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| **Reporting Period** | Final Report (10/01/2011 - 09/30/2014) |
| **Proposal** | [2262 Developing a Comprehensive Management Program for Foliar Diseases of Soybean (Year 1 of 3)](http://moss.unitedsoybean.org/Lists/Proposals/DispForm.aspx?ID=2730&RootFolder=*) |
| **Committee** | Production |
| **Target Area** | Supply |
| **Project Start Date** | 10/1/2011 |
| **Project End Date** | 9/30/2012 |
| **Project Number** | 2262 |
| **Project Status** | **Project Summary –** The goal of this seven-state, multi-institutional program was to develop cost-effective and sustainable management options for major foliar diseases of soybean. This goal was to be accomplished by gaining a better understanding of the epidemiology of foliar diseases which can be used to optimize disease management strategies, identify disease-resistant varieties, assist in the development of resistant germplasm, and refine management recommendations based on results generated from this research. The ultimate goal behind this research is to devise management practices that would minimize the risks of soybean foliar pathogens and reduce losses caused by them.  **Collaborators:**  -      Dr. Burt Bluhm (Co-PI), Plant Pathology, University of Arkansas  -      Dr. Jason Bond, Plant, Soil and Agricultural Systems, Southern Illinois University  -      Dr. Carl Bradley, Crop Sciences, University of Illinois  -      Dr. Alemu Mengistu, University of Tennessee/USDA-ARS  -      Dr. Rouf Mian, Ohio State University/USDA-ARS  -      Dr. Melvin Newman/Dr. Heather Young Kelly, Entomology and Plant Pathology, University of Tennessee  -      Dr. Boyd Padgett/Dr. Trey Price, Plant Pathology, Louisiana State University AgCenter  -      Dr. John Rupe, Plant Pathology, University of Arkansas  -      Dr. Grover Shanon, Plant Sciences, University of Missouri-Delta Center  -      Dr. X. B. Yang, Plant Pathology, Iowa State University  **Project Description:**  **Rationale and Objectives –** The main objective of this research was to develop cost-effective and sustainable management options for major foliar diseases of soybean through gaining a better understanding of the epidemiology of these diseases, identifying disease-resistant varieties, and assisting in the development of resistant germplasm. The specific objectives are:  1.Characterize *Cercospora sojina* population diversity, race structure and race determination and influence of host resistance  2.Conduct extensive monitoring for strobilurin fungicide-resistant strains of *C. sojina*  3.Determine the best fungicide/host resistance programs for managing strobilurin fungicide resistant and sensitive isolates of *C. sojina*  4.Determine the baseline sensitivity of *C. sojina* to triazole fungicides  5.Identify sources of resistance and develop resistant varieties and elite germplasm  6.Quantify the efficacy of current fungicides on management of Phomopsis seed decay  7.Develop a unified soybean foliage disease prediction system for brown spot, frogeye leaf spot and Cercospora leaf blight  8.Provide updated and coordinated outreach material for foliar diseases  **ACCOMPLISHMENTS &FUTURE WORK:**  **Characterize *Cercospora sojina* population diversity, race structure and race determination and influence of resistance**  The genomes of *C. sojina* and *C. kikuchii* were sequenced. The *C. sojina* genome is being formatted in preparation for public release. A publication describing the genome, as well as a web portal, are being prepared. Isolates of *C. sojina* were collected from soybean fields with a high incidence of frogeye leaf spot in the Midwest (IL, IA, and MO) and the Midsouth (TN, LA, and AR). A collection of *C. kikuchii* isolates was also built, and is currently housed and curated at the University of Arkansas. Information from the sequences of both genomes will be used to identify genetic markers (e.g., SNPs) that can be used to assess pathogen diversity, discover genes involved in pathogenesis, and determine the genetic basis of race structure.  A study was conducted to analyze population diversity and mating type distribution in Arkansas populations of *C. sojina.* The work was published in the October 2013 issue of Phytopathology*.* Numerous genetic markers have been created from the draft genome sequence of *C. sojina*. These markers are available to researchers upon request.  Future work will involve the identification of fungal genes associated with specific races. This will be accomplished through comparative genomics. Once the reference genome is acquired, the genomes of other isolates of the same species can be sequenced for a fraction of the cost of the original genome sequencing. Comparative genomics approaches will be used to identify genes or gene variants unique to specific races. Molecular techniques will be used to verify the involvement of candidate sequences (e.g., deleting or adding candidate genes and evaluating the resulting change in race specificity in a specific isolate of the pathogen).  **Extensive Monitoring for Strobilurin Fungicide-Resistant Strains of *C. sojina*, determining the best fungicide/host resistance programs for managing fungicide resistant and susceptible isolates and determining the baseline sensitivity of *C. sojina* to triazole fungicides**  An extensive collection of *C. sojina* isolates were collected from AL, AR, IL, IN, KY, LA, MS,MO, NC, and TN. The isolates were assessed for resistance to strobilurin fungicides using an in-vitro petri dish assay. The molecular basis of the resistance in *C. sojina* to strobilurin fungicides was found to be attributed to a single mutation in the *cyt b* gene in *C. sojina.* A molecular probe was also developed that can be used to differentiate between isolates of *C. sojina* resistant to strobilurins and those susceptible to that family of fungicides. A manuscript has been accepted for publication summarizing conclusions drawn from research partially conducted in this project. In the manuscript, resistance of *C. sojina* isolates to strobilurin fungicides was found to be attributed to a mutation in the *cyt b* gene in the fungus. The molecular probe that can be used to identify fungal isolates resistant to strobilurin fungicides was also described in the manuscript. The probe was used to assess the incidence of resistance to strobilurins in a collection of *C. sojina* isolates collected in Arkansas and Illinois.  Future work will involve the additional collection of *C. sojina* isolates. The isolates will be screened for resistance to strobilurins.  *C. sojina* isolates that had never been exposed to triazole fungicides were assayed to determine their baseline sensitivity level to triazole fungicides such as propiconazole (Tilt; and a component of several pre-mix fungicides), prothioconazole (Proline), flutriafol (Top Guard), andtetraconazole (Domark). Additional testing of *C. sojina* isolates collected from fields that have been sprayed with triazoles will be conducted in the future to determine if any shifts insensitivity have occurred relative to the baseline sensitivity.  Monitoring of sensitivities to thiophanate-methyl, strobilurin, triazole, and SDHI fungicides in *C. kikuchii* was initiated in Louisiana.  Approximately 33and 85% of the CLB pathogen population in Louisiana is resistant to thiophanate-methyl and strobilurin fungicides, respectively.  Populations have been monitored since 2011for shifts in triazole sensitivity.  Baseline and subsequent sensitivities of the *C. kikuchii* pathogen population to SDHI (Group 7) fungicides will be determined in the future from isolates collected across the Mid-south region.  Subsequent sensitivities to SDHI fungicides will be determined from regional isolates and isolates from participating locations.  Results of the conducted research will benefit the soybean industry. An initial assessment of the distribution of strobilurin fungicide-resistant *C. sojina* isolates in the U.S. was completed. Tools were also developed to improve and expedite the screens. This information can be used to alert growers that different management practices may be needed to slow down the development and spread of strobilurin fungicide-resistant strains. In addition, the results of this research will be used to develop management practices that can be used to manage frogeye leaf spot in light of the strobilurin fungicide-resistant strains being present.  **Identify sources of resistance and develop resistant varieties and elite germplasm:**  Two conventional, S08-18186 and S07-2680 and two Roundup Ready S08-9936RR1and S08-9727RR1 group V soybean lines with excellent resistance to frogeye leaf spot and soybean cyst nematode races 3 and 14 were developed.  Each of these lines has the Rcs3 gene for broad resistance to frogeye races. Yields of these lines have been excellent compared to widely grown commercial varieties of similar maturity. Yield across soil types for the two Roundup Ready lines compared to checks of similar on loam, clay and sandy soils across three years was compiled.  In F2:7 RIL populations S05-11482 x PI592294,S07-5049 x PI592294, S05-11482 x PI458021 and S07-5049 x PI458021 were used to map novel frogeye genes from PI592294 and PI458021. One hundred twelve (112)group IV and V advanced elite lines were screened for resistance to frogeye leaf spot.  In addition, approximately 300 diverse group III, IV and V PIs were planted and screened for resistance to frogeye leaf spot.  More than 50 FLS resistant soybean accessions in MG III-V were identified by field screening that did not have Davis (resistant to all known races of *C. sojina*) like haplotype of the *Rcs3* allele based on SNP genotyping of the accessions. These accessions may be very useful and need to be further characterized to determine if they carry novel resistance genes that are different from *Rcs3.* These resistant accessions will be tested in the future with 10 - 12 different races of *C. sojina* in the greenhouse to identify lines that are resistant to all or most *C. sojina* races. Several lines with the broadest resistance to *C. sojina* races will be crossed with susceptible commercial cultivars to develop segregating F2 populations and map new *non-Rcs3* genes for FLS resistance. Such genes will eventually be used to develop commercial cultivars with marker- assisted breeding.  **Determine effect of current fungicides on control of Phomopsis seed decay:**  An in vitro assay was developed to test currently registered foliar fungicides for their effect on *Phomopsis longicolla.* Fungicides were also tested in field experiments. Fungicides were applied at R3, early R5, or late R5, and the effect of the fungicides on *Phomopsis* was assessed at two harvest times.  The highest yields with the early harvest were with Alto SL 5.5 fl. oz/A, Tilt 6 fl. oz/A, both applied at early R5, and Tilt, applied at 4 fl. oz/A at R3.  At the late harvest, yields of all treatments were lower, and the only treatments with yields significantly greater than the control were Alto 4 fl. oz/A applied at R3or Early R5, and Tilt applied at 4 oz/a at R3 or early R5.  Percent seed infected with *P. longicolla* was very low at harvest 1(0 to 0.8%), but rose dramatically when harvest was delayed, reaching 14.4%with Tilt applied at 4 fl. oz/A early R5.  **Develop a unified soybean foliage disease prediction system for Septoria brown spot, frogeye leaf spot, Cercospora leaf blight with a focus on needs of soybean producers.**  The goalof this objective was to develop a soybean foliage disease forecast system to provide a farm-specific forecast of the risk of soybean foliage diseases, including brown spot, frogeye leaf spot, and Cercospora leaf blight. Prediction models help soybean producers determine when and where appropriate fungicides should be sprayed to maximize economic return.  Data was collected during the first two years of the project to construct the predictions models. However, due to a decrease in funds and a re-direction of research efforts by USB, this objective was dropped in the last year of the project.  **OUTREACHACTIVITIES:**  Information from this research was used in presentations to better inform soybean growers and the agricultural industry on the incidence, control and management of foliar diseases of soybean.  A list of some of these presentations is below.  **(Dr. Carl Bradley)**  University of Illinois Extension - Corn and Soybean Classics Meeting Series (January 2014 – at 6 different sites in IL – Champaign, Mt. Vernon, Springfield, Peoria, Moline, and Malta). (Approximately 925 attendees in total).  Iowa Soybean Association – On Farm Network Meeting (February2014, Ames, IA). (Approximately 45 attendees in this particular session).  Ag Reliant Agronomy Training Meeting February 2014, Peoria, IL). (Approximately 150 attendees).  Joint NCERA 212/208 and Southern Soybean Disease Workers Meeting (March 2014, Pensacola Beach, FL). (Approximately 40 attendees).  **(Dr. Heather Young)**  Multiple production meetings were held in counties across Tennessee, in which results from soybean variety and fungicide trials were presented and extension publications provided. Other integrated pest management (IPM) practices were taught and resources were given out.  **(Dr. Trey Price)**  Many producer meetings were held throughout Louisiana where results from this project were presented. Approximately 800-900 attendees total.  Multiple field days were held at research stations and farms throughout Louisiana detailing results from this project.  Approximately 500 attendees total.  Sensitivity of *Cercosporakikuchii* populations to methyl benzimidazole carbamate, quinone outside inhibitor, and demethylation inhibitor fungicides.  Joint NCERA 212/208 and Southern Soybean Disease Workers Meeting (March 2013, Pensacola Beach, FL). (Approximately 50attendees).  Cercospora leaf blight pathogen resistant to fungicides.  Louisiana Agriculture Magazine.  Winter 2014.  Fungicide resistance issues in soybeans.  Mid South Farm & Gin Show.  February 28, 2014.  Approximately 50 attendees.  Soybeans:  disease resistance to fungicides.  Louisiana Agricultural Technology & Management Conference. February 13, 2014.  Approximately250 attendees.  Fungicide resistance concerns in soybean production.  Conservation Systems Southern Corn and Soybean Conference.  January 15 and 16, 2014.  Approximately 100 attendees. |
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