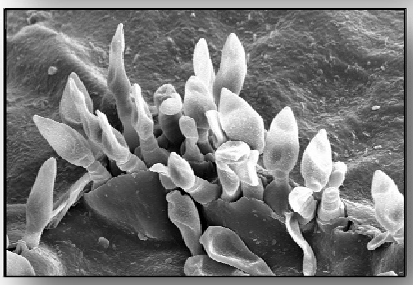
USDA
AGRICULTURAL RESEARCH SERVICE

# NATIONAL PROGRAM 303
PLANT DISEASES

# ANNUAL REPORT FY 2009






# National Program 303 – PLANT DISEASES
# FY 2009 Annual Report

*Introduction*

National Program 303, Plant Diseases, focuses on developing effective disease control strategies that are environmentally friendly, do not threaten the safety of consumers, and are compatible with sustainable and profitable crop production. This Agricultural Research Service (ARS) National Program is conducted in cooperation with related research in other public and private institutions. In addition, NP 303 projects are coordinated with those in NP 301 (Plant Genetic Resource, Genomics, and Genetic Improvement) and in NP 302 (Plant Biological and Molecular Processes) toward the overall goal of crop improvement through increased resistance to biotic and abiotic factors and increased understanding of host-pathogen interactions.

The overall goal of NP 303 is to develop and improve ways to reduce crop losses caused by plant diseases. These diseases reduce yields, lower product quality or shelf-life, decrease aesthetic or nutritional value, and, sometimes, contaminate food and feed with toxic compounds. Control of plant diseases is essential for providing an adequate supply of food, feed, fiber, and aesthetics. Reducing these losses has long been a high priority for agriculture and for ARS. Besides the obvious monetary benefits to producers and processors, successful plant health protection is important for maintaining and increasing food supplies with minimal increases in land under cultivation. Additionally, the knowledge and management of plant diseases of quarantine significance are vital, not only for protecting our domestic crops from foreign disease, but also for maintaining and expanding export markets for plants and plant products.

NP 303 is comprised of the following four components:

- *Disease Diagnosis: Detection, Identification and Characterization of Plant Pathogens*;
- *Biology, Ecology, Epidemiology, and Spread of Plant Pathogens and their Relationships with Hosts and Vectors*;
- *Plant Disease Resistance*; and
- *Biological and Cultural Strategies for Sustainable Disease Management*.

Together, these components yield breakthroughs to understand and control plant diseases and to develop strategies for disease management and control that enhance agricultural production and value. During fiscal year 2009 this program produced many important discoveries and advances. Some of these are described below, grouped by program component, but not necessarily in order of significance:

## Component I – Disease Diagnosis: Detection, Identification and Characterization of Plant Pathogens

- *A new Reo-like virus identified from "crumbly fruit" disease in raspberry.* Crumbly fruit disease in red raspberry and blackberry significantly decreases fruit quality, making the fruit unusable for the fresh or whole berry markets which are the most profitable for the grower. ARS scientists in Corvallis, Oregon, characterized viruses from diseased plants. The researchers conclusively showed infection with three viruses: Raspberry bushy dwarf virus, Raspberry leaf mottle virus, and a new Reo-like virus, and they developed diagnostic tests for the latter two. A polymerase chain reaction (PCR) test is now being used to identify the vector and native hosts of the Reo-like virus. In addition, plants singly infected with each of the three viruses are being developed to study the role of each virus individually and in various combinations in the crumbly fruit symptom. These diagnostic tests have been provided to laboratories carrying out virus clean-up programs to ensure that the plants produced are free of these viruses and to laboratories responsible for quarantine and certification to assist their programs.

- *Fairy ring disease of cranberry: causal agent and life cycle determined*. Fairy ring is a serious fungal disease of cranberry that kills vines and is difficult to control. The causal agent and mechanism of spread were unknown. ARS scientists in Chatsworth, New Jersey, positively identified the causal agent as a new species of *Helicobasidium*. They further determined that this organism has a complex life cycle and an alternate host that contributes to the genetic diversity and spread of the disease in cultivated cranberry beds. These discoveries provide needed information to develop better management practices to control fairy ring disease.

- *Assigning gene functions to the causal agent of sudden oak death*. The DNA sequence of disease-causing organisms can provide clues to their function and potential opportunities to disrupt those functions. However, sequence similarities must be verified biologically rather than simply by computer-generated associations. The majority of the genes sequenced for the fungal pathogen, *Phytophthora ramorum*, that causes sudden oak death, had no experimental evidence supporting their identification until recently. ARS scientists in Davis, California, constructed gene expression microarrays for the fungus and obtained baseline gene expression levels during the three life stages of the fungus which facilitates association and demonstration of specific genes with specific biological processes.

- *Potato zebra chip disease agent identified.* The potato zebra chip disease can cause severe economic loss in all market classes of potatoes. Zebra chip disease has been shown to be transmitted by potato psyllids and has been proposed to be associated with an uncultured bacterium species of Liberibacter. ARS scientists in Beltsville, Maryland, have successfully transmitted zebra chip to healthy potato and tomato plants by grafting and by psyllid feeding, and they consistently detected Liberibacter bacteria. The Liberibacter detected is closely related to Liberibacter associated with

diseased plants in New Zealand. These data strongly implicate Liberibacter as the primary pathogen causing potato zebra chip disease and provide important new information for tracking and combating zebra chip.

**Component II – Biology, Ecology, Epidemiology, and Spread of Plant Pathogens and Their Relationships with Hosts and Vectors**

- *Population genetic analysis infers migration pathways of Phytophthora ramorum in U.S. nurseries. Phytophthora ramorum* is the exotic pathogen that is responsible for sudden oak death in California forests, also termed "ramorum blight" of common ornamentals. ARS scientists at Corvallis, Oregon, conducted a population analysis to infer migration routes of *Phytophthora ramorum* in U.S. nurseries. The nursery trade has moved this pathogen from source populations on the West Coast to locations across the United States. Two eastward migration pathways were revealed, one containing isolates from Connecticut, Oregon, and Washington and the other containing isolates from California and the remaining states. This work has implications for eradication and management practices of the pathogen in U.S. nurseries.

- *Transiently-induced silencing of a sugarbeet and tomato virus.* Beet severe curly top virus (BSCT) and related curtoviruses are responsible for severe losses in numerous crops each year, including tomato and sugarbeet. ARS researchers at Salinas, California used virus-induced gene silencing to obtain high-level resistance against BSCT virus and a related curtovirus in tomato and in a related tobacco species. This induced resistance to BSCT virus provided disease control in tomato and a relative of tobacco, but there was limited control in sugarbeet. The ability to elicit induced silencing of curtoviruses will provide the vegetable and sugarbeet industries with alternative and potentially more effective disease control methods while reducing pesticide usage and without the use of genetically transformed materials.

- *Production of polyclonal antisera and a recombinant phage library against enzymes produced by Penicillium expansum, an important post-harvest decay organism*. It is necessary and ecologically responsible to develop alternatives to chemical control for reducing postharvest disease losses in fruit and vegetables. ARS scientists in Kearneysville, West Virginia, and Beltsville, Maryland, have made significant progress toward the production of polyclonal antisera and a phage library against polygalacturonase, an enzyme produced by *Penicillium expansum*, the causal agent of blue mold of apples. Blocking this enzyme activity on the fruit surface may lead to a novel control strategy to halt postharvest decay caused by *P. expansum* on apples. This control strategy could potentially benefit the postharvest industry by reducing dependency on chemical fungicides.

- *Nematode (Paratrichodorus renifer) resistance in blueberry*. The stubby root nematode, *Paratrichodorus renifer*, has been shown to be widespread in established blueberry plantings in the Pacific Northwest. Very little is known about the biology

and pathogenicity of this nematode in blueberry. A greenhouse experiment was conducted by ARS scientists in Corvallis, Oregon, to determine the host status of different blueberry genotypes to the plant-parasitic nematode *P. renifer*. Blueberry genotypes with genetic backgrounds including *Vaccinium corymbosum* and *V. angustifolim* were excellent hosts for this nematode, but rabbit-eye blueberry (*V. ashei*) was a very poor host for *P. renifer* with fewer nematodes being recovered than were added to plants. Research is ongoing to continue to understand this potential source of resistance which exists in related blueberry (*Vaccinium sp*.) germplasm. Knowledge of a resistance mechanism to plant-parasitic nematodes can lead to the development of nematode resistant blueberry varieties.

- *The genomic sequencing is complete for the bacterial organism associated with Huanglongbing (HLB) disease.* Huanglongbing (HLB), also known as citrus greening, is the most devastating citrus disease for which there is currently no viable means of control. HLB is now widespread in Florida and is an impending threat to the citrus industries in California and Texas. ARS scientists in Fort Pierce, Florida, finished the full genome sequence of *Candidatus Liberibacter asiaticus*, the bacterial organism consistently associated with HLB. Prior to this effort, only limited (less than 50 kb) sequences from three genetic loci were available in Genbank. Annotation of the 1.23Mb genome revealed 1,186 open reading frames, of which 81 percent had a known functional assignment. All sequences have been submitted to GenBank and shared with ARS, university, and other researchers. Knowledge of the full genome is an important scientific advance and will greatly facilitate HLB research and development of new strategies for control of this devastating pathogen.

- *Characterizing Ug99 wheat stem rust strains and alternate hosts.* A virulent new wheat stem rust strain, called Ug99, has appeared in Eastern Africa, and more than 80 percent of the world's wheat acreage is vulnerable. ARS researchers in St. Paul, Minnesota, determined that a barberry species, widely distributed in the highlands of Kenya where wheat is grown, was susceptible to wheat stem rust. These results indicate that the barberry is an alternate host for the African Ug99 stem rust and can serve as a source of new rust variants found recently in the East African region. Researchers in St. Paul also screened thousands of seedlings for U.S. wheat and barley breeders to accelerate breeding of Ug99 resistant varieties. This new information will advance strategies to control the spread of virulent new wheat stem rust strains and accelerate efforts to develop resistant wheat varieties.

- *Factors influencing mummy berry disease severity.* Modeling studies of mummy berry disease of blueberry demonstrated that temperature and the amount and frequency of precipitation in January-March were predictive factors of springtime disease severity. This research by ARS scientists in Chatsworth, New Jersey, aids in understanding the parameters that affect disease and may contribute to an understanding of ways to reduce infection.

**Component III – Plant Disease Resistance**

- *Technological advances in breeding grape for resistance to Pierce's Disease.* Virtually all commercial grape cultivars are susceptible to Pierce's disease (PD), caused by the pathogen *Xylella fastidiosa*. Although some wild grape species from the southern United States are resistant, they are unsuitable for table grape, raisin, and wine production. Current resistance breeding and selection methods require 5 years under natural field conditions and 6 months under controlled greenhouses, and both methods are expensive. ARS researchers in Parlier, California, developed a faster method based on molecular markers to identify resistance traits and demonstrated the usefulness of these markers by tracking resistance genes that were transferred into high-quality susceptible *Vitis vinifera* cultivars that are popular with the grape and wine industry. These scientists also found that plant sap collected from PD-resistant and PD-susceptible grapevines, when added to growth media, showed significant differences in bacterial growth: media containing plant sap from PD-susceptible plants provided enhanced bacterial growth compared to media supplemented with sap from PD-resistant plants. These discoveries will be explored to develop new control strategies to breed and select for resistance to PD.

- *New Fusarium head blight (scab) varieties and management tools developed.* Scab has caused over $1 billion in losses to wheat and barley producers and to the industry in the United States. The U.S. Wheat and Barley Scab Initiative, managed by ARS, is combating scab through the development of resistant wheat varieties and new management tools for producers. New, partially-resistant wheat varieties from university and ARS breeding programs in North Dakota, Minnesota, Michigan, Illinois, Indiana, Kentucky, Virginia, North Carolina, Missouri, Kansas, and other states were developed in 2008 and 2009. Growers are using the resistant varieties, especially in scab prone regions. In North Dakota in 2009, growers planted over 57 percent of the hard red spring wheat acreage in resistant varieties. A new management Web site called "Scab Smart" was activated by the Initiative that provides information on scab forecasting, fungicides, and crop rotation. The benefits of the Scab Initiative research were realized in 2009 with only moderate scab losses reported in a year with weather conditions in the United States that were conducive to major scab losses in previous years.

- *Discovery of "watermelon vine decline" resistant germplasm.* Watermelon vine decline is a new and emerging disease, caused by *Squash vein yellowing virus*, which has caused over $60 million in losses in watermelon producing regions of Florida. The disease causes complete collapse of the plant at or near harvest, resulting in unmarketable fruit. ARS scientists in Charleston, South Carolina, and Fort Pierce, Florida, tested wild watermelon plants collected from different regions of the world looking for resistance to vine decline and found several accessions moderately to highly resistant to the disease. However, none of the plants from the wild watermelon collection were completely immune to the virus. This wild watermelon germplasm

provides an important source of resistance for the development of commercial watermelon varieties with resistance to this economically limiting disease.

- *New almond hybrid resistant to almond leaf scorch.* Reduced yield and tree mortality make almond leaf scorch disease a critical problem throughout California's 700,000+ almond acres. Through conventional plant breeding with a wild almond relative, a hybrid almond was developed by ARS scientists in Parlier, California, that is better than the standard susceptible almond cultivar 'Butte' at overcoming almond leaf scorch disease. The resistance, called "winter-curing," occurs during the winter months. The new hybrid produces edible almonds that are similar to 'Butte' in color and kernel shape. Development of this hybrid demonstrates that a resistant almond variety can be developed through traditional breeding efforts. Almond varieties resistant to leaf scorch disease will be an economic benefit for the California almond industry.

- *New cotton germplasm has high yield, quality, and root-knot nematode resistance.* Root-knot nematodes cause more damage to the U.S. cotton crop than any other pathogen, and host plant resistance is the most consistently effective means of minimizing the losses. Germplasm with a high level of resistance to root-knot nematodes has been available to cotton breeders for more than 30 years, but the yield and fiber quality of those lines is much less than that of contemporary germplasm. After 8 years of breeding and selection, ARS scientists in Tifton, Georgia, successfully created a germplasm line with a high level of resistance, but which has yield and fiber quality similar to modern cotton varieties. This germplasm is an improvement over previous resistant germplasm lines and will be a valuable resource for cotton breeders in developing cultivars with resistance to root-knot nematodes.

- *Resistance to reniform nematode successfully transferred into upland cotton from wild relative.* Reniform nematode has become the predominant nematode causing yield loss on cotton in the mid-south area of the United States, and currently there are no commercially available cotton varieties with resistance to this pest. ARS scientists in Stoneville, Mississippi, have successfully transferred resistance to reniform nematode into cotton from a distant relative, *Gossypium aridum*. Genetic experiments showed that the resistance is controlled by a single dominant gene. Molecular markers closely associated with the resistance were identified that will allow cotton breeders to incorporate the resistance into productive cotton varieties more efficiently. This research has the potential to fill a critical need for cotton varieties resistant to reniform nematode.

- *Resistance of soybean germplasm to Asian soybean rust confirmed.* To identify potential sources of resistance to this important rust disease of soybean, ARS personnel from Urbana, Illinois, and Fort Detrick, Maryland, collaborated to screen 16,595 accessions from the USDA Soybean Germplasm Collection. The evaluation data indicated that many of the breeding lines are resistant in either the western locations (Louisiana) or the eastern locations (such as Georgia and Florida), but few

are highly resistant in both regions. Soybean breeders are using this information to decide which lines to cross and with which existing breeding populations they should continue to work. Development of cultivars with broad and durable resistance to soybean rust in North America, therefore, will require combinations of genes from different sources and will provide sufficient resistance to reduce or eliminate the need for fungicide applications. These lines will be bred further for desirable agronomic traits and high yield.

**Component IV – Biological and Cultural Strategies for Sustainable Disease Management**

- *Development of an effective seed treatment system for an emerging seed-borne virus on tomato.* With an estimated value of $400 million, greenhouse tomato production in the United States has increased significantly in recent years, capturing nearly 46 percent of the U.S. fresh tomato market share. *Pepino mosaic virus (*PepMV), a seed-borne pathogen, is an emerging disease in greenhouse tomato and has a significant impact on production. ARS scientists in Charleston, South Carolina, determined that the PepMV virus particles are located on the surface of the seed coat and thus can be eliminated by various seed treatments with chemo- and thermo-therapies. This discovery advances uses of seed treatments to deactivate virus infectivity and will facilitate planting of virus-free seed, a high priority of the industry.

- *Naturally-occurring microbial residents on apple blossom surfaces and their potential use in fire blight control.* Biological control of fire blight of apple and pear with beneficial microorganisms is a viable alternative to the use of antibiotics, which have become less effective due to resistance development in the disease-causing organism. Although some biocontrol agents have now been commercialized for this disease, information regarding population sizes, distributions, and diversities of natural microbial residents on floral surfaces of apple trees and their potential use in disease control was lacking. ARS scientists in Wentachee, Washington, detected a wide diversity of bacteria and yeasts on apple blossoms and, through laboratory bioassays with detached flowers, identified microbial genera and specific strains that are highly effective in suppressing the pathogen. The information will be useful in developing effective microbial mixtures with complementary modes of action and ecological niches for enhancing biological control of fire blight.

- *Toxicity of a natural antibiotic to nematodes.* Some beneficial bacteria produce 2,4-diacetylphloroglucinol (DAPG), a natural antibiotic, which is active against numerous organisms, including plants, fungi, viruses, and bacteria. ARS scientists in Beltsville, Maryland, in cooperation with scientists from Pennsylvania State University, determined that effects of DAPG also impacted nematodes, but the responses were variable, depending on the nematode species and life stage being studied, and the responses ranged from toxic to stimulatory. This research has allowed scientists to determine which species of plant-parasitic nematodes would be optimal targets for application of DAPG-producing biocontrol bacteria in soil treatments.

- *Cover crops increase the availability of soil nitrogen for grapes and the potential to improve yields.* Cover crops are becoming increasingly popular in vineyards as a means of minimizing soil erosion, but little is known about their potential positive effects on grapevine nutrition or their possible negative effects on greenhouse gas emissions (i.e., nitrous oxide). ARS scientists in Davis, California, demonstrated that cover crops Triticale and rye prevented nitrogen leaching from the soil, primarily by increasing populations of beneficial soil microbes. In contrast, tillage caused declines in populations of soil microbes and should thus be minimized.

- *Use of new molecular probes to screen for virus resistance in walnut.* In California, black line disease (caused by a virus) adversely impacts nut production and longevity of some orchards. ARS scientists in Davis, California, have incorporated a resistance gene from black walnut into English walnuts and developed virus resistant backcrosses for release in areas with high incidence of black line disease. Researchers developed and optimized a molecular assay, based on a marker for resistance, to identify virus resistant germplasm.

- *Host status of transgenic plum lines to ring nematode.* The ring nematode, *Mesocriconema xenoplax*, is associated with making peaches more susceptible to peach tree short life (PTSL) tree death. The use of genetic engineering to increase disease resistance in agricultural crops is becoming acceptable and developing into a complementary technique to traditional disease management methods. Evaluating genetically transformed plum rootstocks for resistance to the ring nematode is important in determining the potential use of these rootstocks as a management tool for the peach industry in the southeastern United States. ARS scientists in Byron, Georgia, found that all three plum lines supported ring nematode reproduction, but one line suppressed nematode populations more than the other two lines. These data provide useful insights into the potential utilization of a genetically transformed plum rootstock to manage ring nematode in peach in the southeastern United States.

- *Development of Blackberry rust management recommendations.* Blackberry rust caused by *Phragmidium violaceum* can cause severe economic damage in several commercial blackberry cultivars. ARS scientists in Corvallis, Oregon, gained new knowledge of the disease epidemiology, pathogen biology, diversity, efficiency, and timing of fungicides to develop an economical management system for Blackberry rust. The management program consists of shifting a dormant lime-sulfur application in the winter to a period 2 to 3 weeks prior to bud break, with a fungicide application prior to bloom if scouting of the crop and adjacent feral blackberries indicates it is warranted. Better understanding of the pathogen biology shows that typical weather conditions are unlikely to be favorable to the development of severe epidemics in most years. These recommendations have significantly reduced the cost of control and reduced the amount of fungicides being used.

- *Identification of the causal agent associated with the almond brown line disease.* Almond brown line disease was discovered in California in the 1990s as a graft union disorder in almonds grown on plum rootstock in orchards on marginal land. When the trees are infected by Peach yellow leafroll-associated phytoplasma, they develop a brown necrotic line at the graft union resulting in tree death. It has been difficult to prove the association of phytoplasma in infected almond trees because of lack of a suitable detection assay. ARS scientists in Davis, California, developed a molecular assay and successfully detected this phytoplasma in almond extracts. This assay can be used to monitor the trees in a commercial orchard impacted by almond brown line disease.