Component I. Protection of Agricultural and Horticultural Crops

2i. Small Fruits – Berries and Grapes (U.S. Farmgate Value 2007: 4.6 billion, however, grapes (and wine) contribute $52 billion to the economy)

***Problem Statement*:** The following pests cause significant economic losses during the production of small fruit crops (grapes, blackberries, blueberries, cranberries, raspberries) due to direct feeding damage, plant diseases caused by insect-transmitted plant pathogens, pest (insects, diseases, weeds) management costs, and reduced yields.

- Glassy-winged Sharpshooter (*Homalodisca vitripennis*)
- Vine Mealybug (*Planococcus ficus*)
- Light Brown Apple Moth (*Epiphyas postvittana*)
- Black Vine Weevil (*Otiorhynchus sulcatus*)
- Garden Symphylan (*Scutigerella immaculata*)
- Two-spotted Mite, *Tetranychus urticae*
- Perennial Broadleaf Weeds

***Research Needs*:**

1. **Glassy-winged Sharpshooter*, Homalodisca vitripennis***

Importance: The glassy-winged sharpshooter (GWSS) is the principal vector of the bacterial pathogen, *Xylella fastidiosa*, the causal agent of Pierce's disease (PD) of grapevines (as well as diseases of other agronomic and horticultural crops, and ornamental and landscape plants). This disease threatens the entire California grape and wine industry. Of secondary concern, feeding by this large leafhopper may rarely cause significant plant damage, although adult insects do excrete copious amounts of liquid that can make leaves and fruit appear whitewashed when dry. During hot weather, this feeding may cause small plants to wilt.

Research Gaps: National and regional long-term solutions are needed for effective, sustainable protection of table and wine grapes and raisins against PD. New or innovative methods must be developed for long-term sustainable management of GWSS in order to reduce the incidence of PD and its threat to the United States grape industry. Research needed for biological- and systems-based GWSS management includes: developing grape rootstock and scion varieties that are resistant/tolerant to PD; elucidating insect–pathogen interactions within the native ranges of the GWSS and *X. fastidiosa* that have optimal growing conditions for grapes; evaluating long-term sharpshooter densities in experimental plantings to quantify the pressure of this vector and pathogen; developing mass rearing systems for the cost-effective production of high quality insects for research and parasitoid production; developing detection methods for the sensitive, accurate, and rapid measurement of the quality of mass produced insects;

assessing plant and environmental factors that affect insect-symbiont relationships; and development of economic, effective, biologically-based, and environmentally-sound GWSS management strategies.

Actions: See the "Pierce's Disease Strategic Plan" (http://www.ars.usda.gov/research/programs/programs.htm?np_code=304&docid=14767) for the comprehensive plan on GWSS research at ARS.

ARS will:

Control, Host Resistance (This work is included in National Program 301 and National Program 303)

- Identify and develop GWSS-resistant/-tolerant grape germplasm.
- Develop and evaluate new rootstock and scion grape varieties for their resistance/tolerance to GWSS.

Control, Biological

- Develop new or improved diet formulations and rearing technologies for production and storage of insects to enhance research and the use of beneficial insects.
- Develop methods for short- and long-term cold storage of GWSS.
- Develop molecular genetic markers and DNA fingerprinting methods to identify and track GWSS and GWSS natural enemies.

Control, Interference with Vector Biology

- Identify chemical and biochemical factors involved in GWSS-host interactions (i.e., feeding, oviposition, dormancy, etc.).
- Identify genetic and biochemical factors involved in health, fitness, and production of insects, and develop those factors as accurate, high-speed biomarkers of those traits.
- Determine the impact of nutrition, immunity, and behavior on the symbiont complex within GWSS.
- Develop semiochemical approaches to managing GWSS.

2. Vine Mealybug, *Planococcus ficus*

Importance: The vine mealybug (VMB) was first reported in the Western Hemisphere in 1994 in the Coachella Valley of California in table grape vineyards. VMB has a wide host range that includes 23 plant species in 17 families. The mealybug can feed on ornamental, temperate, subtropical, and tropical crops including grapes, figs, apples, oleander, citrus, dates, bananas, avocados, and mangos. In addition, the VMB transmits grapevine leafroll viruses. By 2002, the VMB spread to Kern County, California and is now a serious pest of table and wine grapes in Santa Barbara, Napa, and Sonoma Counties. Since its detection in 1994, the VMB has spread to 17 counties in California.

Biological control is the most effective management option. ARS, from its laboratory in France, is assisting APHIS in the biological control of the VMB through collection, identification, quarantine clearance, and delivery of parasitoids from Eurasia.

Research Gaps: Solutions are urgently needed to effectively manage the VMB in grapevines. The most sustainable strategies are likely to be biologically-based systems developed through advances in our knowledge of the biology, ecology, behavior, genetics, biological control agents, and host plant resistance. Research needs to develop biological- and systems-based VMB management include: identification and evaluation of additional biological control agents; knowledge of the species diversity of native parasitoids in the Middle East; knowledge of the relationships of VMB populations from Asia (Pakistan, India) with Eurasian and California populations; and knowledge of the process(es)/mechanism(s)/nature of transmission of leafroll viruses to grapevine by VMB in California vineyards compared to the VMB in Europe.

Actions: ARS will:

Plant Pathology

- No actions proposed in National Program 304

Control, Biological

- Improve and conduct foreign exploration of new strains of parasitoids in areas not surveyed yet, such as the Middle East, India, and Pakistan.

3. Light Brown Apple Moth, *Epiphyas postvittana*

Importance: The first detection of the light brown apple moth (LBAM) in the continental United States was confirmed in California in 2007. LBAM is considered to be a High-Risk pest by APHIS and a Class A pest by CDFA. Accordingly, State (California) and Federal (APHIS) quarantine orders restrict intra- and interstate movement of plant material from counties where LBAM has been detected. Currently, LBAM is known to occur in the San Francisco Bay Area counties of Alameda, Contra Costa, Marin, Napa, San Francisco, Santa Clara, San Mateo, and Solano; in the Central Coast counties of Monterey and Santa Cruz; and in Los Angeles County. International quarantines, prohibitions against shipments, or phytosanitary certification have been implemented against fresh plant products from LBAM-infested areas within California. LBAM has a wide host range that includes many trees and ornamental species, and is known to be a serious pest of grapes, caneberries and strawberries, as well as tree nuts, citrus, pome fruits, stone fruits, and kiwifruit in areas that have climates similar to that in California. Research on LBAM management strategies in California will be difficult under quarantine regulations. If LBAM becomes permanently established in California, the most important impact on growers/producers will likely be trade restrictions on crop exports. Trade restrictions for certain LBAM host species (e.g., almonds) affect 60 percent of the crop. Increased concerns regarding management of LBAM have recently resulted in court orders to halt the use of aerosolized LBAM pheromone for mating

disruption. The use of broadly applied pheromone was one of the more promising control measures available in light of the highly restricted use of pesticides in urbanized areas. Recent progress in sterile insect technologies for LBAM is another promising approach.

Research Needs: In order to enhance and ensure the maintenance of export markets for horticultural crop products (including small fruits); immediate research is urgently needed to develop sustainable LBAM eradication, management, and postharvest commodity treatment strategies. These strategies need to be environmentally-sound and ecologically-safe. Research needs to develop biological- and systems-based LBAM management include: IPM strategies to suppress LBAM populations in areas not yet under intensive eradication; traditional IPM strategies to manage LBAM if eradication efforts are not successful; sterile insect technique (SIT) and release; pheromone mating disruption alternatives (to ones halted by court order); new or improved monitoring techniques; classical biological control tactics; areawide pest management systems; and postharvest commodity treatment(s) to meet domestic and international phytosanitary requirements.

Actions: ARS will:

Control, Interference with Insect Biology

- No actions proposed in National Program 304

Control, Postharvest Treatment

- Evaluate the effectiveness of available postharvest chemicals and fumigants to treat small fruits to meet domestic and international phytosanitary requirements for LBAM. See National Program 308.

4. Black Vine Weevil, *Otiorhynchus sulcatus*

Importance: The black vine weevil (BVW) is a serious pest of a number of small fruit crops including strawberry, blueberry, cranberry, grape, and caneberries. Many small fruit crops are grown perennially, allowing for weevil populations to build over time. Weevil larvae feed on plant roots and can cause loss of vigor and even plant death. Defoliation by BVW adults can also be a serious problem particularly in young plantings. Current management strategies rely primarily on the use of chemical insecticides to target pre-ovipositional adults. Timing of chemical applications is difficult due to the nocturnal behavior of the insects and the preharvest interval required following insecticide application.

Research Gaps: Due to the increased consumer demand for organic fruits, there is an urgent need for developing alternatives to chemical insecticides. Research needs to develop biological- and systems-based BVW management include: monitoring strategies for adults (traps, host plant volatiles, etc.); improved application technologies of microbial control agents; and conservation practices that maintain natural enemies in the field.

Actions: ARS will

Monitoring

- Develop monitoring techniques for adult BVW. (Corvallis, Oregon: Bruck)

Control, Microbial

- Develop new application technologies for applying microbial control agents against the weevil. (Corvallis, Oregon: Bruck)
- Integrate microbial control agents into existing IPM programs. (Corvallis, Oregon: Bruck)
- Identify new, more effective microbial isolates if necessary. (Corvallis, Oregon: Bruck)

Control, Biological

- Determine the role that predators play in controlling BVW populations in the field. (Corvallis, Oregon: Lee)
- Identify cultural practices that enhance predator numbers in the field. (Corvallis, Oregon: Lee)

5. Garden Symphylan, *Scutigerella immaculata*

Importance: Garden symphylans are serious pests of the below-ground parts of numerous fruit crops in the western United States. They are white, soft-bodied "centipede-like" arthropods which are related to insects. Garden symphylans are omnivorous and are commonly found in a wide range of agricultural systems. The damage caused in these systems varies greatly. Severe losses commonly occur in some organically grown strawberries, where damage is believed to be associated with secondary stresses from root diseases such as verticillium wilt (*Verticillium* spp.). Economic damage also frequently occurs in hop and mint crops, and somewhat less frequently in raspberry crops.

Research Gaps: Garden symphylan management is based on preventive treatment (e.g., soil fumigation, soil-applied insecticides, and cultural practices). Accordingly, reliable monitoring techniques to detect the presence and to estimate population sizes of symphylans in the field are needed. Research needs to develop biological- and systems-based garden symphylan management include: sampling protocols for effective estimation of population size; economic thresholds for the various susceptible crops; and effective control measures (biological, cultural and chemical).

Actions: ARS will

Monitoring

- Develop monitoring techniques for detecting the presence and estimating the population size of symphylans in the field. (Corvallis, Oregon: Bruck)

Economic Thresholds

- Determine the economic thresholds of various small fruit crops to symphylans. (Corvallis, Oregon: Bruck)

Control, Cultural Practices

- Develop cultural techniques (cultivation, crop rotation, etc) for effectively managing symphylan populations.

Control, Chemical

- Identify reduced risk chemicals for effective symphylan management. (Corvallis, Oregon: Bruck)

Control, Biological

- Integrate biological control agents into existing IPM programs. (Corvallis, Oregon: Bruck)

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6. Two-spotted Spider Mite, *Tetranychus urticae*

Importance: The two-spotted spider mite is a persistent pest in strawberry, grape, blackberry and raspberry. Feeding by the mite can reduce plant vigor, yield, and cause leaves to drop off. Extensive defoliation in blackberries can reduce yield by 25 percent during the following season. Mite infestations are exacerbated by dry and dusty conditions, and by insecticide treatment for other pests that subsequently kill their natural enemies. Practices that maintain and attract predators to the field can improve control of the mite while reducing the use of insecticides and miticides.

Research Gaps: Predators (e.g., predatory mites, lady beetles, minute pirate bugs, thrips, and lacewing larvae) are very important in regulating mite populations. Research needs to develop biological- and systems-based mite management include: conservation practices and non-toxic semiochemical attractants (herbivore-induced volatiles) to maintain predators in the field.

Actions: ARS will:

- No actions proposed in National Program 304

7. Perennial Broadleaf Weeds

Importance: Perennial broadleaf weed control is a significant annual management issue in small fruits (berries and grapes). Weeds compete with small fruits for nutrients, light, water, and space. Weeds can harbor insect and rodent pests, increase disease pressure, and interfere with irrigation systems. Significant amounts of herbicides are applied to small fruit acreage annually. In other cases, cultural practices to manage weed (e.g., disking and hoeing) are expensive and/or labor intensive. Herbicide use and cultural

practices in some areas may not effectively and economically control weeds, and/or lead to unacceptable environmental impacts, decreased due to use of herbicides crop productivity, increased cold damage, or increased insect and pathogen problems.

Research Gaps: While weeds are an annual consideration for small fruit (grapes and caneberries) producers and are difficult to control, no ARS resources are currently directed to research related to weed management, biology, or ecology in small fruit production systems in this National Program. Research needs to develop biological- and systems-based weed management include: greater understanding of the biology and physiology of weeds; and alternative control strategies.

Actions: ARS will:

- No actions proposed in National Program 304

Anticipated Products:

- Economic, effective, biologically-based, environmentally-sound arthropod pest management strategies.
- Improved arthropod pest sampling and detection methods.
- Increased knowledge of arthropod pest biology, ecology, behavior, genetics and arthropod pest-plant host interactions.
- New species or new strains of biological control agents.
- New knowledge of the diversity of parasitoid species for arthropod pests.
- New knowledge about transmission of grapevine leafroll viruses by the VMB in the New World.

Potential Benefits (Outcomes):

- Improved IPM strategies for arthropod pests of small fruits (grapes and caneberries).
- Additional pest management tools for arthropods in small fruit organic production systems.
- Reduced arthropod pest management costs.
- Reduced losses due to arthropod pests during production of small fruit crops (grapes and caneberries).
- Increased grower/producer profitability.
- Maintenance and enhancement of natural resources.

USDA ARS Resources

- Beneficial Insects Research Unit, Weslaco, Texas
- Biocontrol of Insects Research Unit, Columbia, Missouri

- Commodity Protection and Quality Research Unit, Parlier, California
- Crop Diseases, Pests and Genetics Research Unit, Parlier, California
- Horticultural Crops Research Laboratory, Corvallis, Oregon
- Insect Genetics and Biochemistry Research Unit, Fargo, North Dakota
- Subtropical Insects Research Unit, Fort Pierce, Florida