National Program 308
Methyl Bromide Alternatives
FY 2012 Annual Report

Introduction

The Methyl Bromide Alternatives National Program encompasses research to determine alternatives to this fumigant. Due to scientific evidence that methyl bromide contributes to the thinning of the stratospheric ozone layer, it was officially phased out as of January 1, 2005. However, quarantine uses in developed nations are currently exempt from the phase out and a limited amount of methyl bromide is allowed where no technically and economically feasible alternatives are available for specific uses and where the members of the Montreal Protocol have granted year by year exemptions. Although practical, economical, and commercially available alternatives to methyl bromide have been widely adopted in the United States and world-wide, alternatives have not yet been identified for some uses and for particular environmental conditions. Methyl bromide has been used to rid the soil of pests before crops are planted, as well as, kill pests on postharvest commodities to protect product quality. Preplant use controls soilborne pathogens, nematodes, insects, and weeds. Postharvest use, which kills insects and other arthropods, also includes quarantine treatment, which prevents accidental introduction of organisms into areas where they did not previously exist.

Appropriate alternatives must be found so the United States can continue economically viable production systems that permit agriculture to maintain its role in domestic and international trade. Since quarantine treatments are currently exempted from the phase out, the primary focus of ARS research has been on preplant and postharvest uses. In the near term, much of the U.S. domestic food production of fruits, nuts, and vegetables will be severely impacted if suitable alternatives are not found. In the long term, systems approaches must be developed using combinations of pest-suppressing techniques.

The Methyl Bromide Alternatives National Program (NP 308) is comprised of two components:

- Pre-Plant Soil Fumigation Alternatives
- Postharvest Alternatives

During fiscal year (FY) 2012 this program produced several important discoveries and advances. Those advances and others are described on the following pages, grouped by national program component.

Component 1: Pre-plant Soil Fumigation Alternatives

PROBLEM STATEMENT 1A: Development of New Technologies for Alternatives and Integration into Commercial Crop Production Systems Currently Dependent upon Methyl Bromide Soil Fumigation.

New grafting techniques for tomatoes. In open field production, graft angle has a profound effect on the survival of herbaceous grafted plants both before and after planting. ARS researchers found that initial survival increased with angled cuts at 70 degrees rather than 20 or 45 degrees. The greater angle exposes more surface area to allow greater cell to cell contact. Also, the greater the graft angle the greater the force necessary to separate the scion and the rootstock at the graft union. This is an important factor when planting in open field production where conditions of wind and rain events can compromise plant survival. The increased survivability using this method will reduce the need for overplanting by as much as 30 percent.

Methyl bromide alternatives for Prunus Replant Disease. Tree growth and yield data collected from 10 orchard replant trials by ARS scientists in Davis, California, demonstrated that broadcast, strip, and GPS-controlled spot fumigation treatments with 1,3-dichloropropene, chloropicrin, or mixtures of the two fumigants provided equal or superior control of Prunus Replant Disease, compared to soil fumigation with methyl bromide. Pre-plant spot treatments with steam and pre- and post-plant treatments with various fungicides (all applied to tree planting sites) were ineffective.

PROBLEM STATEMENT 1B: Pest Management Systems to Optimize Efficacy of Pesticides and Reduce Harmful Emissions.

Emission reduction with Totally Impermeable Film. Tarping fumigated fields with Totally Impermeable Film (TIF) can significantly reduce emissions, but it can also increase fumigant residence time in soil and require extended tarp-covering durations to reduce potential exposure of workers and bystanders to fumigants. In collaboration with university researchers, industry, and regulatory agencies, ARS scientists conducted a large field study that found a low emission flux, of a mixture of chloropicrin and 1,3-dichloropropene (Pic-Clor 60), throughout a tarp-covering period of 16 days; total emission loss was <10 percent and loss at the tarp edges was < 1 percent. Emission flux upon tarp-cutting increased, but was substantially lower than emissions when the tarp was cut 5 or 6 days after covering. This study demonstrated the ability of TIF to significantly reduce fumigant peak flux and total emissions and also documented the need for a longer wait time before tarp-cutting time when using TIF.

Induction of nematode suppressive soil system. The tree fruit producer community needs effective non-chemical strategies for long-term control of plant parasitic nematodes because no nematicides are available for post-plant application. ARS scientists in Wenatchee, Washington, examined pre-plant application of *Brassicaceae* seed meal formulations used in conjunction with a virtually impermeable film for control of apple replant disease and suppression of lesion nematode in two organic orchard systems. Seed meal formulations provided multi-year suppression of lesion nematode densities in apple roots to levels significantly below the no treatment control. Although soil fumigation significantly suppressed densities of this nematode during the initial growing season, extensive re-infestation of fumigated soil by the nematode was observed during the two growing seasons to densities dramatically higher than the control or seed meal treated soils. Nematode suppression in the seed meal treated soil was associated with significant changes in soil biology, including increased densities of nematode parasites and predators. This research indicates that a biologically viable alternative to chemical nematicides or soil fumigants can provide extended long-term suppression of plant parasitic nematodes in orchard production systems.

PROBLEM STATEMENT 1C: Identification and Mitigation of Emerging Problems.

Evaluation of blueberry germplasm and grape rootstock nematode management. ARS researchers determined the host status of blueberry varieties to plant-parasitic nematodes and the impact of stubby root nematode (*Paratricodorus renifer*) on blueberry. Blueberry varieties with *Vaccinium* genetic backgrounds including *V. corymbosum* and *V. angustifolium* were excellent hosts for stubby root nematode, but *V. ashei* was a poor host. In field microplots, berry yield was reduced by at least 25 percent by stubby root nematode. Knowledge of a resistance mechanism to plant-parasitic nematodes can lead to the development of nematode-resistant blueberry cultivars. On grape, another plant-parasitic nematode, ring nematode (*Mesocriconema xenoplax*), initially caused decreased root growth, but its above-ground impact on plant productivity was not apparent until the third year of a four-year study. The apparent ring nematode resistance of the rootstock 101-14 broke down in year three, with only the rootstock 420A remaining highly resistant to the nematode. Growers will use this information to select rootstocks for planting and to direct the timing of management practices to minimize the impact of ring nematode on vine establishment and productivity.

Methyl bromide alternatives for forest nurseries. ARS researchers surveyed forest nurseries of the Pacific Northwest for the presence of soilborne pathogens and found eight *Pythium spp*. pathogenic to Douglas-fir seedlings. Reduced-rate alternative fumigant treatments were identified that were as effective as methyl bromide at disease and weed control in forest nursery field studies. Aerated steam, irrigation management,

and certain fungicides were also effective for the control of soilborne pathogens. These findings are significant because they provide economically viable alternatives to methyl bromide for disease control and their implementation can reduce emissions through lower rates of applied fumigants.

PROBLEM STATEMENT 1D: Lack of Commercial Scale Demonstrations of the Technical and Economic Feasibility of Currently Available Alternatives.

Methyl bromide alternatives for sweet potato hotbeds. Sweet potato hotbed production has historically relied on pre-plant soil fumigation with methyl bromide (MB). Due to the MB phaseout, hotbed production practices which do not rely on MB are needed. ARS scientists completed four years of research and demonstration trials in Merced County, California, to test and demonstrate combinations of 1,3-Dichloropropene (brand name Telone®), chloropicrin, and metam sodium with herbicides as MB replacements. Data from the repeated trials indicated that MB is not necessary for sweet potato hotbeds in California and that weed control can be obtained by judicious use of fumigation alternatives such as Telone, metam sodium, or the combination thereof, or no fumigants at all when herbicides are used. Because of the cost and limited availability of MB that occurred after 2011, growers are rapidly adopting many of the alternatives tested in the project.

Multi-tactic approaches for effective management of glyphosate-resistant Palmer amaranth. ARS researchers found that winter cover crops rolled horizontally to form a thick mulch mat will help to hinder establishment of the small-seeded Palmer amaranth (*Amaranthus palmeri* S. Watson). Palmer amaranth populations in the southern United States have resistance to four different herbicide classes (with different mechanisms of action) and based on the genetic variability within the population, resistance to other herbicides is likely to exist within a population. Repeated use of a particular herbicide class will select for this resistance, by allowing plants to establish and reproduce. Successful stewardship of the current herbicide technologies depends on minimizing the number of plants that are under herbicide selection pressure. The physical barrier of the rolled cover crop mulches reduces the established Palmer amaranth plant density. However, the mulch will bind some herbicides, keeping them from reaching the soil surface, to reduce Palmer amaranth control. In addition, weeds that are able to emerge where the cover crop mulch was thin or moved during planting of the summer crop, may have greater growth than those growing without the cover crop. Research continues on methods to maximize consistent ground coverage of the mulch in order to minimize the safe sites for Palmer amaranth establishment.

Component 2: Post-Harvest Alternatives

PROBLEM STATEMENT 2A: Developing Alternatives to Methyl Bromide for Disinfestation of Post-Harvest Food Processing Facilities.

Management of red flour beetles in rice mills without methyl bromide. The red flour beetle is the most important insect pest infesting rice mills and management has historically relied on structural fumigation with methyl bromide. Because this use of methyl bromide is being phased out under the Montreal Protocol, there is a critical need to evaluate the efficacy of alternative treatments. ARS scientists in Manhattan, Kansas, and colleagues at Kansas State University determined that the average reduction in beetle capture in pheromone traps, after 25 sulfuryl fluoride fumigations in six mills, was 66 percent. Beetle captures inside mills tended to follow a seasonal pattern of increased captures in warm months and decreased captures in cool months; these inside captures correlated with outside captures. The reduction in captures and the rate at which beetle captures returned to pre-treatment levels was strongly influenced by seasonal patterns of insect abundance, a pattern that contrasts with the non-seasonal nature of infestation in wheat mills. These data suggest that there are fundamental differences in red flour beetle populations in rice and wheat mills and that the timing of fumigation is critical for maximizing fumigation efficacy of alternatives to methyl bromide.

Tool to target stored products beetles. Knowing when and where to treat stored products for pests is important to limiting the use of fumigation and other pesticide treatments. Accurate surveillance can also increase the effectiveness of integrated pest management by enabling applicators to concentrate efforts where the problem is most severe. ARS scientists in Gainesville, Florida, have developed a new trapping system for stored product beetles. Studies of several beetle species that are pests of stored grains showed that all are preferentially attracted to light at a wavelength of 390 nanometers. Light at this optimum wavelength and a design that took advantage of beetles' tendency to orient towards edges were used to create a trap 20 times better than the current industry standard. Development of this new trapping system significantly improves the ability to monitor stored product pests even when pests are present at extremely low levels. The system promises to significantly reduce pesticide use for control of these pests because instead of fumigating a whole mill or warehouse only specific areas need to be treated.

PROBLEM STATEMENT 2B: Develop Alternatives to Methyl Bromide for Disinfestations of Post-Harvest Durable Commodities.

Methyl bromide alternative for baled hay. ARS scientists conducted a large-scale, commercial confirmatory test in Ellensburg, Washington, to control Hessian fly puparia

in compressed bales of Timothy hay fumigated for 3-days with aluminum phosphide. The commercial test resulted in 100 percent mortality of greater than 45,000 insects, in partial fulfillment of Japanese requirements for a certified quarantine treatment for hay imports. This is a great step forward in opening the Japanese hay market to U.S. producers.

Stored product pest management in grain mills. Grain mills have used fumigants extensively to treat areas where flour, grain parts, and other materials accumulate and support development of stored products pests like the lesser grain borer and the rice weevil. ARS scientists in, Manhattan, Kansas, have systematically tested residuals spray treatments on the kinds of surfaces found in grain milling operations. They have discovered combinations of treatments that can greatly reduce the need for fumigation in the many parts of such facilities that provide good habitats for stored products pests. This work has shown that rice mills are considerably different from flour mills, with much more connection to insect populations outdoors. These findings provide practical guidance on how to minimize the populations of pests that might otherwise infest grain products.

PROBLEM STATEMENT 2C: Develop Alternatives to Methyl Bromide for Disinfestation of Post-Harvest Perishable Commodities.

Alternatives to methyl bromide for clean commodities in California. Fumigation for insects is necessary to export many kinds of products and for wholesome domestic products. For decades, industry has relied on methyl bromide for most of this kind of fumigation. The advantages of methyl bromide are that it is cheap, penetrates most packaging and commodities to reach insect pests, and it kills all stages of most insects. Finding alternatives to methyl bromide that are both effective and do not harm commodities is a priority. Experiments conducted by ARS researchers in Parlier, California, demonstrated the insecticidal efficacy of sulfuryl fluoride and phosphine, which were dispensed by a Horn generator. These fumigants appear to be the primary chemical alternatives to methyl bromide for postharvest disinfestations of perishable and durable commodities in California, but fumigants are not the only alternative to methyl bromide. In collaboration with Washington State University, ARS researchers in Parlier, California, have found that a low pressure-low temperature treatment kills codling moth in fresh fruit and results in a higher quality product than when the produce is treated with methyl bromide. This research limits the current need for methyl bromide while protecting American agricultural interests.

Oxygen and phosphine as an alternative to methyl bromide. Phosphine is commonly used as a fumigant and it does not degrade the ozone layer as methyl bromide does. The effectiveness of phosphine, whether generated from metallic phosphides or applied in pure form, is not as certain as for methyl bromide. Fumigation of leafy vegetables is a particular challenge because the tissues of the plants are easily damaged by fumigation and must be kept at cool temperatures to assure longevity of the product. ARS scientists in Salinas, California, have discovered that the addition of oxygen to phosphine fumigations greatly increases the effectiveness of this fumigant at low temperatures. Oxygenated phosphine fumigation was demonstrated to significantly reduce treatment time and phytotoxicity and achieve effective control of tolerant insects that cannot be controlled with regular phosphine fumigation. Oxygenated phosphine fumigation has the potential to make significant impact on the fumigation industry and replace the need for methyl bromide in some situations.