United States Department of Agriculture
Agricultural Research Service

National Program 305 Crop Production

FY 2022 Annual Report

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

The Nation's rural economic vitality depends on the ability of growers to profitably produce and market agricultural products including food, fiber, flowers, industrial products, feed, and fuels, while enhancing the natural resource base of crop production. 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 controlled environment crop production (e.g., greenhouse and other protected systems) are 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 and diseases; improved methods, principles, and systems for irrigation; improved mechanization and automation; 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-, indoor farm-, orchard-, and vineyard-based production platforms with conventional, organic, or controlled environment strategies. Additionally, adaptation and development of technologies are 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 multitudinous crops. Colony Collapse Disorder (CCD) had increased honeybee (*Apis*) over-wintering mortality to over 30 percent; and while CCD incidence has declined, bee mortality remains unsustainably high. Also, as new crops or niches are introduced, there is an increasing need for non-honeybee pollinators for specific crops or protected environments.

National Program 305 coordinates and collaborates extensively with 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:

Component 1. Integrated Sustainable Crop Production Systems

Component 2. Bees and Pollination

Below are National Program 305 accomplishments from fiscal year 2022, 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 (not all research projects will reach an "accomplishment" endpoint each year).

ARS welcomes your input regarding our ongoing research programs. If you have any questions, please do not hesitate to contact the National Program 305 team: Kevin Hackett (kevin.hackett@usda.gov), Joe Munyaneza (joseph.munyaneza@usda.gov), Jack Okamuro (jack.okamuro@usda.gov), Tim Rinehart (tim.rinehart@usda.gov), Roy Scott (roy.scott@usda.gov), and Steve Young (steve.young@usda.gov)

Component 1. Integrated Sustainable Crop Production Systems

Intelligent spray control systems for precise greenhouse applications. Precision variable-rate spraying technology to deliver pesticides, irrigation, nutrients, and other products is needed for greenhouse production systems to prevent the waste of sprayed products and mitigate environment contamination. ARS scientists in Wooster, Ohio, developed an experimental laser-guided precision spraying system designed as a retrofit attachment for existing horizontal booms to automatically control spray outputs that match real-time plant growth and canopy architectures. Results showed that this precision variable-rate system greatly increased the accuracy of sprayed product applications and was able to reduce spray volume 29 to 51 percent, compared with the conventional constant-rate spray applications. The technology was transferred to an automation company for commercialization. Greenhouse growers will greatly benefit from this environmentally responsible technology to efficiently grow high-quality crops with significant savings of chemicals, water, and nutrients.

Predicting volunteer cotton habitat for boll weevil eradication using GIS and remote sensing. The potential habitat for volunteer cotton in south Texas creates the risk of cotton boll weevil encroachment. Management of these unwanted volunteer cotton plants is needed to avoid damage caused by this major insect pest of cotton. ARS scientists in College Station, Texas, and Texas A&M University collaborators developed a geographic information system (GIS) framework to efficiently locate volunteer cotton plants in southern Texas cotton production regions, thus reducing the time and economic costs of their removal. They applied GIS network analysis to estimate the most likely routes for cotton transportation and created a GIS model to identify and visualize the potential area of volunteer cotton growth. A method based on unmanned aerial vehicle (UAV) remote sensing was also proposed to detect the precise location of volunteer cotton plants in potential areas for subsequent removal. The proposed GIS network analysis model, coupled with UAV remote sensing, will provide boll weevil eradication program managers with an effective tool to identify potential habitat areas and precise locations of volunteer cotton.

Optimizing productivity in relay-cropping and double-cropping systems. ARS researchers in Morris, Minnesota, previously developed relay- and double-cropping systems with winter camelina and pennycress seeded within or following summer annual crops. New research by ARS scientists in Morris and Fargo, North Dakota, identified crop management for these systems that can be used in central Minnesota to optimize yields for both camelina and soybean. The researchers also demonstrated that when an ultra-early-maturing sunflower hybrid was double cropped with winter camelina, sunflower seed oil per acre increased 150 percent over growing sunflower as a single crop. These results provide evidence of the feasibility and profitability of double cropping and relay cropping systems that can benefit farmers, agronomists, extension educators, specialty oil industries, and others interested in adopting these new cropping practices.

Mexican rice borer management for sugarcane production in south Texas. More than 40,000 acres of sugarcane are grown in the south Texas Lower Rio Grande Valley (LRGV), but few acres are treated for the Mexican rice borer, which can cause per-hectare losses of $575, because past control measures have been unsuccessful. ARS researchers in Houma, Louisiana, collaborated with growers in south Texas to evaluate commercial sugarcane varieties for resistance to the Mexican rice borer and to evaluate the effectiveness of foliar applications of a chlorantraniliprole-containing insecticide. Results indicate that two sugarcane varieties (CP 07-1824, and L 01-299) are more resistant to the borer in south Texas compared to other commonly planted varieties. In addition, the insecticidal control of the Mexican rice borer was successful, and crop yields increased when applications are conducted both in the summer and the early fall prior to harvest. Results were communicated to LRGV stakeholders, resulting in an estimated 90 percent of LRGV sugarcane acres being treated for Mexican rice borer in 2022.

New CO2 and lighting control software for greenhouses. Carbon dioxide (CO2) and light are often controlled and supplemented in greenhouse production, although both can be expensive and energy intensive. Resources for precisely controlling these two parameters simultaneously are lacking for most crops. ARS scientists in Toledo and Wooster, Ohio, developed software for simultaneously controlling CO2 concentration and supplemental light levels in greenhouses. Simulations showed performance improvements over existing CO2 and daily light integral controllers for multiple climates in the contiguous United States. The savings vary with climate and crop, but simulations showed lighting energy savings from 16 to 50 percent for lettuce crops, or from 24 to 56 percent in electricity cost savings. When the control system also incorporates CO2 supplementation, simulations showed that for lettuce, electricity costs are reduced from 40 to 50 percent compared to previous daily light integral controllers, or from 62 to 82 percent compared to conventional lighting controls, even when accounting for the cost of CO2 supplementation. The software allows growers to reduce their carbon footprint, energy consumption, and energy costs, and produce crops with a more consistent size and schedule.

Biochar improves blueberry growth and fruit production. Blueberry fields are often amended with bark or sawdust prior to planting, but many growers are seeking alternatives because costs for these materials have increased considerably in recent years. One possibility is to use biochar, a carbon-rich material produced by burning wood or other biomass under low oxygen conditions. ARS scientists in Corvallis, Oregon and Oregon State University collaborators determined that amending the soil with biochar nearly doubled blueberry plant growth and fruit production and reduced costs by more than $500 per acre over the usual practice of incorporating sawdust into planting beds. The biochar used in the study was manufactured from mixed conifers during the conversion of wood debris to bioenergy at a 30-megawatt power plant. These findings indicate that using biochar as soil amendment is cost-effective and a good way to improve soil health and increase early returns in blueberry.

Electronic nose system to diagnose whitefly and aphid infested tomato plants. Tomatoes are subject to attack by insect pests, particularly whiteflies and aphids, from the time of first emergence as seedlings until harvest. Technologies to detect these insects early are needed for better treatments. An experimental electronic nose (E-nose) system equipped with a gas sensor array and real-time control panel was developed by ARS scientists in Wooster, Ohio, with their collaborators at The Ohio State University. The E-nose system was designed to diagnose whitefly and aphid infestations of tomato plants by tracking different levels of volatile organic compounds emitted from infested greenhouse-grown tomato plants. The scientists designed an interface computer program to analyze the release of volatile organic compounds for fast diagnoses and confirmed the program's accuracy and its potential use as a non-destructive and portable tool. Further validation is needed for the sensitivity, reliability, and repeatability of the E-nose system in large greenhouses; however, this new system provides new opportunities for growers and researchers to accurately diagnose infested plants at early stages and thus establish a smart platform for insect control and pest management to grow healthy crops.

The genetic control of resistance to demethylation inhibitor (DMI) fungicides in the pecan scab pathogen. Fungicide resistance is an issue with the scab pathogen, reducing effectiveness of control. ARS researchers in Byron, Georgia, confirmed that a high level of resistance occurred in the field to DMI fungicides, and that the resistance was associated with specific mutations in two genes (CYP51A and CYP51B) that result in abnormalities of the protein, and how much of the protein is made. The knowledge identifies causes of resistance in the pathogen and provides a basis to develop detection methods to rapidly identify and track specific resistance traits in orchard populations of the scab pathogen.

Effects of nanomaterial on plant and soil health. Copper-based fungicides are widely used in agriculture, especially in vineyards. New nano-sized copper oxide fungicides have been developed, but concerns were raised about their potential harm to plants and soil microbes. ARS researchers in Prosser, Washington, and Davis, California, in collaboration with numerous university scientists and researchers at Advanced Light Source and Canadian Light Source, investigated the effects of nanomaterials on carrots, lettuce, and soil microbes. This research showed that these new products are generally less harmful to plants and soil microbial communities than other, more commonly used copper-based products. These results will help growers have confidence in using new nanomaterial fungicides to protect their crops.

Two natural substances are excellent insecticides against spotted-wing drosophila. Spotted-winged drosophila (SWD) is an intractable fruit pest of small fruit crops. In conventional agriculture, this fly is effectively controlled by powerful synthetic insecticides. In contrast, organic berry producers have only two control options, but the effectiveness of these products varies considerably. ARS researchers in Poplarville, Mississippi, and Miami, Florida, and University of Hawaii cooperators identified two compounds from pennyroyal and basil plants that were neurotoxic to SWD and that killed more than 60 percent of eggs and adult flies in blueberry fields. Laboratory tests revealed that these compounds eliminated SWD reproduction at concentrations of 0.5 percent. These monoterpene substances are readily available and are being formulated as a new organically certified biopesticide targeting small-bodied crop pests.

Mitigating heat wave damage to wine grapes using supplemental irrigation. Heat wave intensity and frequency are worsening across California, and irrigation is one of few practical mitigation methods to prevent crop damage to wine grapes during these extreme weather events. An ARS researcher in Davis, California, in collaboration with industry and researchers from University of California-Davis, found that supplemental irrigation of wine grapes during heat waves mitigated damage to vines, fruit, and resulting wine. While supplemental irrigation was useful to a point, too much water had detrimental effects on fruit and wine quality; therefore, optimal levels of irrigation need to be determined in real time for each heat wave event, location, and variety of wine grape grown. In this study, optimal irrigation was calculated using tower-based optical-remote sensing to continuously monitor vineyard response during stress events and evaluate plant responses to environmental stress. Under what seem to be persistent water-limited growing conditions of California, these results will help growers identify adequate watering for preventing plant and crop damage, and prevent overwatering, which can be detrimental to fruit and wine quality.

Several Phytophthora species cause rhododendron root rot in nurseries. Rhododendrons are an important component of the ornamental nursery industry, but are prone to *Phytophthora* root rot, despite decades of research. One *Phytophthora* species, *P. cinnamomi*, was previously thought to be the primary pathogen causing rhododendron root rot, and although recent research suggests there are several other *Phytophthora* species that may cause root rot, little is known of their virulence and risk to the industry. ARS researchers in Corvallis, Oregon, and Oregon State University researchers determined that at least three other Phytophthora species isolated from Oregon nursery plants can cause similar disease severity as *P. cinnamomi*, but not all species are equally virulent. This research provides valuable information for other researchers and industry in developing more effective disease control measures.

Protecting California table grapes from trunk diseases. ARS researchers in Davis, California, determined that the fungicide thiophanate-methyl is effective for protecting pruning wounds from pathogens that cause Botryosphaeria dieback (*Neofusicoccum parvum*) and Eutypa dieback (*Eutypa lata*). These findings come after three years of research in a southern San Joaquin Valley vineyard of the seedless table-grape 'Autumn King'. This young vineyard, planted in 2016, was a demonstration to encourage growers to adopt preventative practices against trunk diseases, rather than waiting (as most growers do) until the vineyard is mature and severely symptomatic. Given the high cost of labor in California vineyards, fungicides were spray-applied with a tractor to dormant grapevines immediately after pruning, rather than hand-painting fungicides onto individual pruning wounds, which is more labor-intensive and not practical for commercial production. Thiophanate-methyl was effective in this study against pathogens that causes the trunk diseases Botryosphaeria dieback and Eutypa dieback.

Hyperspectral imaging to detect disease and insert stresses of tea developed. Plant monitoring for disease and insect stresses is essential for crop management. ARS scientists in Stoneville, Mississippi, collaborated with Hangzhou Danzi University researchers on developing a hyperspectral imaging method to rapidly detect and discriminate disease and insect stresses in tea plants. The results indicated that the method could detect and distinguish between stresses caused by diseases or insects. This study provides valuable information on a hyperspectral imaging method that can be applied to tea plant monitoring to effectively monitor for insects and diseases in crops.

Cryopreservation of malaria mosquito germplasm. In 2020, the World Health Organization reported 241 million cases of malaria resulting in approximately 627,000 deaths. To help combat this devastating disease and advance research, scientists developed genetically altered strains of the mosquito that transmit malaria. These strains are expensive to develop and maintain and can be lost due to disease, equipment failure, or other calamities. Working with collaborators at the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, ARS researchers in Fargo, North Dakota, developed a method to cryopreserve the mosquito sperm. The CDC is now working to employ this new technology to safeguard their colonies, thereby ensuring the availability of these strains for future researchers.

Component 2. Bees and Pollination

New supplemental honeybee diets include algae-based diets. Honeybee colonies managed for agricultural pollination are highly dependent on human inputs, especially for disease control and supplemental nutrition. ARS researchers in Baton Rouge, Louisiana, conducted a large-scale field experiment in collaboration with a commercial beekeeper and showed that the amino acid ratios in various artificial feeds were correlated to honeybee colony performance. This will help inform the industry regarding the need for the development of improved bee feed. They also collaborated with scientists at the University of North Carolina-Greensboro and found that novel microalgae-based artificial diets developed at the Baton Rouge location improved individual honeybee growth and health characteristics. The ARS researchers used bioengineering technologies to develop these microalgae strains to stimulate honeybee immune systems, which effectively enabled the microalgae to function as an edible vaccine (patent pending) that improves resistance to Deformed Wing Virus, a major pathogen responsible for honeybee losses worldwide. Producing these new microalgae strains is scalable to meet the capacity needs of the beekeeping industry, and they can be incorporated into supplemental feed to improve resistance against current and emerging pathogens in managed pollinators.

Cold storage scheduling for winter-adapted honeybees. Every year, increasing numbers of honeybee colonies are overwintered in cold storage to reduce losses that have averaged 40 percent during the winter. However, beekeepers need to know when to put colonies in cold storage and if colonies from different U.S. regions, especially the U.S. South, do equally well as colonies from temperate regions when overwintered in cold storage. ARS researchers in Tucson, Arizona, found colonies that summered in northern latitudes and were put into cold storage by mid-October were larger and had more brood after cold storage and after almond pollination than those put into cold storage in November. They also found differences in physiological markers between bees from northern and southern latitudes, which suggests colonies that summer in southern latitudes do not evolve to functional winter bees that can survive long periods of confinement in the hive. When overwintered in cold storage, colonies from southern latitudes were smaller and had lower survival rates after cold storage and almond bloom than those from northern latitudes. Therefore, cold storage is useful for beekeepers that have winter adapted bees and who begin bee storage in mid-October.

The source of microbes and pollen is key for bee larval development. Native bee species are a critical component of cranberry production since they pollinate cranberry flowers, and bee larvae require microbes to complete their development. ARS researchers in Madison, Wisconsin, showed that the mother bee supplies larvae with a blend of microbes and pollen species that are partially derived from her own brood cell and partly from the flowers she visits, all of which tend to be conducive to larval growth. To demonstrate the critical importance of this particular microbial seeding, microbes from a different species were substituted as the source of microbes (and pollen). Despite having ample pollen and microbes, the bee larvae that had the wrong kind of pollen and microbes substituted for their diet suffered significantly. This is the first evidence that bees require a particular microbial community and pollen community in their diet, underscoring the importance of microbes for supporting pollinator health.

Two major honeybee probiotics have no long-term effect or efficacy for antibiotic recovery. Antibiotic treatments can greatly distort the honeybee gut microbiome, reducing its protective abilities and facilitating the growth of antibiotic resistant pathogens. Commercial beekeepers regularly apply antibiotics to combat bacterial infections, often followed by an application of probiotics advertised to ease the impact of antibiotic-induced imbalances in gut microbiota that contribute to poor health (dysbiosis). ARS researchers in Tucson, Arizona, performed a large longitudinal study of commercial honeybee colonies over winter to explore the effects of probiotics and antibiotics. The researchers found no difference in the gut microbiome or disease incidence by probiotic application or by probiotic treatment associated with antibiotic recovery. These results demonstrated the lack of probiotic effect for antibiotic rescue, detailed the dysbiotic states resulting from different antibiotics, and highlighted the importance of the gut microbiome for honeybee health.

Importance of pollen fatty acid analysis in plant breeding. ARS researchers in Tucson, Arizona, extracted fatty acids and showed that pollen fatty acid content varies among canola (a species of *Brassica*) cultivars. Interestingly, the genetic variation in pollen fatty acid content did not correlate to seed fatty acid content, suggesting that selection on seed traits is independent of selection for pollen fatty acids. Based on these observations, canola breeders can develop cultivars with desirable seed traits that also produce pollen that is nutritious for bees. Additionally, several *Brassica* species are used in almond orchards prior to bloom as important early season forage for bees. High-nutrient *Brassica* species can be incorporated into the seed mixtures that are currently planted in California to increase pre-bloom colony nutrition. Similar differences between fatty acid profiles were found in sunflower (*Helianthus annuus*), which also varied in profiles between Arizona and North Dakota, indicating the importance of environment. This information can inform efforts to grow sunflower with desired seed oil, yet with high nutrition for bees.

Environmental effects such as drought on native bee diversity. Climate change is anticipated to impact bee health and survival and potentially disrupt pollination of plants in both agriculture and natural ecosystems. Despite two years of exceptional drought in the eastern Mojave Desert, ARS researchers in Logan, Utah, found more than 250 native bee species in Nevada's Gold Butte National Monument and recorded many bee-plant interactions. These findings indicate that some resilient species can survive the harsh conditions of this desert region. The types of bees found in the spring were different from those in late summer and fall. Mesquite, desert marigold, arrow weed, indigo bush, and rabbit brush supported these diverse bee species, and a new mining bee species was discovered on turpentine broom. In a separate study, the researchers documented a continued rich bee flora at Pinnacles National Park over three decades. The findings illustrate the need to monitor bee populations for several years to determine the stability of the bee communities and impacts of climate change in different environments, and the value of protected landscapes.

New traits of honeybee resistance to the damaging varroa mite. Honeybee colonies face a variety of parasites and pathogens that result in significant annual losses to beekeepers. Breeding efforts for resistance traits and a greater understanding of how resistant populations prevent damaging infestations, particularly from the damaging varroa mite, are of the utmost importance for the sustainability of the beekeeping industry. ARS researchers in Baton Rouge, Louisiana, partnered with Louisiana State University researchers and a commercial beekeeper on testing the functionality of mite-resistant Pol-line bees. This stock expresses a high level of resistance to the varroa mite due to a trait called Varroa Sensitive Hygiene (VSH), which results in the inability of mites to reproduce in a colony and transmit fewer viruses. The Pol-line bees were found to be highly productive in the commercial migratory operation and were more successful through almond pollination than the control bees that the beekeeper would have normally relied on. While Pol-line bees benefit from VSH behavior, other stocks like the Russian honeybee express multiple traits of resistance that are still being elucidated. Research recently identified that Russian honeybees exhibit social apoptosis, where pupae infested with varroa mite die more quickly, which prevents mites from successfully producing offspring on pupae. These results shed light on how important it is to fully evaluate stocks to enhance resistance traits and that breeding for multiple traits of resistance can provide robust support against parasites like varroa mites.

Development of novel bee medicines. Various challenges currently facing honeybees, and diseases caused by pathogens pose a significant threat to the health and well-being of honeybees. The development of antibiotic-resistant microbes made an already dire situation even worse, so new therapeutic interventions that are safe and effective for bee disease treatment are urgently needed. ARS scientists in Beltsville, Maryland, screened 50 natural products from plants and provided evidence that several compounds, including those commonly found in pollens and nectars of plants that often attract honeybees, could lead to a significant improvement in immune function and significantly reduce virus levels in bees. These natural products provide a rich source of candidate treatments for bee and hive health. One plant compound, methyl jasmonate, was approved for patenting as a control measure for viral disease.

Simple management tactic to maintain bees for timed pollination of alfalfa seed crops. The alfalfa leafcutting bee is an essential pollinator managed by seed growers for alfalfa seed production. Coordinating bee emergence with alfalfa bloom is critical for maximum seed production, but when weather conditions disrupt this coordination, bee managers retain alfalfa leafcutting bees in incubators while waiting for the plants to bloom. ARS researchers in Logan, Utah, found that feeding the bees honey-water for five days or less assures that the bees will perform well as pollinators, while not feeding the bees or only providing water caused the bees to die quickly or perform badly. Growers can benefit by using this tactic during uncertain weather conditions associated with climate change.

“Idiopathic brood disease” symptoms linked to Acute Bee Paralysis Virus in honeybees. Brood disease has been implicated repeatedly as a precursor to colony collapse disorder in commercial honeybee operations throughout the United States. There are only three known causes of larval disease, but more than 50 percent of honeybee larval disease remains undiagnosed. In two major and widespread larval diseases, referred to as idiopathic, larvae appear melted at the bottom of cells due to an unknown cause. ARS scientists in Tucson, Arizona, provide the first evidence linking “melty” larval symptomology to Acute Bee Paralysis Virus in honeybee colonies. Various bacteria act as secondary invaders, producing a variety of odors unassociated with known brood disease. Since antibiotics do not control viruses, and may upset healthy bee gut microbes, this finding serves as a caution against applying antibiotics when melty symptoms appear.

Hormone-mimicking insect growth disruptors (IGD) alters adult worker bee response to queen pheromones. During foraging, honeybees may be exposed to IGD pesticides that accumulate in wax and pollen. ARS researchers in Davis, California, demonstrated that exposing worker larvae to IGDs causes reduced interest in queen pheromones. In young workers, queen care behavior is elicited in response to queen-produced pheromones, and if queens do not have enough attendants responding to them, they will not be as productive. These results provide evidence that exposure to hormone mimicking IGDs during development can affect important behaviors that may contribute to decreased colony expansion. Understanding how developmental IGD exposure can influence the behavior of workers informs management recommendations for improving the health of honeybee colonies.

Control of parasitic wasps to protect alfalfa leafcutting bees. The alfalfa leafcutting bee is an essential pollinator managed by seed growers for alfalfa seed production. These bees are attacked by several kinds of parasitic wasps that can cause a large and costly loss of bees needed for pollination. ARS researchers in Logan, Utah, found that moving the bees into winter cold storage in October decreased the destruction of the developing bees by the wasps and prevented major infestations. ARS researchers also found that dichlorvos strips can be placed in incubators at the start of spring incubation to control multiple parasitic wasp species. This early and prolonged use of dichlorvos did not affect bee emergence and survival if the pesticide was removed before adult bees emerged. These new management tactics help guarantee the grower can have an adequate number of bees for crop pollination.

Cryopreservation of semen from varroa-resistant honeybee lines. Honeybee colonies have been declining significantly due to environmental factors, habitat loss, and an increasing prevalence of parasites and disease. For many years, the most serious pest of honeybees has been the varroa mite, and there is an urgent need for new control methods for this pest. Three lines of highly varroa-resistant honeybee were recently developed by ARS researchers in Baton Rouge, Louisiana. ARS researchers in Fargo, North Dakota, developed a cryopreservation media that significantly improves honeybee sperm quality after retrieval from liquid nitrogen storage and that safeguards this critical biological resource by cryopreserving sperm from these varroa resistant lines. These preserved stocks are now available to honeybee breeders in case breeding stock of these lines is lost.

The greatest pesticide risks to bees pollinating blueberries comes from off-farm pesticide applications. Bees are often exposed to pesticides during crop pollination; however, not all exposures are dangerous to bee health. It is critical to understand what risk these pesticides have for bees. ARS researchers in Logan, Utah, determined pesticide risks encountered by bumble bees and honeybees providing pollination services at blueberry farms. Risk calculations considered the level and frequency of pesticide exposure, as well as the toxicity of specific pesticides. They found most of the risk was due to pesticides that are not permitted for use on blueberry bushes; instead, the risk was associated with pesticide drift from nearby areas. These results highlight the need to develop landscape-scale practices that reduce pesticide exposures for bees and protect them on farms where bees are placed for pollination.