. Shipping, handling, storage, and outplanting become considerations in dealing with disease and insect problems. The geographical sites of production may have great differences in climate, soil, and pest problems. Production systems are also influenced by a variety of manager and market demands.

Methyl bromide has been widely used to control soilborne root diseases, nematodes, insects, and weeds. The primary use of methyl bromide has been to treat ground beds. However, it has also been used to treat container mixes and containers to eradicate soilborne plant pests known to limit production and quality.

Commodities, Pest Problems, and Scope

The wide diversity of forestry and ornamental commodities produced in nurseries and greenhouses includes trees for reforestation, Christmas tree farms, and landscape and ornamental purposes, as well as fruit trees and small fruits.

The soilborne pests of these commodities include pathogens, nematodes, insects, and weeds. The scope of these problems is national or regional. Additional problems are expected to arise and the scope of current problems will increase if methyl bromide is not available for use in producing these commodities.

Pathogens. Soilbome fungal pathogens include *Fusarium, Pythium, Phytophthora, Rhizoctonia, Cylindrocladium,* and *Verticillium,* which are national problems. Regional problems are caused by *Macrophomina* in the South and West, and *Phoma* in the West.

Soilborne bacterial pathogens include *Agrobacterium* and *Erwinia,* which are national problems, and other deleterious bacteria, which are a regional problem in the West.

Nematodes. Plant parasitic nematodes are a national problem and include a large number of species. Different species may be important in each region. Estimated annual yield loss throughout the world due to damage by plant parasitic nematodes on ornamental plants is 11.1%. *Meloidogyne* species are a major problem in container-grown ornamentals.

Insects. Cutworms, white grubs, and root weevils are national problems. Regional insect problems include lesser cornstalk borer, pine sawflies, fire ants, mole crickets, and ground pearls in the South; sod and pine webworms in the North and South; cranberry girdler and black vine weevil in the North and West; root aphids, strawberry weevils, and western flower thrips in the West; and fungus gnats in the South and West.

Weeds. Spurges, nutsedges, grasses, chickweeds, hardwood trees, pigweed, clover, thistle, mustards, geraniums, and mosses and liverworts are national weed problems. Regional weed problems include bird's foot trefoil in the West, and sicklepod and carpet weed in the South.

Control of Soilborne Pests in Nurseries

Integrated pest management systems for control of soilborne pests are used in forest tree nurseries and ornamental nurseries. Methyl bromide has been an important and primary component of these systems. The regulatory withdrawal of methyl bromide (and possibly of other pesticides) will necessitate an increasing reliance on more complex integrated pest management systems in the future. These systems will incorporate existing and potential cultural, physical, biological, and chemical control practices. Outlined in the text that follows are needs that must be addressed for development of short-term and long-term integrated pest management programs in order to maintain nursery productivity. A summary of existing and potential alternative pest control practices that can be incorporated into these integrated pest management programs is provided in the subsequent sections.

Short-term (2 to 6 years) integrated pest management systems. It is imperative that integrated pest management programs be developed for the short term to ensure that the removal of methyl bromide causes minimal disruption of nursery and greenhouse operations that produce forest-tree seedlings and ornamental crops. These integrated pest management programs would emphasize the integration of existing cultural, physical, biological, and chemical control practices. Included in these programs would be the use of other existing soil fumigants, as well as other pesticides where appropriate. Investigations are needed on the timing of applications, determining rates, and how best to apply and utilize other existing pesticides (including alternative soil fumigants). An emphasis should be placed on minimizing pesticide use by maximizing understanding of when, how, and at what rates to use pesticides.

Long-term (more than 6 years) integrated pest management systems. Issues regarding environmental quality and concerns over public health and safety are only likely to become progressively greater with time. Therefore, the use of many currently existing soil fumigants and other pesticides may be questioned in the future. Crop production managers will be forced to rely increasingly on nonchemical control strategies. It is therefore imperative that long-term research efforts be initiated in the development of biologically based, environmentally sound integrated pest management programs. These programs should emphasize the integration of existing and potential cultural, physical, and biological cultural control practices. Integration of environmentally safe chemical control practices that target specific organisms should be emphasized. Host resistance should be utilized where appropriate and economically feasible. Methods to detect pest population levels and accurately forecast their impact are essential and need to be developed.

Existing Alternatives to Methyl Bromide

Other chemicals. Some fumigants such as Basamid® and metham sodium are available for use in the production of forest-tree seedlings and ornamental crops. In addition, fungicides (for chemical drenches, root dips, and seed treatments), herbicides (including mineral spirits), and insecticides are available to control some soilborne diseases, insects, and weeds. However, none of these alternative chemicals appear to be as effective as methyl bromide. Also, these chemicals may be potential environmental contaminants, may pose health and safety concerns, and may require more time, labor, and space allocations. The future use of at least some of these chemicals is likely to be limited by regulatory challenges and uncertain legal longevity.

Cultural practices and systems. Management of some soilborne plant pests of forestry, nursery, and ornamental crops may be achieved to a limited extent by crop rotations, fallowing, water management, soil amendments, cover crops, intercropping, mulches, and sowing. These cultural practices are currently available, are environmentally compatible, conserve beneficial soilborne organisms, and are subject to no or minimum regulation. However, they are not uniformly applicable nationally, require more land, are labor intensive, require a greater knowledge base, are potentially more variable qualitatively, may be more site and problem specific, may cause damage to soil properties, and require increased energy consumption and equipment maintenance.

Physical methods. Physical methods that may be used to a limited extent for managing some soilborne plant pests of forestry, nursery, and ornamental crops include soil solarization, heat pasteurization using steam, flaming for weeds posternergence, cultivation of weeds, mechanical weeding, hand weeding, mulching, composting, trapping, and erecting physical barriers. These methods are generally readily available, broad spectrum, environmentally benign, subject to minimal regulation, and some at least have a short turn-around time. Soil uniformity and altered microbial ecology may be adversely affected by some of these methods. Primary disadvantages of these methods include tarp disposal problems, increased energy costs, reduced efficacy, and smaller/narrower windows of opportunity.

Biological control. Biological control systems can be used to a very limited extent for the control of some soilborne pests in the production of forest-tree seedlings and ornamentals. These systems are based on the use of bioactive composts, soil amendments, beneficial organisms (predators, parasitoids, parasites, competitors, and antagonists), pheromones, bioherbicides, and bioinsecticides. A narrow pest specificity may be a problem with some of these methods. Other disadvantages include: a lack of uniform quality, unknown compatibility with other treatments, a need for repeated applications in some cases, transportation of compost, reduced efficacy and increased variability of pest control, potential toxicity from high salts and heavy metals in composts, as well as a limited knowledge base from which to work. A major positive attribute of biological control practices is that they are generally considered to be environmentally acceptable.

Potential Alternatives to Methyl Bromide

Other chemicals. Anhydrous ammonia, reregistered pesticides, pesticides with expanded use labels, new combinations of existing and available chemical pesticides, and naturally occurring pesticides are potential alternatives to methyl bromide for controlling soilborne pests of forestry, nursery, and ornamental crops. However, many of these approaches have not yet been developed sufficiently for widespread use. Other limitations include possible adverse environmental impacts, longer posttreatment waiting periods, regulatory challenges, and uncertain legal longevity.

Cultural practices. In addition to further developments and refinements to increase efficacy of cultural practices described above under "Existing Alternatives,"potential pest control practices also include: improved irrigation systems; better sowing technology; new cultivation technology; survey and detection systems; refinements in compost technology; and integration of practices to maximize pest control.

Physical methods. Soil solarization; composting; irradiation; electronic heating (microwave); insect trapping; use of physical barriers such as mulches, matting, and soil stabilizers; and greenhouse heating are broad-spectrum, environmentally benign approaches. Many of these technologies are available; however, they have not been sufficiently developed for widespread use to manage soilborne pests of forestry, nursery, and ornamental crops. Some of them provide a short turn-around time. These approaches are subject to minimal regulation. Problems associated with these approaches include tarp longevity and disposal, greater energy costs, reduced efficacy, smaller/narrower window of opportunity, negative public perception of irradiated products, and worker safety issues involving use of irradiation and microwave equipment. Composting and new cultivation technology are needed.

Biological control. Biological control systems for soilborne pest management for forestry, nursery, and ornamental crops are based on introduction, augmentation, and conservation of biocontrol agents; enhancement of resident microbes; microbial combinations; insect behavior modification chemicals; and allelopathy. These systems are generally environmentally sound, but may be of limited use due to narrow pest specificity. Other limitations include unknown compatibility with other treatments, need for repeated applications, reduced efficacy and increased variability of pest control, and the currently limited knowledge base. Improved production, formulation, and delivery technologies for microbial antagonists need to be developed. Microbial antagonist combinations need to be evaluated. Biological control strategies need to be integrated with cultural and chemical approaches.

Genetics and biotechnology. Genetics and biotechnology are potential approaches to developing pestresistant hosts through gene transfer or induced pest resistance. These approaches were considered to be largely impractical as a means of pest control in the production of forest and ornamental crops, because of the wide diversity of plant species grown and the large number of pest problems encountered.

Detection systems. Biotechnological approaches may be used to identify specific organisms and to distinguish pathogenic organisms from nonpathogenic and beneficial microorganisms. Such systems are highly desirable for use in any integrated pest management program. Potential negative aspects are the high cost of biotechnologically derived products.

Host resistance. Plant breeding and biotechnology are potential approaches to developing pest-resistant hosts through gene transfer or induced plant resistance. Widespread development and use of pest-resistant hosts were generally considered to be impractical as a replacement to methyl bromide for forest-tree nurseries and ornamental crops. The primary reasons were the large diversity of plant species grown and the large number of pest problems encountered in the production of forestry and ornamental crops. Generally, host resistance is an environmentally benign approach to pest management. Biotechnology approaches to developing pest-resistant hosts could result in lower production costs, less cultural management, and increased energy efficiency. Moreover, host resistance to pests is compatible with other pest management systems or treatments. In most cases, pest resistance is limited to a specific pest. Major limitations include impracticality due to crop diversity, expensive development and final products, long development time, uncertain public acceptance of biotechnology-derived plants and plant products, limited knowledge of sources of pest-resistance genes and technology to identify, isolate, transfer, and manipulate genes, and overly optimistic expectations.

Research Needs and Priorities

High-priority, short-term needs and priorities.

- Develop integrated pest management systems that make maximum use of existing chemical, cultural, physical, and biological control practices.
- Develop new chemicals and chemical application technology. The emphasis in the short term should include timing of application, determining rates, and how best to apply and utilize other existing pesticides (including alternative soil fumigants). An emphasis should also be placed on minimizing pesticide use by maximizing understanding of when, how, and at what rates to use pesticides.
- Develop new culture/crop production systems. Improve the efficacy of currently available cultural control systems. Test locally effective methods for their effectiveness on a broader basis.

High-priority, long-term needs and priorities.

- Develop new culture/crop production systems and integrate appropriate existing cultural practices. Conduct research that develops a fundamental knowledge on cultural control practices and use this knowledge to develop new and improved systems.
- Develop biologically based, environmentally sound integrated pest management systems that place increasing emphasis on the integration and use of cultural, physical, and biological control practices. Integration of pest-resistant hosts into these systems should be emphasized only where applicable and economically feasible. Emphasis should be placed on the use of safer chemicals that affect specifically the target organisms.
- Develop physical pest management treatments and integrate into crop production systems. Increase research on soil solarization, pasteurization, and heat treatment methodologies. Develop methods to detect pest population levels and accurately forecast their impact.

Medium-priority, short-term needs and priorities.

- Develop physical pest management systems
- Develop biological pest control management systems, including the development of basic knowledge and a fundamental understanding of biological pest control.

Medium-priority, long-term needs and priorities.

- Develop biological pest control practices, including development of basic knowledge and a fundamental understanding of biological pest control.