

## National Program 305 • Crop Production FY 2014 Annual Report

National Program 305, Crop Production, supports research to develop knowledge, strategies, systems, and technologies that contribute to greater cropping efficiency, productivity, quality, marketability, and protection of annual, perennial, greenhouse, and nursery crops while increasing environmental quality and worker safety.

The Nation's rural economic vitality depends on the ability of growers to produce and market agricultural products – including food, fiber, flowers, industrial products, feed, and fuels – profitably, while enhancing the natural resource base upon which crop production depends. Future financial success depends on increasing productivity, accessing new markets for specialized products, developing technologies to provide new opportunities for U.S. farmers, and utilizing tools and information to mitigate risks and enable rapid adjustments to changing market conditions. The farm sector has great and varied needs driven by a wide variety of resource, climatic, economic, and social factors that require an equally diverse array of solutions.

Contemporary cropping enterprises are complex and depend on highly integrated management components that address crop production and protection, resource management, mechanization, and automation. U.S. annual, perennial, and greenhouse (protected systems) crop production are all based on the successful integration of these components. The development of successful new production systems requires a focus on new and traditional crops; the availability and implementation of improved models and decision aids; cropping systems that are profitable and productive; production methods fostering conservation of natural resources; efficient and effective integrated control strategies for multiple pests; improved methods, principles, and systems for irrigation; improved mechanization; and reduced inputs – all while sustaining or increasing yield and quality.

Production systems must better address the needs of small, intermediate, and large farming enterprises including those using field-, greenhouse-, orchard-, and vineyard-based production platforms, through conventional, organic, or controlled environment strategies. Additionally, adaptation and/or development of technologies are/is required to ensure a sustainable and profitable environment for production agriculture. New technologies must address the need for lower cost, higher efficiency inputs that foster conservation of energy and natural resources, while maintaining profitability and promoting environmental sustainability.

In addition, declining bee populations and honey production require special attention. Over the past several years, a myriad of pests and potentially adverse cultural and pest management practices have been threatening many of the bee species required for pollination of a multitude of crops. Colony Collapse Disorder has now increased losses of the honey bee (*Apis*) to a total mortality of over 30 percent. Also, as new crops or niches are introduced, there is an increasing need for non-honey bee pollinators for specific crops or protected environments.

National Program 305 draws heavily on other ARS National Programs, universities, and industries in adapting and incorporating technologies, approaches, and strategies that enable the advancement of the Nation's agricultural industry and enhanced international competitiveness.

This National Program is divided into two main research components, with several sub-components:

- Component 1: Integrated Sustainable Crop Production Systems
  - Problem Statement 1A: Productive and Profitable Systems for Sustainable Production of Agronomic Crops
  - Problem Statement 1B: Productive and Profitable Systems for Sustainable Production of Temperate Fruit and Nut Crops

- Problem Statement 1C: Productive and Profitable Systems for Sustainable Production of Tropical and Sub-Tropical Crops
- Problem Statement 1D: Productive and Profitable Systems for Sustainable Production of Ornamental, Nursery, and Protected Culture Crops
- Problem Statement 1E: New and Improved Mechanization
- Component 2: Bees and Pollination
  - Problem Statement 2A: Bee Management—Improving Bee Nutrition and Performance
  - Problem Statement 2B: Bee Health—Mitigating the Impacts of Pathogens, Pests, and Pesticides
  - Problem Statement 2C: Maximizing Bee Pollination and Quantifying Bee Forage Requirements
  - Problem Statement 2D: Conserving Bee Diversity and Improving Bee Taxonomy

Below are National Program 305 accomplishments from fiscal year 2014, grouped by research component. This report is not intended to be a progress report describing all ongoing research, but rather an overview that highlights accomplishments, some of which are based on multiple years of research. As a result, not all research projects will reach an “accomplishment” endpoint each year.

## Component 1 – Integrated Sustainable Crop Production Systems

**Intelligent spraying system for nursery and orchard applications.** Conventional spray application technology can require excessive amounts of pesticide to achieve effective pest control in floral, nursery, and fruit crop productions. ARS researchers at Wooster, Ohio, invented an automated, variable-rate, air-assisted, precision sprayer that minimizes human involvement in determining the amount of sprays needed for applications. This intelligent spraying system is able to characterize the presence, size, shape, and foliage density of target trees and applies the optimum amount of pesticide in real time. Field experiments have shown that the intelligent sprayer reduces the variation in spray deposition due to changes in tree structure and species, and it increases the uniformity of spray deposition on targets at different growth stages, as compared to conventional sprayers. The pest control efficacies of the new sprayer are comparable to those of conventional sprayers, while the new sprayer reduces average pesticide use by 46-68 percent, for an annual average pesticide cost savings of \$230 per acre. Additional tests in an apple orchard have shown that the new sprayer reduces spray loss beyond tree canopies by 40-87 percent, reduces airborne spray drift by up to 87 percent, and reduces spray loss on the ground by 68-93 percent. This new intelligent spraying system significantly advances the technology for efficient variable-rate pesticide applications, and offers an environmentally responsible approach to controlling pest insects and diseases.

**Grapevine yield estimation can be automated.** Worldwide, grapes are the most planted fruit crop, and rank third in tonnage produced. There is a need to estimate yield in vineyards to allow for contract negotiation, harvest logistics, and marketing projections. ARS scientists at Prosser, Washington, developed a trellis tension monitoring system that can be used to estimate crop yields that is as good as or better than the current labor-intensive method used for estimating yield. This system monitors the tension in the trellis wire as the fruit increases in size. Fruit yields can now be estimated before veraison (the onset of ripening) to within 20 percent of actual yields. This new yield estimate method is already being used by the juice grape industry and is being evaluated in wine grapes to optimize processing capacity and predict labor needs.

**A rotating cross-arm trellis system for blackberry production.** Blackberry production in the Midwestern United States is limited by cold winter temperatures that kill the fruit buds and vines. ARS researchers at

Kearneysville, West Virginia, developed a rotating, cross-arm (RCA) trellis system that allows the vines to be rotated to the ground and covered with a protective, floating row cover as needed to protect dormant vines from extreme temperatures. This new production system reduces the risk of blackberry crop failure and crop losses from extreme and untimely cold temperatures. In January-February 2014, much of the Midwest experienced temperatures below 20 C, which killed blackberry plants grown in conventional systems with no winter protection, and less than 10 percent of a normal crop was harvested. In contrast, growers who are using the RCA trellis and winter protection system had little winter damage and harvested 80 percent of a normal crop. Since 2010, 120 ha of new blackberry plantings on 40 farms (1- to 10-ha size) have been established from Pennsylvania to Iowa with the RCA trellis system. In 2014 alone, these new plantings are expected to generate \$60,000/ha in gross returns. It is projected that the RCA trellis production system will expand to over 500 ha by 2018.

**Sugar and cane yields optimized with variable-rate (VR) application of fertilizer.** Sugarcane crops must receive proper levels of nitrogen (N) and potassium (K) for profitable yields. ARS scientists at Houma, Louisiana, conducted studies to determine if VR application of N and K could help optimize sugarcane yields, while increasing production efficiency. Results from two years of field trials indicate that VR application of both N and K may offer Louisiana sugarcane producers a viable method to decrease costs, while increasing production efficiency. Nitrogen rates were decreased by 15-25 percent, and this potential decrease in fertilizer costs could save Louisiana sugarcane producers from 3-4 million dollars.

**A new method to identify cacao lines that can thrive in soil with low potassium levels.** Potential cacao yields are reduced in soil with inadequate potassium levels. ARS scientists at Beltsville, Maryland, developed a method to identify cacao genotypes that use potassium more efficiently employing a sand-culture method. Varied levels of potassium can be applied in the medium and subsequent effects on growth, physiological traits and metabolites of cacao genotypes measured. Scientists can use this new method to identify potassium-efficient genotypes for cacao improvement programs and also use the results to provide recommendations to cacao farmers for optimal fertilization management practices to improve cacao sustainability and yield.

**Mobility of immature invasive brown marmorated stink bug impacts their dispersal capacity.** Understanding the movement of brown marmorated stink bugs (BMSB) at all life stages is critical for developing effective monitoring and management programs. ARS scientists at Kearneysville, West Virginia, demonstrated that BMSB immatures (i.e., 2<sup>nd</sup> through 5<sup>th</sup> nymphal stages or instars) have strong walking capacity on horizontal and vertical surfaces in field plots, and their walking distance is affected by temperature. This new information that immature bugs can easily move among host plants and to other attractive stimuli on farms provides critical new information to researchers developing methods to protect crops from BMSB damage.

**Gasified rice hull biochar is a source of phosphorus and potassium for container-grown plants.** Worldwide phosphorus supplies are becoming limited, and as a result phosphorus fertilizer prices are increasing rapidly. Phosphorus is also implicated in surface water impairment when it is leached from crop production sites into surface water systems. ARS researchers at Wooster, Ohio, documented that gasified rice hull biochar (GRHB), a waste byproduct of rice processing, could be used as a source of phosphorus in production of ornamental crops in containers. GRHB was incorporated into typical greenhouse container substrates at 5 percent or 10 percent by volume. Plants received no other source of phosphorus, yet grew vigorously. Greenhouse and nursery producers can benefit from these results by using this recycled form of phosphorus, while reducing reliance on traditional phosphorus fertilizer supplies.

**Cover crops and no-till systems benefit soils without negatively impacting winegrape production in an irrigated vineyard.** ARS researchers at Davis, California, evaluated impacts of cover crops and no-till practices on winegrape production in Lodi, California, an important winegrape growing region in California's Central Valley, where diminished air quality from particulates could mandate the use of no-till soil management practices. Over three years, soil nutrient availability, vine nutrition, growth, and yield characteristics of *Vitis vinifera* cv. Merlot, grown under regulated deficit irrigation, were not impacted by cover crops and no-till systems. Importantly, winegrape yields from the zones of the vineyard where cover crops and no-till practices had occurred were similar to conventional management. The outcomes indicate that growers can use cover crops and/or no-till practices to reduce erosion and air particulates, and improve soil infiltration with no effect on yield and nutrition in irrigated, mature vineyards.

**Early detection of grapevine trunk diseases.** Detection of wood-canker pathogens of grapevines, also called trunk diseases, is only possible at the late stage of infection, when disease symptoms have become obvious and the opportunity for disease prevention is lost. Towards developing an early detection tool, ARS researchers in Davis, California, developed methods to detect grape genes expressed at an early stage of infection before the fungus spreads through the stem. This new detection tool can be used to identify and facilitate the quick removal of infected plants and better control the disease in both nurseries and commercial vineyards. Growers will benefit who would otherwise bear the cost of unknowingly farming diseased grapevines doomed to a lifetime of low productivity.

**Profitable practices for organic production of highbush blueberries identified.** ARS scientists in Corvallis, Oregon, conducted a long-term field study in collaboration with Oregon State University to evaluate management practices for organic production of highbush blueberry. The cultivars included 'Duke' (early-season) and 'Liberty' (mid- to late-season) and the practices included flat or raised planting beds, two fertilizers at different rates, and three different types of mulch. The greatest growth and yield were found when plants were grown on raised beds, fertilized with a low rate of fish emulsion or a high rate of feather meal, and mulched with either compost plus sawdust or weed mat. These results have been provided to organic growers, and adoption of these practices will increase growth and early production of the crop, and improve weed control.

**What's really in your black raspberry supplements?** Controls are needed to ensure that dietary supplements already in the marketplace meet a certain minimum quality, and that they contain their labeled contents (i.e., black raspberry supplements contain a minimum anthocyanin concentration). All available black raspberry products marketed as supplements were purchased for this work. Each was analyzed for authenticity and anthocyanin concentration by ARS researchers at Parma, Idaho. Results revealed that seven out of nineteen samples did not contain any black raspberry fruit, and three out of those seven had no detectable anthocyanin. Results indicate that food sources may be a more reliable method of obtaining dietary phenolics than dietary supplements.

**An airborne two-camera imaging system for agricultural remote sensing.** Recent advances in imaging technologies have made consumer-grade digital cameras an attractive option for remote sensing due to their low cost, compact size, and user-friendliness. ARS researchers at College Station, Texas, assembled and evaluated an airborne multispectral imaging system based on two identical consumer-grade cameras. One camera captures normal color images while the other obtains near-infrared images with filtering techniques. The color camera is also equipped with a GPS receiver to allow images to be geotagged; a remote control is used to trigger both cameras simultaneously. Geotagged images from the system can be viewed on any image viewer and on Google Earth for quick assessment prior to digital image analysis. The imaging system was tested under various flight and land cover conditions; optimal camera settings were determined for airborne image acquisition. Analysis of example images established that this system has

good potential for crop condition assessment, pest detection, precision aerial application, and other agricultural applications.

**Development of improved integrated management of pecan foliar and fruit diseases, with emphasis on pecan scab.** Fungicide resistance is a looming issue for pecan growers. Recent work by ARS scientists at Byron, Georgia, identified a novel biorational compound with activity against pecan scab. The compound, trans-cinnamic acid, is produced by symbiotic bacteria from the gut of entomopathogenic nematodes. Isolation of the compound, and in-vitro testing, showed it to be 100 percent efficacious in reducing scab. These results can be used to develop better management methods to protect pecan production from disease losses.

**Establishing the host status of litchi and rambutan for the West Indian fruit fly.** The host status of litchi and rambutan for the West Indian fruit fly was unknown. An extensive survey of mature fruit collected from the field (3732 litchi and 5534 rambutan fruits) by ARS researchers in Mayagüez, Puerto Rico, yielded no tephritid fruit fly larvae or pupae. Exposing ripe litchi and rambutan fruit to 12-day-old females did not result in viable fruit fly larvae. This is a robust indication that litchi and rambutan fruit exported from Puerto Rico do not pose a risk of transporting the West Indian fruit fly to trade destination countries. As a result of this research, the regulatory agency USDA-APHIS has changed its policies concerning the eligibility of rambutan for exportation from Puerto Rico, benefitting fruit growers in Puerto Rico.

**Asian citrus psyllid abundance declines with elevation.** The Asian citrus psyllid (ACP) transmits huanglongbing, or citrus greening, the most devastating disease of citrus worldwide. There have been anecdotes that ACP becomes less abundant as elevation increases. ARS researchers in Mayagüez, Puerto Rico, tested that hypothesis by monitoring ACP populations in citrus orchards at 17 different elevation sites (between 10 and 880 meters above sea level) in Puerto Rico. Results provided strong evidence that ACP abundance declines with elevation. No ACP was detected above 600 meters. Identifying the factors affecting the geographical and ecological distribution of psyllid populations could help develop management strategies for the insect and the disease it spreads.

## Component 2 – Bees and Pollination

**Honey bee protein supplements not as good as natural pollen.** In addition to the parasites and pathogens that attack honey bees, poor nutrition adds to honey bee stress and is thought to be a contributing factor to colony decline. When pollen – a source of honey bee nutrition – cannot be collected due to the absence of flowering plants, beekeepers will often feed their honey bee colonies a protein supplement. ARS scientists in Tucson, Arizona, demonstrated that these supplements have less protein than pollen, and are not digested as well by the honey bees. Furthermore, bees in colonies fed protein supplements experienced a higher incidence of disease and queen loss and, overall, had higher mortalities than those colonies that consumed pollen. These findings underscore the need to supply bees with pollen, and this information will be used by beekeepers and extension agents working with honey bees to ensure colonies are receiving proper nutrition.

**Chemicals and pathogens that impact honey bees.** The honey bee is an important beneficial insect, pollinating crops with an added value of more than \$15 billion, and producing honey for human consumption. The health of honey bee colonies is jeopardized by numerous parasites and pathogens, as well as the numerous insecticides and herbicides these plant-visiting insects come into contact with during their foraging activities. ARS scientists in Beltsville, Maryland, found that a diverse variety of chemicals applied to agricultural crops accumulated in beeswax, honey, and in the bees, themselves, and levels of

one fungicide in particular (chlorothalonil) were shown to be correlated with lack of overall colony health, including susceptibility to the fungus *Nosema ceranae*. This information will be of interest to beekeepers, extension agents, agrochemical companies, and regulatory officials interested in honey bee health.

**Evaluation of honey production by mite-resistant honey bees.** Among the parasites that attack honey bees, the varroa mite is considered the most damaging and the biggest threat to honey bee colony survival. Russian honey bees, which are varroa-resistant, were evaluated over a two-year period for honey production and mite infestation in Montana, and compared to non-resistant honey bee lines. ARS scientists from Baton Rouge, Louisiana, reported that while the Russian bees produced less honey per colony (127 lbs) in the second year of the study than the non-resistant honey bees (162 lbs), they still produced more honey than the 60 to 90 lbs per colony reported nationally the last few years. Importantly, Russian bees had lower (by half) levels of mites when compared to the colony-threatening levels of mites found in the non-resistant honey bees. This research showed that mite-resistant honey bees function well under commercial honey-producing conditions, information that will be useful to the entire beekeeping industry.

**Nest attractant developed for the blue orchard bee.** The blue orchard bee (BOB) is a bee species native to North America that can be used as a pollinator of several commercial crops, including almonds, a multi-billion dollar industry. ARS scientists in Logan, Utah, in collaboration with ARS scientists in Fargo, North Dakota, and a pollination company in California identified chemicals that attracted BOB to artificial nesting materials, which led to better nest establishment and improved management of this bee. A patent has been filed for this chemical attractant. This information is useful to companies and individuals involved in almond pollination using native bees.

**Greenhouse tomatoes benefit from bumble bee pollination.** The bumble bee is a solitary bee species native to the United States. ARS scientists in Logan, Utah, evaluated the ability of different species of bumble bees to pollinate tomatoes grown in greenhouses. They discovered that not only were all species equally effective pollinators, but that tomato plants pollinated by bumble bees produced more and 13 percent larger tomatoes than those plants with no access to these bees. This information will allow bumble bee producers to better focus their efforts and will inform greenhouse tomato producers of the benefits of using bumble bees as pollinators.

**Female alkali bees must eat pollen.** The alkali bee is a ground-nesting solitary bee native to the western United States, and is a pollinator of alfalfa. ARS scientists in Logan, Utah, in collaboration with scientists in Washington State, showed that female alkali bees ate pollen at the end of each day, after they had collected nectar and pollen for rearing their offspring. The researchers extended this study to show that a species of mason bee needed to eat pollen in order to develop mature eggs. This information is useful to individuals and organizations that rear solitary bees for pollination services.

**Analysis of bacteria associated with honey bee pollen and nectar collectors.** The honey bee is an important insect pollinator of many agricultural crops. In an effort to improve honey bee nutrition, ARS scientists in Tucson, Arizona, catalogued the bacteria found in foraging honey bees that collected pollen and nectar. Genetic analyses of these bacteria are ongoing and will provide essential information to scientists researching honey bee nutrition.