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NATIONAL PROGRAM 308
METHYL BROMIDE ALTERNATIVES

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FY 2009 Annual Report

Introduction

The Methyl Bromide Alternatives National Program encompasses research to determine alternatives to the pesticide, methyl bromide, which has been officially phased out as of January 1, 2005. This is because of scientific evidence that it contributes to the thinning of the stratospheric ozone layer. In addition to quarantine uses, which are currently exempt from the phase out, a limited amount of methyl bromide is used where alternatives do not give sufficient efficacy for specific uses and where the members of the Montreal Protocol have granted year by year exemptions specifically for those purposes. Use of methyl bromide remains an extremely important pesticide in the United States and in the rest of the world where practical, economical, and available alternatives have not been identified. Methyl bromide has been used to rid the soil of pests before crops are planted and on postharvest commodities to kill pests to protect product quality. Pre-plant 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 that the United States can continue economically viable production systems that permit agriculture to maintain its role in domestic and international trade. Quarantine treatments are currently exempted from the phase out, thus the primary focus of research has been on pre-plant 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 will 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*; and
- *Postharvest Alternatives.*

During fiscal year (FY) 2009 this program produced several important discoveries and advances. Some of these are described below, grouped by program component:

Component 1: Pre-plant Soil Fumigation Alternatives

Methyl bromide alternatives for cut flower and bulb production. Cut flower and bulb production operations in California need effective replacements for preplant soil fumigation with methyl bromide, which is typically applied by shanks in field operations and the “hot gas” method in enclosed operations (i.e., greenhouses, hoop houses). Multiple research and demonstration trials conducted by ARS scientists at Davis, California, were completed statewide in commercial plantings of Ranunculs and calla lily (field operations), iris, freesia, and snapdragon (enclosed operations) to test drip applications of chloropicrin and combinations of it with 1,3-dichloropropene and metam sodium as alternatives to shank and hot gas applications of methyl

bromide. The trials demonstrated to growers that drip-applied alternatives provide pest control and crop yields equal to or better than those obtained with the conventional methyl bromide treatments. The work is resulting in commercial transition to the drip alternatives for cut flower and bulb production and is reducing reliance on methyl bromide and reducing fumigant emissions to the atmosphere.

Integration of alternative fumigants with improved plastic mulches for replacement of methyl bromide for strawberry production. Strawberry fruit production operations in California need effective replacements for methyl bromide that are compatible with tightening regulatory restrictions. ARS scientists at Davis, California, in collaboration with commercial strawberry growers, completed multiple research and demonstration trials across California's coastal strawberry production districts to test reduced rates of drip-applied fumigant alternatives to methyl bromide in combination with low permeability plastic mulches. The trials demonstrated to growers that low rates of fumigant alternatives (i.e., combinations of chloropicrin with 1,3-dichloropropene), if applied under a low-permeability plastic mulch, can be used to obtain strawberry yields equivalent to those following conventional treatments with methyl bromide - chloropicrin combinations. Furthermore, data were obtained to confirm that the low permeability mulches retain fumigants in soil longer than conventional high density polyethylene mulches, thereby improving fumigant efficacy and reducing atmospheric emissions. This research also has demonstrated the feasibility of gluing impermeable films for broadcast fumigation. The work has provided strawberry growers with valuable alternatives to methyl bromide that are effective and conducive to use under current regulatory restrictions.

Development and application of two protein extraction protocols for proteomic investigations of Rhizoctonia solani to examine virulence and pathogenicity. Rhizoctonia solani (essentially an asexual fungus) is highly intractable to genetic manipulations for pathogenicity studies. Proteomics is a functional genomic approach to identify factors that could be useful to control the pathogen. ARS scientists at Beltsville, Maryland, developed two protocols for purification of total cellular proteins of *R. solani*, resolved proteins in 2-D gels, and identified proteins. Identification of proteins involved in pathogenicity may lead to new means of disease control. This is the first comprehensive report of proteomic investigation of a known anastomosis group (AG 4) of *R. solani*.

Tree site specific spot fumigation can reduce total fumigant emissions. Reducing emissions of volatile organic compounds (VOCs) from fumigant pesticides is mandatory in California, especially in "nonattainment areas" like the San Joaquin Valley that do not meet federal air quality standards. When orchards are replanted, soil is fumigated to prevent replant syndrome which can seriously stunt new trees and decrease future productivity. A 2-year field study conducted by ARS scientists in Parlier, California, examined the feasibility of applying fumigant just to the actual future site rather than to the entire orchard to reduce the amount of fumigant that would need to be applied to the orchard and decrease the environmental consequences of fumigation. Cumulative atmospheric emission of the fumigants was estimated to be 18 to 23 percent of the applied active ingredients in plots that had been cover cropped with Sudan grass

and 2 to 6 percent in plots that had remained bare for several months before treatment. Compared to whole orchard fumigation, spot fumigation may achieve a 10-fold reduction in atmospheric volatile organic compounds load from fumigant pesticides.

Clove oil as an effective antibacterial treatment for soilless substrates to control Ralstonia solanacearum. Methyl bromide had been an important component of soilborne plant pathogen control, but due to the phase out of its use, there is a need for developing alternative control strategies. ARS researchers in Washington, D.C., and Beltsville, Maryland, identified the oil of clove (*Syzygium aromaticum*) as a potential treatment to eradicate major groups of plant pathogenic bacteria. Clove oil inhibited the growth of both gram (+) and gram (-) bacteria and its effect was dose-dependent. The bacteria also displayed different degrees of sensitivity to the clove oil, with Ralstonia being the most sensitive and Rhodococcus the least. In greenhouse experiments, pre-plant treatment of soilless potting mix with a clove oil formulation effectively controlled bacterial wilt of geranium and tomato caused by *R. solanacearum* race 1, biovar 1, resulting in disease-free plants. The phytotoxic effect of clove oil was reduced by extending the evaporation time following treatment of soil. This antibacterial activity, in addition to previously reported fungicidal and nematicidal properties, makes clove oil a candidate to control various soilborne pathogens in soilless substrates.

Rapid disease assay of Verticillium on lettuce developed. Conventional greenhouse assays for examining the pathogenicity of the soilborne fungus *Verticillium dahliae* require lengthy testing periods. ARS researchers at Salinas, California, developed a growth chamber technique that enables a more rapid assessment of pathogenicity of *V. dahliae* on lettuce. The technique takes advantage of an early flowering lettuce accession line that develops symptoms quickly and speeds analyses of the *V. dahliae*-lettuce interaction. The reduction in time to assess pathogenicity of *V. dahliae* from 100 days to 42 days using this technique represents a significant savings in time and cost.

Web site supports Phytophthora research. The genus Phytophthora has approximately 90 species and is responsible for a wide range of crop plant diseases on a worldwide basis, but due to similarities in morphological features their identification to a species level can be a challenge and are often incorrect. ARS researchers at Salinas, California and Peoria, Illinois, in collaboration with researchers at Penn State University, University of California at Riverside, and North Carolina State University, developed a Web-based database to enhance understanding of the genus, simplify identification, and stimulate research. The Phytophthora database includes complete morphological descriptions, information on host range and geographical distribution, a comprehensive molecular phylogeny using seven nuclear genes (four mitochondrial genes will be added shortly), and a section on molecular detection and identification. The database will serve as a resource for researchers working on the genus as well as a repository of future relevant research progress and information.

Alternatives to methyl bromide demonstrated in key crop systems and regions dependent upon methyl bromide. The phase-out of methyl bromide as a soil fumigant has created an urgent need to find effective alternatives for growers of vegetables, forest nursery seedlings, flowers, and

several other crops on a field-scale basis. To test the effectiveness of various methyl bromide alternatives, ARS scientists at Fort Pierce, Florida, conducted 40 large-scale field demonstration trials using the best available, industry-appropriate alternatives to methyl bromide. The alternatives included substitute fumigants and supporting integrated pest management practices. Trials were conducted in five states in partnership with commercial growers at sites ranging in size from half an acre to 58 acres adequately representing the biological and environmental diversity of the production systems. Methyl bromide dependent commodities evaluated included tomato, pepper, eggplant, strawberry, forest nursery seedlings (loblolly pine), sod, ornamentals (caladium), and cut flowers (delphinium). These trials demonstrated that technically feasible alternatives to methyl bromide soil fumigation are available.

Component 2. Post-Harvest Alternatives

Determination of effective sampling range of food-based attractants for capture of caribflies. Sampling range, i.e. the maximum distance from which an insect can reach an attractive source in a given period of time, is an important aspect of trap efficacy. Release/recapture studies using laboratory reared fruit flies have been used traditionally to determine sampling range. However, response of these flies to food-based attractants may not be directly applicable to response of wild flies due to differences in nutritional background. ARS scientists at Miami, Florida, conducted a release/recapture trapping study to determine the sampling range from field-collected caribflies in south Florida. Field collected wild flies were attracted to the food-baited traps from longer distances that laboratory reared flies. Thus trapping data developed with laboratory reared flies would tend to overestimate the population level of wild flies when estimated using food traps. This information will be used by regulatory agencies, growers and researchers to determine coverage of traps used for population delimitation; for implementation of mass trapping control strategies; to pin-point areas of infestation for precision targeting of control measures; and to determine the minimum distance between treatments to avoid trap interference in field tests.

Monitoring stored-product insect populations in food processing facilities. Ongoing research in commercial food facilities conducted by ARS scientists at Manhattan, Kansas, and industry cooperators indicates considerable variation in efficacy against the target pest species, differences in seasonal patterns in pest activity, and geographic variation in species abundance and diversity. The specific information being generated from this project is currently being used by industry cooperators to help guide their management programs and the combined information from multiple locations will be used to determine average impact of treatments.

Field trials show effectiveness of aerosols. Small-scale tests have shown the potential of combination treatments with the insect growth regulator methoprene to control the Indianmeal moth. ARS scientists at Manhattan, Kansas, conducted several field trials by exposing eggs of the Indianmeal moth in different foods and on different packaging materials treated with synergized pyrethrins applied alone and in combination with the insect growth regulator methoprene. Results of the field trials show the aerosols penetrated underneath pallets, and the combination of pyrethrin and methoprene was optimal for both best control of eggs and lowest

economic cost. There was some variation depending on the specific diet or package exposed, but overall results show that the aerosols could be used to control the eggs of the Indianmeal moth in a commercial facility.

Development of quarantine strategies to control hessian fly in exported hay. China, Hong Kong, South Korea, and South Vietnam are emerging markets for U.S. hay exports, and regulatory agencies seek new methods to ensure that Hessian fly, a domestic pest, is not accidentally introduced through hay shipped from the western states. ARS scientists at Parlier, California, developed novel fumigations using a carbon dioxide and phosphine gas mixture and simulated hay drying conditions on the resistant stage of the insect as control techniques to reduce the risk of infestation in exported bales. The National Hay Association supported further research of these hay handling procedures as potential quarantine treatments for Hessian fly. This work helps protect the U.S. hay export market, which is valued at more than $600 million annually.

Ultra-low oxygen treatment for postharvest control of western flower thrips on lettuce. Presence of western flower thrips on U.S. fresh commodities, including lettuce, is a major obstacle to their exportation to Taiwan. ARS researchers at Salinas, California, developed an efficacious, ultralow oxygen (ULO) treatment to control the pest on harvested lettuce. A 3-day storage period immediately prior to ultralow oxygen treatment of different lettuce cultivars achieved complete control of thrips without any negative effects on lettuce quality in a pallet-scale study. The research reduced overall time needed to complete ULO treatment and thereby made the ULO treatment more practical for commercial adaptation.