Component IV: Protection of Postharvest Commodities and Quarantine

4a. Fresh Commodities

Problem Statement: There is the need to stop the geographical spread and adverse impacts of exotic fresh commodity insect pests by providing for the safe movement of commercial agricultural commodities from areas already invaded, reducing costs and damage to agriculture in those invaded areas, and developing environmentally acceptable and economically-efficacious systems to suppress and/or eradicate established populations of invasive species. Key pests of fresh commodities include:

- Fruit Flies (Mediterranean fruit fly, Oriental fruit fly, melon fly, Malaysian fruit fly, olive fly, Caribbean fruit fly, Mexican fruit fly, peach fruit fly, apple maggot, cherry fruit fly)
- Moths (codling moth, Oriental fruit moth, oblique banded leafroller, light brown apple moth, fall armyworm, banana moth, litchi fruit moth, nettle caterpillar)
- External Quarantine Arthropods (aphids, thrips, mealybugs, scale insects, leafminers, ants, spiders)
- Post-harvest Disease Management (gray mold, citrus green mold, brown rot, other post-harvest diseases)

Research Needs:

1. **Fruit Flies**

   Importance: Fruit flies have a severe economic impact on tropical and subtropical agriculture and pose an increased threat of establishment into new areas. When new fruit fly species are introduced into the United States mainland, they often require large-scale eradication programs at great public expense. In California, where the total annual value of the fruit and vegetable industry has been estimated at more than $14 billion, the California Department of Food and Agriculture estimated that an established Mediterranean fruit fly infestation would cost from $855 million to $1.4 billion during the first year of establishment. In Hawaii, production of fruits and vegetables is severely limited by fruit flies and other introduced alien insect pests.

   Invasive (and potentially invasive) tephritid fruit flies include: Caribbean fruit fly, *Anastrepha suspensa* (attacks guavas, peaches and grapefruit)*;* Mexican fruit fly, *A. ludens* (principally attacks citrus); West Indian fruit fly *A. obliqua* (principally attacks mango); species of *Ceratitis* (primarily Mediterranean fruit fly, *C. capitata*, attacks a very broad host range); *Bactrocera* species, particularly the Oriental fruit fly, *B. dorsalis*; and melon fly, *B. cucurbitae* (principally attacks citrus, guava, mango, papaya); olive fruit fly (olives), and *Rhagoletis* species (attacks walnuts, cherries, apples, and blueberries).

Research Gaps: User-friendly, economical, and environmentally acceptable technologies are needed to control fruit flies. Area-wide pest management (AWPM) systems for fruit fly suppression are under development but are often, not always, sustainable and economical for farmers in all geographic areas and for all crops. Systems approaches for movement of export commodities are essential to expansion of specialty crops. More information is also needed to increase the practice of biological control for fruit flies, including information on ecology, physiology, and behavior of the pests and their natural enemies; mass-rearing techniques and strain development; and augmentative release strategies and tactics. Effective use of the sterile insect technique (SIT) requires an understanding of sexual behaviors and improved technology for genetic marking, sperm marking, genetic sexing (male-only) strains and male sterilization. Fundamental studies are needed in the areas of fly odorant and gustatory receptor gene identification and isolation, and identification of strain specific genetic markers in fruit flies.

Actions: ARS will:

Basic Biology

- Conduct studies of population dynamics and fruit fly interactions with their natural enemies, host plants, and other pests in the ecosystem.
- Provide baseline information for development of low prevalence and/or fly-free zones, and detection, control, containment, and suppression and eradication technologies for use in Hawaii and the United States mainland.
- Determine the responses of fruit flies to host plant volatiles, particularly in relation to oviposition and the maintenance of sexual signaling sites.
- Conduct full genome and specific EST sequencing projects in fruit flies to identify genetic reagents necessary for transgenic strain development, odorant/gustatory receptor gene identification and isolation, and highly specific strain identification.
- Create transgenic strains incorporating fluorescent protein markers for organismal detection and sperm detection in mated females.
- Create transgenic strains that allow conditional lethality specific to embryos of mass-reared females or progeny of released males.
- Use odorant and gustatory receptor genes for microarray analysis.

Surveillance, Detection and Monitoring

- Identify attractants from host and non-host plants and determine physiological and environmental factors that influence fruit fly behavior.
- Improve male lures and trapping systems for fruit fly surveillance, detection, and control.
- Develop automated methods for monitoring pest fruit flies and develop improved methods of trapping female fruit flies.

Biological Control and SIT

- Assess the efficacy of new and established parasites and predators and the sterile insect technique for fruit fly control, and determine factors limiting their effectiveness.
- Determine the best conservation and augmentation methods to improve the effectiveness of entomophagous insects to suppress fruit fly populations.
- Evaluate field behavior of parasitoids and sterile fruit flies.
- Improve quality of laboratory-reared fruit flies and their parasitoids compared with counterparts in nature.
- Explore for and investigate the characteristics of candidate fruit fly biological control agents..
- Explore tritrophic interactions among fruit flies, hosts, and natural enemies with the goal of developing new attractants and increasing biological control efficacy.
- Manipulate sex ratios in mass-reared parasitoids to produce more females.
- Determine the role of host and fruit fly host plant odors in the foraging of fruit fly parasitoids.
- Develop cultural control methods to reduce field populations of fruit flies.
- Create transgenic strains that allow conditional lethality specific to embryos of mass-reared females or progeny of released males.
- Conduct foreign exploration in Africa and Asia for biological control agents of olive fruit fly, and develop rearing methods for these agents.

Area-wide Integrated Pest Management (IPM) Systems

- Develop area-wide IPM approaches to reduce the economic impact of fruit flies.
- Enhance the role of natural enemies in IPM systems.
- Integrate environmentally friendly replacements for organophosphate pesticides used to control fruit flies.

Quarantine Treatments and Other Mitigation Approaches

- Develop heat, cold, irradiation, controlled atmosphere, and other post-harvest commodity treatments.
- Determine commodity tolerance and efficacy of controlled atmosphere plus heat and other combination treatments.
- Increase knowledge of pest biology and physiology as it relates to the development of quarantine procedures and risk of pest establishment.
- Develop multiple-component systems approaches to maintain current or establish new trade markets.

2. Moths

Importance: Moths are probably the second most significant pests of economic and quarantine concern for fresh fruits and vegetables. Moth pests can limit agricultural production and may disrupt trade if not detected and allowed to become established in major production areas. Codling moth is a serious economic pest of pome and stone fruits and a pest of quarantine concern to many Pacific Rim countries that import U.S. fruit. Oriental fruit moth is a quarantine pest for Mexico and Canada and light brown apple moth, an exotic pest, recently became established and is spreading in California, resulting in trade restrictions imposed by foreign countries. Fall armyworm overwinters in Texas and Florida and may migrate from more southerly locations in the Caribbean, Mexico and even South America serving as a model for exotic pests that migrate into the United States. False codling moth, a pest of 40 commodities, has recently been found in California.

Research Gaps: User-friendly, economical, and environmentally acceptable technologies are needed for control of moth pests. Sustainable economical area-wide pest management systems for suppression of moths need further development. Quarantine treatments and systems approaches for movement of export commodities are essential to expansion of specialty crops. More information is also needed to increase the practice of biological control for moths including information on ecology, physiology, and behavior of the pests and their natural enemies; mass-rearing techniques and strain development; and augmentative release strategies and tactics. Effective use of the sterile insect technique requires a better understanding of insect dispersal and improved technology for genetic sexing (male-only) strains and male sterilization. Little is known about the annual long-range movements of migratory pests and the potential for hemispheric migration.

Actions: ARS will:

Basic Biology

- Conduct studies of population dynamics and moth interactions with their natural enemies, host plants, and other pests in the ecosystem.
- Provide baseline information for development of low prevalence and/or moth-free zones, detection, control, containment, suppression and eradication technologies.

Surveillance, Detection and Monitoring

- Identify attractants from host and non-host plants and determine physiological and environmental factors affecting or modulating moth behavior.
- Improve lure and trapping systems for surveillance, detection, and control of moths.
- Identify genes and molecular markers to distinguish between species, strains or subpopulations.

Biological Control and SIT

- Assess the efficacy of SIT for control of moths and determine factors limiting their effectiveness.
- Evaluate the field behavior of sterile moths.
- Improve the quality of laboratory-reared insects compared to their wild counterparts.
- Develop area-wide IPM approaches to reduce the economic impact of moths.

Quarantine Treatments and Other Mitigation Approaches

- Improve pre-harvest procedures to reduce the incidence of moths in harvested fruit and packed boxes.
- Develop heat, cold, irradiation, controlled atmosphere, and other post-harvest commodity treatments.
- Determine commodity tolerance and efficacy of controlled atmosphere plus heat and other combination treatments.
- Increase knowledge of pest biology and physiology as it relates to the development of quarantine procedures and risk of pest establishment.
- Develop multiple-component systems approaches to maintain current or establish new trade markets.

3. External Quarantine Pests

Importance: External or surface feeding quarantine pests and hitchhiker pests are as important as internal quarantine pests in interrupting import/export marketing channels of fresh commodities. Although these pests can be detected through inspection and culled, many go undetected (e.g., when pests are hidden inside fruit clusters or protected within various plant parts in the exported commodity). A postharvest quarantine treatment or systems approach (pre- and/or post-harvest) may be required to treat external pests such as thrips, mealybugs, scale insects, leafminers, ants, mites, and spiders.

Research Gaps: Fundamental scientific information is lacking for most exotic surface feeding anthropod insect pests and is necessary in order to develop effective quarantine and safeguarding programs. This information also is necessary to develop basic detection and delimitation tools and to determine the types of systems approaches or commodity treatments that are appropriate to minimize the risk of their introduction and spread. The effectiveness of most current quarantine treatments against these external surface or hitchhiker pests is poorly understood.

Actions: ARS will:

Basic Biology

- Study the population dynamics and pest interactions of surface-feeding or hitchhiker pests with their natural enemies, host plants, and other pests in the ecosystem.
- Provide baseline information for development of low prevalence and/or pest-free zones, detection, control, containment, and suppression technologies, as needed.
- Target pest populations with the appropriate predators through genomic, physiological and comparative studies that define species-specific abundances and niches in greenhouses and in the field.

Surveillance, Detection and Monitoring

- Identify attractants from host and non-host plants and determine physiological and environmental factors affecting or modulating pest behavior.
- Improve lure and trapping systems for surveillance, detection, and control of the pest.
- Map the annual migration of populations of moth pests in North America in order to target control measures.

Biological Control and Sterile Insect Technique

- Assess the efficacy of new and established parasites and predators and determine factors limiting their effectiveness.
- Determine the best methods to improve the effectiveness of entomophagous insects in suppressing pest populations through conservation and augmentation.
- Identify nutritional components that will contribute to improved diets for rearing predators. (Gainesville, Florida: Shapiro, Shirk)
- Develop molecular and genetic methods for disrupting moth-larval physiology to be used in area-wide controls. (Gainesville, Florida: Meagher, Nagoshi, Shirk)
- Improve methods for mass-reared predator distribution and so increase efficacy.

Quarantine Treatments and Other Mitigation Approaches

- Develop heat, cold, irradiation, controlled atmosphere, and other post-harvest commodity treatments.
- Determine commodity tolerance and efficacy of controlled atmosphere plus heat and other combination treatments.
- Increase knowledge of pest biology and physiology as it relates to the development of quarantine procedures and risk of pest establishment.
- Develop multiple-component systems approaches to maintain current or establish new trade markets.

4. **Postharvest Disease Management** (gray mold, citrus green mold, brown rot, stem end rots, body rots, anthracnose, and other post-harvest diseases)

Importance: Postharvest diseases cause major losses due to spoilage and reduced shelf life. Papayas and other tropical fruits are susceptible to postharvest diseases with incidences in the range of 40-60 percent. Without postharvest disease control, fruit quality would be diminished with mild blemishes to severe rots resulting in poor consumer acceptance or marketability. In citrus, postharvest diseases that currently cause losses of 3 to 5 percent in retail trade can become much higher. These diseases occur early in the harvest season when fruit are de-greened with ethylene gas, later in packinghouse storage, or among fruit where sales were delayed. These diseases also make deliveries of sound fruit to certified organic buyers or distant foreign markets risky and difficult, particularly when customers reject the use of conventional fungicides or if pathogen resistance to these compounds has diminished their effectiveness.

Research Gaps: In order to deliver fresh agricultural products of high quality to satisfy the growing domestic demand for organic fruit and vegetables, or to reach distant but profitable foreign markets, the research capacity to develop new postharvest treatments and practices to prolong their shelf and shipping life are needed. Integrated disease control regimes are also needed with elements that employ OMRI (Organic Materials Review Institute)-approved treatments, generally recognized as safe compounds, biological control, and/or thermal treatments.

Actions: ARS will:

Monitoring

- Improve sampling and monitoring methods to detect and manage the development of pathogen fungicide resistance among postharvest pathogens.

Control, Chemical

- Discover treatments based on reduced risk compounds that can become elements in integrated postharvest disease control programs and, if applicable, to be elements in programs to minimize food safety risks as well.
- Monitor pathogen populations within packinghouses and fruit shipments to determine the extent of fungicide-resistance.
- Determine efficacy of chemical controls under various storage temperatures and using different packaging systems.
- Determine the efficacy of chemicals combined with postharvest quarantine treatments, such as heat, cold or irradiation.

Control, Biological

- Develop biological control agents, determine feasibility of their mass production, formulation, and tolerance to their use in current commercial practices.
- Determine efficacy of biological control agents under various storage temperatures and using different packaging systems.

5. **Post-harvest Commodity Quality**

Importance: Quarantine treatments for fresh commodities are urgently needed but often cause unacceptable injury to the commodity that reduces marketability.

Research Gaps: The effect of quarantine treatments on fruit quality is often inconsistent due to poor understanding of the biochemical basis of an observed quarantine-induced injury and a lack of complete information regarding the influence of pre-harvest factors on the injury. These are long-standing problems that cause failures of treatments already in place or hinder the development of new treatments. There is limited and unreliable data available on crop tolerances to quarantine treatments, particularly for irradiation.

Actions: ARS will:

- Determine tolerance thresholds and compositional quality for tropical and temperate crops subjected to quarantine treatments.
- Utilize genomic, proteomic and metabolomic techniques to answer basic questions regarding the influence of quarantine treatment-induced stresses (e.g., high or low temperature) on fresh commodity physiology.
- Enhance understanding of the influence of maturity on fresh commodity quality following quarantine treatment.
- Increase understanding of the influence of pre-harvest factors, such as growing temperature and other environmental influences, on fresh commodity quality following specific treatment protocols.
- Develop novel methods to alleviate damage caused by quarantine treatments.

Anticipated Products:

- New or improved quarantine treatments or approaches that allow safe import or export of fresh commodities.
- Increased knowledge of pest biology, ecology, behavior, genetics, and biological control agents, and of plant traits conferring pest resistance.
- Discovery, characterization, and synthesis of insect attractants, repellents and confusants.
- New biological control agents.

- Increased knowledge of the genomics and basic biology and ecology of biological control agents.
- Information on endosymbionts associated with subtropical and tropical insect pests.
- Identification of plant traits that might be used to develop pest-resistant plants.
- Development of plants with pest resistance.
- Novel methods of reducing the impact of anthropod pests of fruit, vegetable and ornamental plants.
- Improved pest sampling and detection methods.
- Improved mating disruption technology.
- New or improved quarantine treatments or approaches that allow safe import or export of fresh commodities.

***Potential Benefits (Outcomes)*:**

- Exclusion of exotic pest from the United States.
- New or expanded markets for U.S. fresh commodities using improved quarantine procedures.
- Increased income for U.S. producers through increased trade.
- Increased availability of fresh commodities for the consumer.
- Increased availability of suitable quarantine treatments for fruits and vegetables that meet organic labeling requirements.
- Reduced impact of integrated pest management tactics and postharvest quarantine treatments on the environment.
- Strategies for improved integrated pest management of temperate, subtropical and tropical insect pests.
- Reductions in crop losses due to insect pests and plant diseases.
- Reductions in expenditures to manage insect and disease pests.
- Reduction in the use of methyl bromide and organophosphate pesticides.

***USDA ARS Resources*:**

- Euroean Biocontrol Laboratory, Montpelier, France
- Fruit and Vegetable Research Unit, Wapato, Washington
- Insect Behavior and Biocontrol Research Unit, Gainesville, Florida

- Post-Harvest Tropical Commodities Research Unit, Hilo, Hawaii
- Subtropical Insects Research Unit, Fort Pierce, Florida
- Tropical Plant Pest Research Unit, Honolulo, Hawaii