National Program 308 – Methyl Bromide Alternatives

Assessment Report

Executive Summary

A panel of five met by a conference call hosted in Beltsville, MD October 18-19, 2011 to conduct a 5-year retrospective review of USDA-ARS National Program 308 (Methyl Bromide Alternatives). NP 308 was formed as a response to the US becoming signatory to the Montreal Protocol and the resulting need to phase out methyl bromide in a relatively short time frame. The review was meant to be an overarching one rather than a project-by-project review that is regularly conducted by the Office of Scientific Quality Review. The panel was provided with a retrospective Accomplishment Report (2006-2011) that focused on the overall impacts of selected projects within the national program. In addition, panelists were able to draw on other resources including publications, databases and their professional knowledge of the research areas within NP 308. The panel was also given a brief overview of NP 308 by USDA-ARS leadership (Dr. Kay Simmons, Deputy Administrator, Crop Production and Protection; Dr. Sally Schneider, National Program Leader, Postharvest Entomology; Dr. Deb Fravel, National Program Leader, Plant Diseases; Dr. John Lydon, National Program Leader, Crop Protection and Quarantine) prior to its deliberations.

The panelists would like to thank ARS Program Staff including Tracy L. Botelho-Havermann and Stephanie Young for their assistance during the review process.

The NP 308 panel was:

Dr. James D. Schaub, Office of the Chief Economist, USDA, Panel Chair
Dr. Paul Fields, Agriculture and Agri-Food Canada
Mr. Gary L. Obenauf, Agricultural Research Consulting
Dr. Stanley Culpepper, University of Georgia
Mr. Brian Correiar, Golden State Bulb Growers, Inc.

The Accomplishment Report of NP 308 was developed by the national program leadership staff based on impact statements submitted by ARS scientists. The panel assessed these accomplishments against commitments (goals and objectives) identified in the action plan created at the beginning of the five year cycle. Based on this assessment and review, the panel reached a consensus rating for each of the problem areas defined in NP 308. For operational purposes, the panel translated the goals and commitments in the action plan to the following assessment criteria:

- Knowledge building and innovation
- Pursuit of environmentally sound and safe solutions
- Outreach, communication, and dissemination of information
- Efficacy of identified alternatives
- Economic feasibility and commercial adoption
- Contribution to Sustainability (where appropriate)

The panel rated each of the seven problem areas spanning the two major components. In the case of Pre-plant Component Problem Statement 1D, Lack of Commercial Scale Demonstrations of the Technical and Economic Feasibility of Currently Available Alternatives, the panel chose to rate the area-wide portion separately from the other efforts. The objective was to clearly communicate the High Impact rating merited by the area-wide effort. Ratings for the program elements ranged from Medium Impact to High Impact with the majority of the problem area efforts including all of the postharvest problem areas rated High. No problem area was rated Low because in all cases the mass of activity warranted a medium or better rating. The panel looked beyond the number of projects and accomplishment statements provided in the accomplishment report, focusing on what was achieved and how well the objectives of the action plan were satisfied. Overall the 2006 – 2011 accomplishments map well to the commitments and outcomes established in the NP 308 Action Plan.

Across NP 308 the panel found effective collaboration with private and public sector scientists. Outreach and dissemination of research finding followed many channels to reach relevant stakeholders and add to the accessible body of knowledge on direct methyl bromide alternatives and foundational knowledge for future research. The panel noted that some agricultural stakeholders receiving valuable information through secondary sources do not fully appreciate that the ARS NP 308 research underlies the information.

The program focuses on an urgent need for methyl bromide alternatives in the food and agricultural sector to curtail harm to the environment and human health. Accomplishments in the program show effort to identify environmentally sound and sustainable alternatives. A number of accomplishments involve refinement of practices and new technologies and knowledge that are simultaneously environmentally sound and cost saving.

The panel did not consider the resources used in NP 308 focusing instead on outcomes. The breadth and depth of accomplishments under NP 308 is impressive. Thus, over the last five years NP 308 has delivered a comprehensive program of research which in some cases resulted in immediate high impacts while others parts of the program are expected to have near term impacts. Accomplishments that contribute to new scientific knowledge of agricultural pests may ultimately have an impact. In conclusion, the assessment finds NP 308 generally met its goals and commitments and in most cases has had or displays significant potential to have high impacts on the food and agricultural sectors that need for methyl bromide alternatives.

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Background

Agricultural Research Service (ARS) National Program (NP) 308, Methyl Bromide Alternatives, focuses on discovery and development of alternatives to methyl bromide in two broad areas of research—preplant soil fumigation to control pests, pathogens and nematodes, and weeds, and postharvest fumigation to protect harvested crops from pests during storage, including disinfesting structures in which commodities are processed or stored.

The mission of NP 308 is to develop environmentally compatible and technically and economically feasible alternatives to the use of methyl bromide for preplant soil fumigation and as a postharvest commodity treatment. This national program supports U.S. compliance with the Montreal Protocol, an international treaty, and provides scientific knowledge for regulatory agencies and new technologies for producers impacted by regulations such as the Clean Air Act.

Because of the wide range of pathogens and pests managed with methyl bromide, there is no single replacement for methyl bromide, but rather combinations of approaches, which are often developed for specific commodities or uses. While NP 308 research centers on finding, developing, and/or improving materials and technologies that can be readily adopted by industry as alternatives to methyl bromide, research on fundamental aspects of disease and pest detection, identification, and management are also conducted to optimize performance of methyl bromide alternatives.

NP 308 was initiated after methyl bromide was listed as a stratospheric ozone depleting substance by the Parties to the Montreal Protocol (Parties) in 1992. The Parties agreed to freeze production levels of methyl bromide for developed countries at 1991 levels in 1995 and to a complete phase-out later on. In developed countries, complete phase-out of manufacturing and importation of methyl bromide occurred on January 1, 2005, except for quarantine/pre-shipment (QPS) uses and Critical Use Exemptions (CUEs), which are granted on a case-by-case yearly basis. Although no decision was taken by the Parties to regulate QPS uses, research on the development of new alternatives to replace methyl bromide as a quarantine fumigant is included in the postharvest component of NP 308. CUEs are granted by the Parties when a technically and economically feasible alternative is not available to replace methyl bromide for a specific crop or commodity use, and significant market disruption would occur with the loss of methyl bromide. Further, NP 308 enables the United States to demonstrate compliance with an additional CUE eligibility criterion requiring research programs to develop and deploy alternatives and substitutes. By the start of the 5-year program cycle in 2006, significant reductions in methyl bromide use had been made, compared to the 1991 baseline, but for some uses and some circumstances adequate alternatives had not been identified, developed, received regulatory approval, and marketed.

Growers' experience with potential alternatives for preplant use of methyl bromide has shown that the efficacy of some alternative treatments declined in each successive year, indicating the need for additional, commercial-scale, multi-year evaluations of methyl bromide alternatives. To address this need, in addition to the appropriated, longer-term research projects in NP 308, a 5-year Areawide Pest Management (AWPM) Project for Methyl Bromide Alternatives (MBA) was established in fiscal year 2007. AWPM projects are centered on the utilization of ARS developed technologies

(biological, cultural, physical, and chemical) in an integrated pest management (IPM) approach to effectively manage pests impacting large areas spanning multiple states or regions. The MBA-AWPM project focuses on fruit, vegetable, and floral/nursery crop production areas in the western and southeastern United States.

Assessment

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.

Anticipated Impacts:

- New chemicals controlling targeted pests.
- Additional commercially viable biological control agents.
- New germplasm lines with improved resistance to pests and acceptable horticultural characteristics.
- Multi-component management systems that address current and emerging pest problems to keep productions systems viable and avoid the potential for future dependence on any single chemical pesticide.
- Knowledge base containing performance measures for various target pests and cropping system conditions comparing newly developed approaches or integrated systems with methyl bromide soil fumigation.

Review Team Rating: Medium Impact

Review Team Assessment:
USDA's efforts in developing resistant host crops and rootstocks in perennial crops has been vital with widespread impacts in commercial systems occurring currently or expected to occur in the near future. Also of importance have been USDA's efforts in testing and demonstrating effective methyl bromide (MB) alternative fumigant systems with growers. Many of the chemicals (fumigants, other pesticides) are not new, but USDA has developed several new and effective delivery approaches making these products more effective. USDA's direct impact influencing grower adoption of alternatives varies by region but these differences are likely in response to the unique relationships of USDA, Cooperative Extension, and growers in these areas.

Efforts in biocontrol, grafting of resistant rootstock for annual crops, steam, anaerobic soil disinfestations, solarization, and seedmeals are to be commended as quality research; however,

the impacts and adoption of these practices are minimal and expected to remain that way for some time. High costs, lack of effectiveness, and/or geographical restrictions are likely the primary reasons prohibiting adoption of the efforts. These projects may have a fit in small specific areas as EPA regulations restrict the use of economically effective alternatives.

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

Anticipated Impacts:

- Improved understanding of the impact of fumigant concentration, movement through soil, pest exposure time, soil temperature, soil moisture, soil type, and pest species on fumigant efficacy.

- Improved fumigant application methods to reduce emissions and enhance efficacy with less potential for negative environmental impacts.

Review Team Rating: High Impact

Review Team Assessment*:*
Managing gas emission is critical to the sustainability of all production systems that rely on preplant fumigation. USDA's research accomplishments make significant contributions to understanding emissions of numerous fumigants.

Specifically, understanding the influence of soil characteristic, irrigation, and soil amendments on fumigant movement have already influenced fumigant applicator decisions. Additionally, USDA's efforts in understanding the relationship of fumigant emissions through various mulches (VIF, TIF) has been groundbreaking and has forever changed the industry. These efforts are among the greatest contribution from USDA in the search for sustainable methyl bromide alternatives because they 1) reduce fumigant rates, 2) reduce fumigant emissions, 3) often reduce grower costs, and 4) have been rapidly adopted throughout the country.

The only concern with these efforts is that more work should be conducted in this area.

Problem Statement 1C: Identification and Mitigation of Emerging Problems.

Anticipated Impacts:

- New diagnostic and detection tools.

- Timely identification of emerging pest problems.

- Quantification of pest impacts on crop production.

Review Team Rating: Medium-High Impact

Review Team Assessment:
New diagnostic and detection tools were developed. These tools will aid in the timely identification of emerging pest problems. Both increased speed and accuracy in detection and identification of soil pathogens are key components of not only crop management, but also in pre-cropping selection of land. Timely, correct identification of the presence of pathogenic microbes will assist growers in planting decisions.

Improved diagnostics for *Phytophthora ramorum* will increase the ability of APHIS to trace infected nursery stock. It will also help to build confidence among customers who are now reluctant to purchase from nurseries in quarantined areas by reducing the risk of false results whether positive or negative.

Excellent communications and outreach were shown in the work done to support APHIS regulatory efforts on Sudden Oak Death (SOD). Sharing findings with APHIS on a high-priority regulatory issue is a direct benefit to the nursery and forestry industries. The development of the web-based *Phytophthora* database is an important example of the use of electronic media to communicate results and further research efforts.

Identification of emerging pests will be of increasing importance as methyl bromide is phased out. The timely identification of emerging pests is critical for commercial growers. Growers farming without methyl bromide are encountering soil pathogens that were previously controlled by methyl bromide fumigation. In some instances, significant losses have occurred. Not only does the movement of introduced pathogens across distances need to be considered, but also the growth of endemic pathogens previously controlled by methyl bromide fumigation.

Accurate identification of pathogens to the species level is vital to economic control of soil-borne pathogens as fumigation is increasingly restricted. The summary of the Pacific NW forest nursery project is exactly on target with the statement that "Knowledge of pathogen identity is the first step…" Additional work to develop tools to identify pathogen risk levels for a wider range of crops is needed to increase the impact of this work.

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

Anticipated Impacts:

- Commercial-scale economic information comparing the various alternatives to methyl bromide.

- New pest management systems that have been field validated under the range of biological and edaphic conditions that typify large geographic regions.

- Optimized pest management systems using methyl bromide alternatives.

- Technology transfer program to deliver concepts, assessments, and technologies needed for adoption of methyl bromide alternatives.

- A list of the sources of variability that affect the performance of methyl bromide alternatives.

- A knowledge base of the relationships between pest complexes and methyl bromide alternatives.

- Model for area-wide management of soilborne pests that can be utilized beyond initially targeted locations and commodities.

Review Team Rating: Medium/High Impact

Review Team Assessment:
Accomplishments in this problem area fell into two groups—Area-wide project results and other. The Panel chooses to distinguish between the two noting a high impact rating for the area-wide research and a medium rating for the other portion of research in this problem area.

The area-wide PMP is a large element of the 308 program and a capstone to the many years of ARS research. It is a clear effort to use demonstration projects to promote alternatives and best practices. It is novel in the sense that research programs seldom undertake such a broad effort to promote technology transfer to end users and validate research in commercial scale conditions.

The Western and Southeastern area-wide programs were found to have comparably high impact. Collaboration, outreach, and communication efforts were strong. The concept of area-wide program effort was inherently innovative with potential for emulation by others. The projects were a model in terms of inclusiveness of researchers and cooperators. The continuing efforts of project participants to communicate results will continue to increase the importance of this effort. The major downside to the area wide project approach has been the short duration of the projects relative to the scale of the problem being addressed.

The accomplishments in other research under this problem area appear variable in realized and potential impacts. Collaboration on new technology for spot treatments to prevent replant disease demonstrated success in reducing human and environmental risk, costs savings, and reduced fumigant use and emissions. Pest and disease control research with non-chemical and organic amendments was not deemed highly innovative or likely to be widely adopted. Knowledge building research was judged to have only medium impact.

Component 2. Post-Harvest Alternatives

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

Anticipated Impacts:

- Efficacy matrix including, for example, fumigant concentration, exposure time, temperature, pest species, and life stage that compares methyl bromide with alternative fumigants in laboratory tests.

- A knowledge base of field validation data of alternative fumigants and assessment of factors influencing efficacy.

- An evaluation of the impact of different systems approach/IPM techniques at reducing the need for structural fumigations.

Review Team Rating: High Impact

Review Team Assessment:
The work done in developing alternatives to methyl bromide in the post-harvest sector is very important for the US agriculture and food processing industry. Approval of several Critical Use Exemptions (CUEs) from 2005 to 2011 allowed the use of methyl bromide in certain applications beyond January 1, 2005 thus avoiding significant market disruptions and providing time for postharvest alternatives research. These CUEs for methyl bromide will be drastically reduced in the coming years resulting in a crucial commercial test of alternatives to methyl bromide in post-harvest sector. There is some concern that a major alternative for methyl bromide fumigants in cereal processing facilities, surfuryl fluoride (SF, trade name ProFume), may not be available in the future or its use may be limited to empty structures. This would make it difficult for the post-harvest sector to function without methyl bromide.

Most of the goals set out at in 2006 in the post-harvest sector have largely been met.

The work on the efficacy matrix is considered of medium impact. This is good work on insect pests, cigarette beetle and psocids. These are minor problems in sites that often do not require methyl bromide fumigation. The cigarette beetle can be a major insect pest in a few specific locations: tobacco processing plants and warehouses, botanical/spice processing plants and warehouses. This insect is not a major pest in cereal processing plants, where the bulk of the methyl bromide is or was used. Psocids are becoming a problem in stored commodities. They can be found in cereal processing plants, however there is less information on their occurrence in cereal processing plants than in commodities. New work on SF to control the eggs of psocids is reported, and will provide valuable information for fumigators using SF to control psocids. The panel notes research on heat treatment of psocids was also conducted and published.

The work on field validation of fumigants is considered high impact. It provides valuable information to the industry on the efficacy of SF, the impact of IPM and the use of monitoring. The rice mill work measured the efficacy of nine SF fumigations. It appears that similar work was not carried out in rice mills that were fumigated with MB; hence the authors are left to make comparisons with MB fumigations in flour mills. This makes direct comparison between SF and MB in rice mills difficult. The flour mill work measured the efficacy of 21 fumigations of SF and MB, along with different sanitation practices. This work provides valuable information to the industry on the efficacy of SF, the impact of IPM and the use of monitoring. The simulation model predicting flour beetle populations has great potential to help industry predict problems with *Tribolium spp.*, and be used as a teaching tool to understand the effects of various factors within a flour mill.

The work on IPM is considered high impact. The corner stone of any IPM program is sampling. Cereal processing facilities are complex structures that are difficult to sample quantitatively. Therefore the work on monitoring summarized here is very valuable. Three examples of increasing trap catches are outlined. Two examples of how traps work in flour mills are given. Replacing the fumigant MB with another fumigant or heat treatment is not the only answer to controlling insects in cereal processing facilities without MB. The work on aerosolized insecticide applications provides detailed, practical information, tested in industrial settings on the efficacy of contact insecticides. This work will be of immediate value to the industry. The work on repellants and surface treatments in the laboratory will lead to expansion of the label for an insecticide (trade name Phantom) to include stored-product insects. This will significantly help managers trying to control stored-product insects by providing access to a new insecticide. This will help prevent the development of resistant strains by allowing managers to use different classes of insecticides. The genomic work on the red flour beetle is a significant scientific finding. This basic work may make it possible to find new insect-specific toxins.

The quality of the work is good being published in national and international scientific journals. Much of this work has been presented at the MBAO conferences, workshops at Kansas State University and scientific conferences. The USDA-ARS group in Manhattan KS working on postharvest entomology is recognized nationally and internationally for their basic and applied work on their insect pests in cereal processing facilities. The website for this group is one of the best in the stored-product research groups anywhere in the world. http://ars.usda.gov/main/site_main.htm?modecode=54-30-05-30 . It provides published papers, posters and presentations for all scientists at the USDA-ARS-NPA-CGAHR, Stored Product Insect Research Unit.

The impact of this work is that the efficacy of SF in flour mills and rice mills has been monitored and compared to MB fumigations in flour mills. This has shown the effectiveness of SF and has given recommendations for how to monitor insect in cereal processing facilities. Current aerosols and contact insecticides can be better used because of the new information on duration of efficacy, effect of sanitation and rates of application. The work on the genomic work on the red flour beetle will have no impact on methyl bromide alternatives in the next few years, but may lead to the discovery of new insecticides.

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

Anticipated Impacts:

- Efficacy matrix including, for example, fumigant concentration, exposure time, temperature, pest species, and life stage that compares methyl bromide with alternative fumigants in laboratory tests.

- A knowledge base of field validation data of alternative fumigants and assessment of factors influencing efficacy.

- Physical treatment parameters for the most tolerant target pests with efficacy of the most promising physical treatments under commercial conditions.

- Models for predicting field pest population growth and evaluating the effect of management practices on pest pressure.

- More effective monitoring methods, including improved pheromone lures, for use by the models.

- IPM strategies which include biorational control methods, such as mating disruption, natural enemies, and pathogens.

- Enhanced methodologies to capture methyl bromide being used under CUEs or QPS Exemptions.

Review Team Rating: High Impact

Review Team Assessment:
Quarantine and preshipment methyl bromide use is exempt under the Montreal Protocol. However, there have been some proposals to cap or eliminate this use of MB as it now makes up almost 50 percent of the world wide use. It takes several years to develop a quarantine treatment that is acceptable to the industry and the importing countries; therefore although the quarantine aspects of this work may not be used by industry as long as methyl bromide is available it is valuable work that could be crucial if MB becomes unavailable in the future.
It was felt that all the research under disinfestation of postharvest durable commodities was supportive of the objectives and that they provided knowledge and would have a potential impact upon the corresponding commodities. The results of these projects have been effectively reported to the appropriate stakeholders. Most of the research is environmentally sound and safe. Most of the alternatives researched are efficacious and economically feasible. The research products are in various stages of adoption but most are either being evaluated or used in handling durable commodities. Comments on the specific anticipated products are given below.

Four research accomplishment statements address *Efficacy matrix including, for example, fumigant concentration, exposure time, temperature, pest species, and life stage that compares methyl bromide with alternative fumigants in laboratory tests*. These are Toxicity of sulfuryl fluoride to insect eggs as compared to other life stages, Persistence of beta cyfluthrin, bifenthrin, and methoxyfenozide in almonds and pistachio, Methyl bromide alternatives for insect control in walnuts, and Quarantine strategies to control Hessian fly in exported hay. All add to the knowledge of the specific insects and commodities researched and have a significant potential to impact the affected commodities. All four of the research projects have been effectively communicated to appropriate stakeholders. All four projects will have a benefit relative to the goal of environmentally sound and safe alternatives. Not all of the alternatives are as effective as methyl bromide but research continues in hopes that efficacy will improve. Some of the alternatives are economically feasible but some will depend upon rate of fumigate necessary and still needs additional research. One of the best alternatives, sulfuryl fluoride, may be lost in a couple years unless EPA changes its stated plans to cancel use of the fumigant. The panel is aware that part of the results reported on *Hessian* fly in exported hay was already done before this first year time frame so assume it was confirming some of the early finds and verifying them.

Two research accomplishment statements address *A knowledge base of field validation data of alternative fumigants and assessment of factors influencing efficacy*. Navel orangeworm damage patterns in almond and Identify risk factors for navel orangeworm damage in pistachios are sound projects that do build on our existing knowledge and will impact control of this significant pest in almonds and pistachios. This knowledge will probably be used in walnuts after research on that commodity. This information has been communicated to both the almond and pistachio industry. It should be pointed out that this work is preharvest rather than postharvest but certainly impacts the postharvest infestation. The approach is environmentally sound and will help create a safer farming environment. This research does not produce an alternative but adds information to create effective control measures. This information could improve costs of controlling navel orangeworm. This research does lead to more sustainable production of these nut crops.

Three research statements address *Physical treatment parameters for the most tolerant target pests with efficacy of the most promising physical treatments under commercial conditions*. Effect of product moisture on efficacy of vacuum treatments, Determination of the most heat tolerant stage of the cowpea weevil and Ultra-low oxygen treatment for control of vine mealybug on grape rootstocks all are good research that adds to our knowledge of controlling these pests on these commodities and will have a significant impact to the commodities. The research results have been presented to the appropriate stakeholders. This research is environmentally sound and safe. The alternatives are efficacious and appear to be cost effective.

Four research statements address *Models for predicting field pest population growth and evaluating the effect of management practices on pest pressure*. Assessment of the emergence of overwintering navel orangeworm, Prediction of navel orangeworm damage to almonds using egg traps, Development of a predictive model for navel orangeworm damage to Nonpareil almonds, and Indianmeal moth simulation model developed and tested in stored corn are all good research

that is leading to better knowledge in control the in the specific pest/commodity combinations. Again it should be pointed out that the three navel orangeworm projects involve preharvest interventions and not postharvest while the project on Indianmeal Moth (IMM) is postharvest. The research results have been presented to the appropriate stakeholders. This research will lead to more environmentally sound and safe farming practices with almonds and controlling IMM in corn. The research will add to the timing, rates and selection of materials to use in more effective control programs. These projects will probably lead to the reduction of costs in controlling these pests/commodities complex. The research will lead to more sustainable farming or handling of these commodities.

Research involving collection of host volatiles for attraction of navel orangeworm addresses *More effective monitoring methods, including improved pheromone lures, for use by the models*. The research adds to our knowledge of effective attractants for navel orangeworm. It is information that does lead to more environmentally sound and safe farming practices. The new information will improve monitoring of target pest and will help make almonds more sustainable.

Two research statements addressed *IPM strategies which include biorational control methods, such as mating disruption, natural enemies, and pathogens*. Efficacy of entomopathogenic nematodes applied by chemigation for navel orangeworm control and the Navel Orangeworm Areawide Pest Management Project are good projects that have led to a significant improvement of our knowledge concerning control of navel orangeworm. The areawide research was diverse and included Changing sanitation guidelines for navel orangeworm in almonds, Phenology of navel orangeworm, and The impact of mating disruption on non-target almond pests and beneficial insects. The work has been presented to appropriate stakeholders. The projects lend themselves to more environmentally sound farming practices and helps improve the efficacy and cost effectiveness of the control strategies. This work does lead to more sustainable farming of almonds.

Regarding *Enhanced methodologies to capture methyl bromide being used under CUEs or QPS Exemptions*, the panel is aware of the new five year FAS supported research that is a cooperative project involving ARS-Parlier, Connecticut Agricultural Experiment Station, Yale University, University of California at Berkeley, a private consultant, retired ARS staff and commodities groups. Significant progress has been made to date and some of the results will be presented at the upcoming MBAO Conference.

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

Anticipated Impacts:

- List of the most effective fumigation parameters (time/temperature matrices, dosages, and concentration-times time products) for each promising material for the least susceptible life stage of the targeted species.

- Knowledge of the quality of fumigated commodities using the most effective fumigation.

- Pest monitoring, population suppression by mass trapping and mating disruption, host acceptability, new and more effective methods for pest inspection throughout the system, physical controls, application of pest-free or low-pest prevalence zone and their combinations, and predictive models along with validation tests of those models.

- New management strategies utilizing sterile insect release technologies and biocontrol with parasitic beneficial insects.

- Additional non-chemical control measures (temperature, pressure, controlled atmospheres, combined treatments, and irradiation) for the least susceptible life stage of the target species, along with the impacts of these techniques on commodity quality.

- Enhanced methodologies to capture methyl bromide used under CUEs or QPS Exemptions.

- Multiple, cost-effective treatments incorporating novel approaches that are safe and provide competitive products in international trade.

Review Team Rating: High Impact

Review Team Assessment:
Quarantine and preshipment methyl bromide use is exempt under the Montreal Protocol. However, there have been some proposals to cap or eliminate this use of MB as it now makes up almost 50 percent of the world wide use. It takes several years to develop a quarantine treatment that is acceptable to the industry and the importing countries; therefore although the quarantine aspects of this work may not be used by industry as long as methyl bromide is available it is valuable work that could be crucial if MB becomes unavailable in the future.

Research under disinfestation of postharvest perishable commodities was supportive of the objectives and each provided knowledge and will have a positive impact on the corresponding commodities. Results of these projects were reported to appropriate stakeholders. The research

generally is environmentally sound and safe. All projects produced efficacious results that in most cases are thought to be economically feasible. More commercial scale work needs to be done on some emerging control techniques. Comments on the specific anticipated products are given below.

Five accomplishment statements address *List of the most effective fumigation parameters (time/temperature matrices, dosages, and concentration-times time products) for each promising material for the least susceptible life stage of the targeted species*. The panel finds Western flower thrips control on lettuce and broccoli, Control of black widow spiders in table grapes, Penetration of methyl bromide through sheets wrapping table grapes imported into the United States, Effect of cherry size on methyl bromide fumigation, and New soil drenches for eradication of fruit flies in orchards are all good projects that have developed new knowledge concerning the various pests. The Black Widow project has not been adopted by the industry as they already have an accepted postharvest treatment that has been in use for over 20 years and the ozone treatment would be more costly but it is good to have an alternative on the shelf. Ozone may be a good treatment to reduce MRLs and thus could be used more for Black Widow control. It is not clear why this research was conducted by ARS rather than by parties in the country of origin. Results have been effectively communicated to the appropriate stakeholders. Some of the research is a viable alternative to methyl bromide and some is more environmentally sound and safe. The alternatives researched are effective but costs are of concern on some of them.

Cold temperature fumigation of perishable commodities with phosphine and Residue remediation using ozone and ozone-ethylene fumigations are both good projects addressing *Knowledge of the quality of fumigated commodities using the most effective fumigation* that have added valuable knowledge for industries to use. The results of this research are being communicated to the proper stakeholders. This research is environmentally sound and safe. The treatments are efficacious but costs are a concern at least at this point. These treatments have not been adopted to date. The research is still relatively new and further research is needed before industry will utilize them.

Pest monitoring, population suppression by mass trapping and mating disruption, host acceptability, new and more effective methods for pest inspection throughout the system, physical controls, application of pest-free or low-pest prevalence zone and their combinations, and predictive models along with validation tests of those models was addressed by research organized about these research areas: Pest Monitoring, Lures, Attractants, Baits and Host Status. These research areas have been very productive, adding significant new knowledge concern various pests. The results of this research have been communicated to the appropriate stakeholders. This research will lead environmentally sound and safe farming practices. These research projects are really not alternative but various ways of helping make better pest control decisions. The research will lead to more economical pest control strategies. This research should lead to more sustainable production of the commodities in this research area. The breadth of this work is notable. Pest monitoring research included Combining attractants for cost-effective fruit fly monitoring traps, Evaluation of methods for detecting cherry fruit fly larvae, Determination of effective sampling range of food based attractants for capture of medflies and caribflies, Signature chemicals for detection of hidden insect infestation, Infestation sources can

help identify the pathway of invasive fruit flies, and Phenomena between weather patterns and fruiting on pest populations of the Mexican fruit fly. Lures, attractants and baits research included New female attractant for melon fly, Synthetic lure combinations show improvement, Cadaverine in a food based synthetic attractant for pest tephritid fruit flies, Bait station and fruit-derived bait testing in central Mexico, and Spinosad replacement for organophosphate male annihilation treatments in California. Host status research included Improved methods for evaluating non-host status of horticultural crops for fruit flies, New approaches to host status evaluation, Host status of grapefruit and oranges for the serpentine fruit fly, and Tropical fruit fly host status.

Biological control of olive fruit fly, Augmentative releases of multiple natural enemies for melon fly control, and New genes for lethality in fruit flies are all good research projects producing new knowledge of several species of fruit flies and addressing *New management strategies utilizing sterile insect release technologies and biocontrol with parasitic beneficial insects*. The research has been communicated to appropriate stakeholders. The research is environmentally sound and safe. This research will be of great value in controlling these pests. The research is economically feasible as is being used. This research will help with sustainable crop production.

*Additional non-chemical control measures (temperature, pressure, controlled atmospheres, combined treatments, and irradiation) for the least susceptible life stage of the target species, along with the impacts of these techniques on commodity quality neces*sarily involved research on a wide range of non-chemical approaches. These included Cold treatment for *Bactrocera invadens* adopted by APHIS, Heat exposure threshold to maintain flavor quality of navel oranges, Ultra-low oxygen treatment for control of postharvest pests, Controlled Atmosphere Temperature Treatment System (CATTS), Radiation, High pressure washing and organosilicones for removal of surface arthropods, and Fate of codling moth in apples exported to tropical climates. These are all good research projects producing a useful new knowledge on numerous pests. This research has been reported to appropriate stake holders. The research is environmentally sound and safe and in most cases has resulted in effective alternatives. More needs to be done relative to cost effectiveness on a commercial scale. Research under ultra low oxygen included Black widow spiders in table grapes and Western flower thrips on lettuce. CATTS research included Codling moth metabolism, Oriental fruit moth in boxed peaches, Oblique-banded leafroller and peach moth, Grain chinch bug (*Macchiademus diplopterus*) and snout beetle (*Phlyctinus callosus*). Radiation research included Potential increase in live fruit fly larval interceptions using radiation treatments, Quarantine treatment against scale insects, Dragon fruit shown to be tolerant of irradiation quarantine treatment, and Ionizing radiation as a phytosanitary treatment against the European corn borer.

Regarding *Enhanced methodologies to capture methyl bromide used under CUEs or QPS Exemptions*, the panel is aware of the new five year FAS supported research that is a cooperative project involving ARS-Parlier, Connecticut Agricultural Experiment Station, Yale University, University of California at Berkeley, a private consultant, retired ARS staff and commodities groups. Significant progress has been made to date and some of the results will be presented at the upcoming MBAO Conference. Based on a review of quarterly reports and the year-end report the panel believes this will be a very productive project.

Seven research accomplishment statements address *Multiple, cost-effective treatments incorporating novel approaches that are safe and provide competitive products in international trade*. These are Phytosanitary treatments are adopted by the International Plant Protection Convention, Pure phosphine fumigation at low temperature for control of western flower thrips on lettuce, broccoli, asparagus, and strawberries, Low temperature oxygenated phosphine fumigation for controlling lettuce aphid, Insecticide mix prevents egg laying by cherry fruit fly, Precision management of codling moth, Data to WTO for expansion of apple exports, and Areawide Pest Management of Fruit Flies in Hawaii. These are all scientifically sound projects that have provided new knowledge relative to the pests covered. The results of this research have been appropriately reported to the correct stakeholders. This research produced environmentally sound and safe pest control strategies. The alternatives are effective and in most cases help produce a more sustainable farming system. The Areawide fruit flies research and demonstration project included Registration of key control for fruit flies, Suppression of fruit fly in papaya orchards using bait sprays and field sanitation and, Soil drenches to control fruit flies.