**USB Proposal**

**Sub/Contractor Information**

**Principal Investigator Name:** Paul P. Price, III (Trey)
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**Proposal Information**

**USB #:** 1920-172-0124

**Title:** Enhanced Pest Control Systems for Mid-South Soybean Production

**Primary Contractor:** SmithBucklin

**Manager’s Name:** Kelly Whiting

**Anticipated Start Date:** 10/1/2018

**Completion Date:** 9/30/2019

**Proposed Budget:** $213,851 (USB share) $373,851 total

**Other Cooperators/Funding Sources:** $160,000 (Mid-South Soybean Board)

**Copy this information from the RFP.**

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| **Target Area:** | Sustainability |
| **Action Team:** | Supply |
| **Program Goal:** | Sustainable Production |
| **Road Map:** | Sustainable Production Practices - Advancing sustainability by developing and promoting advanced production practices and facilitating adoption of digital farming technology. |
| **Track:** | Technical Solution (Creating competitive advantage for U.S. soy growers by differentiating soy offerings throughout the value chain, leveraging the latest technological advancements and innovations) |
| **Milestone(s):** | Create soybean germplasms that contain new genetic sources of resistance to soybean diseases and tolerance to environmental stresses. |
| **Audience:** | Public Researchers |
| **Stage:** | Technical Solution Stage 2 - Investigation Stage - Explore important problems, opportunities & potential solutions for feasibility |
| **Innovativeness:** | Moderate (New but familiar market or solution) |

**Proposal Summary:**

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| Soybean farmers lack resistant varieties for major diseases and pests that have long plagued the Mid-South region and are an emerging threat to the Midwest. The purpose of this project is to identify and develop sources of resistance for frogeye leaf spot, Cercospora leaf blight, other foliar diseases ($190-$312 M annually), and the stink bug complex ($220 M annually in AR, LA, MS, and TX). The resistant sources will be applicable to all regions, and this project will incorporate resistance into germplasm that is adapted to the Mid-South. The ultimate deployment of resistant varieties means less reliance on fungicide and insecticide applications (and associated costs) and more consistent control of diseases or stink bug pests. **The total annual cost of this project** **is 0.002% of the minimum annual total damage due to foliar diseases alone.** |

**Proposal Description:**

Largely due to climatic conditions, susceptible varieties, and over-wintering capability of pathogens in the Mid-South, many foliar diseases are an annual production issue for soybean producers. These diseases may significantly affect the yield and quality of soybean. Potential threats in the proposed research area include: anthracnose, Cercospora leaf blight, frogeye leaf spot, pod and stem blight, Rhizoctonia aerial blight, Septoria brown spot, and soybean rust. Please refer to the table below for detailed losses over the past four growing seasons across 16 southern states (Allen et al., 2015-2018 Proc. Southern Soybean Disease Workers).

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| **Disease** | **Annual loss range (M bu)** | **Annual loss range ($M)** |
| Anthracnose | 0.4-1.4 | $4-14  |
| Cercospora leaf blight/purple seed stain | 4.3-8.6 | $43-86 |
| Frogeye leaf spot | 9.3-11.9 | $93-119 |
| Pod and stem blight | 1.4-2.9 | $14-29 |
| Rhizoctonia aerial blight | 0.7-2.1 | $7-21 |
| Septoria brown spot | 2.9-3.9 | $29-39 |
| Soybean rust | 0.0-0.4 | $0-4 |
| **Total** | **19.0-31.2** | **$190-312** |

Frogeye leaf spot, Cercospora leaf blight, and Rhizoctonia aerial blight are of particular concern because strobilurin (QoI, Group 11) fungicide resistance has been discovered in these pathogen populations, which have rendered Group 11 fungicide applications useless for management over widespread areas. It is inevitable that other pathogen populations will (or already have) become resistant as well, with automatic prophylactic applications of Group 11 fungicides the standard operating procedure in the Mid-South. The rise in fungicide resistance makes variety selection a priority in Mid-South soybean production, and the easiest and most economical way to manage soybean diseases is by choosing resistant varieties. However, because of pathogen variability and environmental conditions, disease reactions may vary across locations within the region.

Frogeye leaf spot was the most prevalent disease in the Mid-South during the 2016 growing season, and there are resistant varieties available, which may save producers the cost of fungicide applications. On the other hand, some of the varieties that are most susceptible are among the highest yielding, so producers are likely to continue planting them and may have to manage the disease with fungicides. Furthermore, soybean varieties may be highly resistant, partially resistant, partially susceptible, or highly susceptible to frogeye leaf spot and many are unaware of these nuances. Some producers and consultants may decide to unnecessarily apply fungicides to a partially resistant variety only if they see a few spots. Additionally, the frogeye leaf spot pathogen population is diverse and may have the ability to overcome varietal resistance.

In the case of Cercospora leaf blight over the past 15 years, fungicide efficacy has significantly declined, and there are no current fungicide strategies that are consistently effective on this disease. To compound the situation, very few tolerant varieties have been identified, and this pathogen population is genetically diverse.

Identification of Cercospora leaf blight resistance and the development of soybean germplasm lines and cultivars with resistance to both Cercospora leaf blight and frogeye leaf spot would provide producers with an effective means of control for these diseases. Furthermore, identification of quantitative trait loci (QTL) and markers for Cercospora leaf blight and frogeye leaf spot would help breeders to more quickly select for resistance to these two important diseases.

Stink bugs are one of the most important insect pests of row crops. Stink bug feeding reduces yield by causing flower abortion, fruiting structure deformation, seed weight reduction, and tissue wounding, allowing for pathogen entry. In addition to yield losses, stink bug seed feeding causes losses in quality and oil content, reduces germination, and delays maturity. Finally, stink bugs vector bacterial, fungal, phytoplasmal, and viral plant diseases. Thus, reduced harvest and unacceptable marketable produce due to quality issues leads to reduced farmer revenue. Reductions in yield and quality from stink bugs have cost southern soybean producers as much as $78 million/year.

In the past, U.S. soybean producers have faced a stink bug complex comprised of the southern green, brown, and green stink bugs. However, Mid-South U.S. producers are currently faced with a new stink bug threat, the redbanded stink bug. Prior to 2000, RBSB had never been an economic threat to U.S. agriculture and had been found only in the states of Florida, Georgia, and South Carolina. In South America it is a serious pest and in Brazil, RBSB has replaced the southern green stink bug as the principal stink bug pest. This appears to have happened in the

U.S. as it has quickly moved throughout the lower Mississippi Delta. Soybean insect costs and losses experienced during 2017 season were collected and compiled from 16 states. Stink bugs were the most costly pest, comprising 38% of all insect costs + losses. For the first time last year in MS, redbanded stink bug was the most dominant species (65%) and in AR, it comprised 35% of species caught. In LA and TX, redbanded stink bug has comprised 59 to 72% of the total species found in soybean. **This species continues to march northward and has continued to increase costs to producers with a total estimated loss plus cost of control of $214 M in these four states alone.**

What makes RBSB the most important stink bug pest is its sheer damage potential. Studies have shown that the RBSB has the greatest capacity to damage soybeans among stink bug species. Data from caged experiments indicates RBSB is an aggressive soybean feeder, damaging 94 percent of pods and 79 percent of seeds, and reducing seed weight by 78 percent within 72 hr. Soybean seed with heavy to severe stink bug feeding has little to no value for oil, meal, or plant seed.

Historically, effective control of stink bugs has been through the use of insecticides. Unfortunately, RBSB is very tolerant of many products available for stink bug control, and consequently, insecticide applications have significantly increased. Insecticide field efficacy experiments during five years indicated pyrethroid control was 94.4 ± 1.3 percent for southern green stink bug and 75.1 ± 1.9 percent for RBSB, organophosphate control was 89.8 ± 2.7 percent for southern green stink bug and 84.8 ± 1.7 percent for RBSB, and neonicotinoid control was 78.0 ± 5.6 and 63.2 ± 6.0 percent, respectively. Lab bioassays of adults validated results in the field. RBSB was four to eight-fold less susceptible to pyrethroids and two to eight- fold less susceptible to organophosphates than was the southern green stink bug. Research indicates that even when insecticides were applied for RBSB control starting at R5 (full pod), four to six applications were needed to significantly reduce yield loss. Since the primary line of defense against this pest is multiple insecticide applications and a minimum of three applications are being applied, insecticide resistance is inevitable and host plant resistance becomes of paramount importance.

For over 60 years, soybean breeding has sought to reduce yield losses to insects by incorporating resistances from wild soybean species. Though insect resistance has been the goal of U.S. public soybean breeding programs for decades, only three cultivars have been released with insect resistance; however, these cultivars have not found grower acceptance due to low yields and inadequate resistance levels. Commercial soybean production in the mid- South relies on heavy pesticide use, which effectively eliminates predators and can flare insecticide-resistant populations. Host plant resistance has an advantage over biological control in that it is entirely compatible with insecticide use. Insect resistance found in cultivars, in combination with biological control or reduced insecticide use, should provide substantial control, reducing reliance on pesticides and saving money for growers.

In the face of a constantly evolving industry, Mid-South soybean producers need to be armed with as much up-to-date varietal information as possible. If we can manage diseases and insects by developing resistant varieties, we may be able to avoid the costs and consequences of fungicide and insecticide applications. In periods of lowered commodity prices, lowering production costs is crucial for soybean farmers to remain profitable.

Two full seasons (2016 & 2017) of this project have been completed, and a formidable amount of varietal resistance data has been generated. Because of the large volume of data and time required to analyze it, we have hired a post-doctoral researcher, Dr. Brian Ward (formerly of Dr. Ray Schneider’s group) to take on this responsibility. In addition to analyzing the data, he is responsible for traveling to all locations, sampling variety trials to determine the pathogen(s) involved, and initiating a screening protocol to compliment the variety trials. Dr. Ward’s work will help further define the epidemiology of CLB. Brian will also work closely with Drs. Burt Bluhm and Ahmad Fakhoury of the “foliar” project to determine the interaction of the specific isolates infecting each variety trial location with the type and level of symptom expression to ultimately understand the role of the environment, isolate species, and pathogenicity on CLB symptom expression.

Our goal for the 2018 growing season is to have a core set of no more than 50 commercial varieties and breeder selections screened at 15 locations in the southern United States. Additionally, approximately 500 plant introductions will be screened in 8 locations in the mid-south. A stink bug screening trial will be conducted in at least four strategic locations to maximize insect pressure. Research goals and efforts are similar for the 2019 growing season, which is encompassed by this proposal.

For the 2018 and 2019 season, we plan to focus more on the stink bug portion of the project with Dr. Davis and Dr. Chen coordinating a breeding effort with promising PI lines (16 total) discovered in 2016 and 2017. The ultimate goal is to incorporate resistance into industry acceptable varieties, which will begin with seed increases over the winter to allow for mapping populations and crosses during 2018. During 2019, plans are to cross recombinant inbred lines with stink bug tolerant lines and stress tolerant (high nighttime temperatures) plant introductions. This process will develop an initial set of lines with elite material to improve agronomics. Substantial changes in the budget compared to FY 16 and FY 17 were required to begin to address these objectives during FY 18 and FY19.

Overall, the results obtained from these efforts will directly benefit soybean producers and seed companies in all states where stink bugs and these diseases are yield limiting pests. The benefits from these extensive research efforts will certainly impact the southern region states, but will ultimately impact the entire soybean industry. Public and private/seed company soybean breeders will utilize the germplasm and genetic markers developed by this project to ultimately develop commercial varieties available to producers that contain improved genetic resistance and utilize them to better control key disease and pests, and thereby result in higher yields and less use of fungicides and insecticides.

**Timeline:**

This proposal is for funding year three of an on-going project with annual evaluations. The investigators were able to demonstrate “proof of concept” after the 2017 season. Disease and insect resistant varieties and breeding materials have been identified, and breeders involved in the project will focus on completing longer term objectives if the project is selected for continuation after two years. Other entomologists in participating states will be invited to participate (probably under the auspices of the cooperating pathologist in that state) as more stink bug resistant material becomes available. Efforts will be made to communicate and cooperate with other soybean breeding programs (e. g. Agricultural Research Service – Stoneville, MS) to prevent redundancy and improve project efficiency. The participants also will communicate and collaborate with others involved in projects addressing related issues (e. g. USB Foliar Project – SIU).

**Expected Outputs/Deliverables:**

* Useful information concerning varietal resistance to multiple diseases will be generated for utilization by stakeholders.
* In the short term, important disease resistance data will be generated for new plant introductions (breeding stock) and selections to serve as a guide for breeder selections and longer term goals.
* Breeding efforts are expected to identify resistance to Cercospora leaf blight in the short term. Plant introductions (PIs) from GRIN and advanced breeding lines will be screened for CLB and resistant lines will be used a source for future research. A total of 580 PIs will be screened and used for association mapping for CLB and those PIs have 50K SNP chip data available. Interaction between CLB and purple seed stain (PSS) will be studied using advanced breeding lines as well as PIs. Identification of QTL/markers for CLB and FLS and the development and release of high yielding germplasm lines /cultivars resistant to CLB and FLS are expected in the long term. Breeders will work closely with plant pathologists to observe if reactions to CLB vary and observe possible isolate variations.
* The key outcome will be high yielding, locally adapted soybean cultivars that are resistant to both stink bugs and diseases. In addition, a set of germplasm will be created to easily incorporate resistance into new cultivars.
* Once resistance has been identified, our future approach will be to identify and map markers contributing to stink bug and disease resistance and to use marker assisted selection (MAS) to pyramid beneficial genes into current high-yielding adapted cultivars. By using MAS, it is possible to quickly screen large quantities of plant materials and remove progeny lacking the marker prior to testing for phenotypic response. Development of recombinant inbred lines (RIL) for mapping CLB and FLS resistance and selection within advanced breeding populations for resistance is expected by the end of 2017. Confirmation of QTL/markers for CLB and FLS resistance and regional evaluation of breeding lines for resistance and yield is expected in 2019.
* Increase seed of promising stink bug resistant lines in winter nurseries for 2018.
* Initiate mapping populations for stink bug resistance.
* Make crosses to develop an initial set of stink bug tolerant lines with elite material to improve agronomic characteristics.
* By the end of the 2016 growing season, preliminary mechanisms of resistance to stink bugs were identified and shared with the target audience. By the end of the 2018 growing season, specific mechanisms of resistance to stink bugs will be identified.
* The benefits of using stink bug and disease resistant varieties will be promoted directly to growers during field days and on-farm demonstrations. Results and pertinent project updates will be reported to the entire mid-South soybean industry in appropriate participating statewide media. For example, in Louisiana it would be the Louisiana Agriculture Magazine, the official publication of the Louisiana State University AgCenter; the Louisiana Soybean & Feed Grain Review, and at commodity and professional meetings, e.g., Louisiana Soybean and Grain Research and Promotion Board Annual Meeting, and the annual branch and national meetings of the Entomological Society of America.

**Key Performance Indicators:**

* A regional variety trial will be conducted, using core commercial varieties, advanced breeding lines, and plant introductions, where natural disease reactions will be recorded and compiled in an annual publication for public researchers, extension personnel, and farmers that is made available for inclusion in each state’s SVT publication or similar venue, that provides farmers with variety choices that are more resistant and thus more profitable.
* Consistency of disease reactions among locations will be compared and promising plant introductions, germplasm, or cultivars with stable resistance across environments will be identified for breeding stock and results shared with private and public soybean breeders to incorporate resistance into commercial varieties that benefit farmers.
* Release of high yielding lines with CLB and/or improved FLS resistance is expected in 2020 which can result in greater control of these diseases.
* By the end of 2018 growing season, soybean producers, breeders and consultants in the Mid-South should have begun using confirmation of QTL/markers for CLB and FLS resistance and regional evaluation of breeding lines for resistance and yield is expected in 2019 that can result in seed company offerings to farmers where this resistance is needed to avoid significant yield loss.
* Top performing advanced soybean lines which have a significant level of resistance to stink bugs and are appropriate for each state’s growing conditions are slated for development by 2022 which would represent a significant breakthrough in pest control i.e. a class of insects currently only partially controlled by insecticides.

**Credentials:**

**Tom Allen** has been an Extension/Research plant pathologist with Mississippi State University, stationed at the Delta Research and Extension Center, since 2007. His responsibilities include working on corn, cotton, grain sorghum, rice, soybean, and wheat diseases for the Delta region of Mississippi. His Extension efforts in soybean have included managing the Soybean Rust Monitoring program, and conducting fungicide trials to determine effective management practices for the major soybean diseases in Mississippi and the Mid-Southern United States. More specifically, research trials have been conducted to determine the effectiveness of seed applied nematicides, help address seed rot/seed quality management with foliar fungicides and insecticides, as well as the management of important yield-limiting disease issues in the Mississippi soybean production system through foliar fungicide applications.

**Blair Buckley** is a plant breeder with the LSU AgCenter and conducts breeding of legume crops with emphasis on identifying and incorporating resistance to important diseases of soybean and cowpea. Developing soybeans with resistance to Cercospora leaf blight (CLB) is a major objective of the soybean breeding program. Breeding efforts for CLB have included utilizing existing cultivars with identified moderate resistance as well as screening soybean germplasm to identify stronger resistance. Breeding efforts for increasing soybean yield have included utilizing exotic germplasm with new genes for yield.

**Pengyin Chen** has been a soybean breeder since 1991 working on cultivar development and germplasm enhancement. He has developed and released 9 high yielding conventional cultivars including Osage and UA 5612 as current yield checks for the USDA Southern Uniform Tests, 12 food grade varieties, and 8 germplasm lines with high protein, genetic diversity, or drought tolerance. He has also been actively conducting and publishing research on gene discovery, QTL mapping, disease resistance, stress tolerance, and seed quality attributes. Dr. Chen has published 158 referred journal articles, 8 book chapters, and more than 200 abstracts. He has received over $7.5 million research funds for soybean research during the last 10 years.

**Jeff Davis** is an Associate Professor in the Department of Entomology at the Louisiana State University Agricultural Center. His research, both applied and basic in scope, has focused on establishing and maintaining a sustainable soybean IPM program to reduce soybean grower costs and improve yields by utilizing biological, cultural, physical, and chemical tools to regulate pest populations while minimizing environmental risks. His research is generating the necessary data on pest density, distribution and biology that is critical to improve the overall soybean IPM program; locally, nationally, and internationally. This information is forming the groundwork for the application of tools and tactics to predict and manipulate pest population dynamics in soybean fields.

**Heather Kelly** has a 70% Extension and 30% Research appointment and is the leader of the UT Extension and Research disease management programs for field crops including soybean, corn, cotton, and wheat. Common duties include developing and conducting field, greenhouse, and laboratory research on diseases of agronomic crops. Dr. Kelly manages cooperative efforts to develop disease control strategies and information on the epidemiology of plant disease that is utilized in disease forecast modeling. She publishes results in peer-reviewed journals and provides appropriate information to agricultural newsletters and extension publications. Dr. Kelly’s program develops, delivers, reports and evaluates a nationally recognized research and extension education program focused on crop disease control that includes traditional and web-based training efforts.

**Boyd Padgett** is a LSU AgCenter Plant Pathologist domiciled at the LSU AgCenter Dean Lee Research, Extension, and Education Center. He has an 85% extension and 15% teaching appointment with an emphasis on disease management in row crops (cotton, corn, small grains, grain sorghum, and soybean). He also serves as the Small Grains and Peanut Specialist and the IPM Coordinator for Louisiana. He has over 30 years of experience in variety/fungicide screening, resistance monitoring to fungicides, and yield loss assessments.

**Trey Price** is an Assistant Professor at the Macon Ridge Research Station in Winnsboro, Louisiana. He has an Extension (70%) and Research (30%) appointment and conducts basic and applied research in corn, cotton, grain sorghum, oats, rice, soybean, and wheat in Louisiana. Dr. Price has statewide responsibility in cotton pathology and disease management education. He provides immediate assistance to stakeholders statewide via laboratory diagnostics, field calls, phone calls, text messages, and other means. Trey is also responsible for evaluating disease in multiple variety trials in multiple crops at multiple research stations in the state. A portion of his current research program is dedicated to discovery and definition of fungicide resistance in major row crop pathogens and defining the effects of fungicides on crop plants in the presence and absence of disease.

**Terry Spurlock** is an Assistant Professor and Extension Plant Pathologist at the Southeast Research and Extension Center (SEREC) in Monticello, AR. His extension row crop responsibilities include all wheat in the state as well as soybean, grain sorghum, corn, and cotton south of I-40. He graduated in 2013 with a PhD in Plant Science from the University of Arkansas-Fayetteville and has been in his current position since graduation. His expertise and current research objectives center on site-specific management of plant diseases (precision agriculture) as well as development of more efficient IPM solutions in the economically important row crop production systems in Arkansas.

**Xin-Gen (Shane) Zhou**, Assistant Professor of Plant Pathology, is stationed at Texas A&M AgriLife Research, Beaumont, TX. He has more than 20 years of work experience in the epidemiology and management of diseases on soybeans, rice and other crops. The station has the facilities, land and farming equipment available for this proposed research.

**Budget:**

*Please see the attached Excel file.*