

# ANNUAL RESEARCH REPORT



MISSOURI  
SOYBEANS

Photo by Logan Jackson - University of Missouri



LETTER FROM THE EXECUTIVE DIRECTOR

The Missouri Soybean Merchandising Council is our state’s Qualified State Soybean Board - the entity authorized by the USDA to oversee soybean checkoff dollars for Missouri soybean growers. With that comes the responsibility for investing the one-half, of one-half of one percent of farmers’ soybean checkoff dollars that stay in Missouri for state-specific work (the other one-half goes to the United Soybean Board and national-level programs).

The Missouri Soybean Merchandising Council (MSMC) is truly a farmer-run organization, with 13 farmer-directors from across the state elected by their peers to oversee investments into research, promotion and education programs – never lobbying. Those programs are focused on fulfilling the Merchandising Council’s mission for maximizing Missouri soybean farmer profitability. From a grassroots level in seven soybean districts to those elected farmer leaders, we rely on the men and women raising soybean in Missouri to guide our work on behalf of soybean farmers. In the following pages, we share details on some of the research projects the farmers have chosen for checkoff funding. Some of these are short term projects with immediate applications on the farm or in industry, others will have a longer timeline.

We appreciate your interest and engagement in the research process, and hope you’ll not hesitate to contact your farmer leaders and staff with your questions, ideas and challenges. We’re honored to work for you.

*[Signature]*

Gary Wheeler - MSA / MSMC Executive Director / CEO



Gary Wheeler, MSA/MSMC Executive Director / CEO



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Robert Alpers, Prairie Home	Tim Gottman, Monroe City	Bob Littleton, Dalton	Lewis Rone, Portageville
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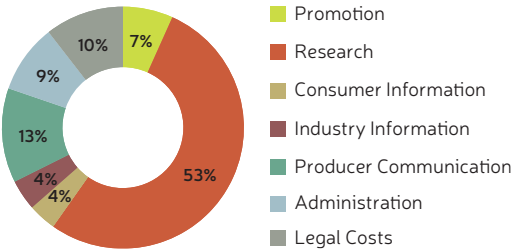
Executive Director / CEO Gary Wheeler gwheeler@mosoy.org	Director of Business Development & New Markets Tony Stafford tstafford@mosoy.org	Director of Compliance & Research Administration Ebby Neuner eneuner@mosoy.org	Office Manager Mary Kever mkever@mosoy.org
Director of Communications & Public Relations Christine Tew ctew@mosoy.org	Director of Research Greg Luce gluce@mosoy.org	Industry & Producer Relations Manager Ryan Gill rgill@mosoy.org	Accounting Manager Jeff Bruemmer jbruemmer@mosoy.org
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LETTER FROM THE MSMC BOARD CHAIR

Research is the highest priority area for the Missouri Soybean Merchandising Council board of directors both long-term and as we set plans each year. It’s integral to fulfilling our mission to use innovation to solve problems facing soybean producers, and to ensure profitability for soybean farmers – now and well into the future.

Research is also what soybean growers across Missouri continue to tell us is most valuable for their long-term profitability and freedom to operate. Results from the questionnaires you fill out at field days, district meetings and other events throughout the year consistently point to the priority Missouri soybean farmers as a whole place on investing in developing new traits, technologies and practices. That feedback helps guide our decisions and we appreciate the thought each of you puts into those throughout the year.

MSMC Program Expenses



Several of the farmers serving on your board of directors put a special emphasis on these decisions, voluntarily serving on the Missouri Soybean Merchandising Council’s Research Committee. Special thanks are in order for those individuals – Cecil DeMott of Rockport, who serves as chair of the committee, as well as Robert Alpers of Prairie Home, Kyle Durham of Norborne, Lewis Rone of Portageville and Rex Wood of Meadville. Thanks are also in order for the staff at the Missouri Soybean Association and Missouri Soybean Merchandising Council for their work throughout the year to make these projects and this report possible.

Thank you for helping make this work possible, and for the trust you’ve placed in those of us working on your behalf. This research shows a bright future for soybean in Missouri, and I’m looking forward to seeing what’s ahead.

*[Signature]*

John Kelley - MSMC Board Chair



John Kelley  
MSMC Board Chair

MSMC Research Comittee



MSMC Research Committee Left to Right: Cecil Demott, Robert Alpers, Kyle Durham, Lewis Rone and Rex Wood

Research Project Review Process





## RESEARCH PROJECTS FOR 2017-2018 ANNUAL REPORT

Current projects supported by checkoff funds distributed by the Missouri Soybean Merchandising Council are listed below, divided by type of research – Agronomic, Soybean Breeding, SCN and Crop Physiology, Feed, Food and New Uses, Research Educational Opportunities and Regional Affiliations.



## Agronomic

### INTERACTION OF COVER CROPS AND NEMATICIDES IN RELATION TO SOYBEAN CYST NEMATODE POPULATION MANAGEMENT AND SOYBEAN YIELD

*Bruce Burdick, Melissa Mitchum, Tim Reinbott & Andrew Scaboo; University of Missouri*

The goal of this project is to evaluate the magnitude and contribution of cover crops and nematicides on soybean cyst nematode populations. It will also compare the yield of several resistant and non-resistant soybean varieties within the study. As new management tools like iLeVo seed treatment, and more widespread cover crop use is embraced by soybean producers, the need to determine best management practices and measure their impact becomes apparent. This study specifically measures the ability of the tested practices in the management of SCN in soybean fields.



Cover crop strip trial at the Bay Farm Research Facility

### MU CERTIFIED STRIP TRIAL INITIATIVE

*John Lory, Peter Scharf, Bill Wiebold, Greg Luce, Wayne Flanary and Kent Shannon, University of Missouri*

This program is an integrated research, education and demonstration project that helps Missouri producers validate management decisions on their own farms and document their efficiency and environmental stewardship. Strip trials are focused, easily implemented experimental tests farmers can perform on their fields using their own equipment or that of a commercial applicator. The adoption of yield monitors and precision agricultural tools and strategies provides an opportunity for wide-spread acceptance of strip trials throughout Missouri. Comparisons are made across soil types to determine the variability throughout the field and the impact of management practices. The Missouri Strip Trial Program is an unbiased data source for nutrient management, agronomic, and conservation practices. Practices that are compared include nitrogen timing, phosphorus application comparisons and cover crop impacts on corn and soybean yield. Future evaluations are planned for other agronomic comparisons.



## BEST MANAGEMENT OF SOYBEAN IN A DOUBLE CROP SYSTEM

*William Wiebold, University of Missouri*

In the last five years the percentage of total soybean acres that are double cropped after wheat ranges from 8 to 11 percent. This translates into 450,000 to 630,000 acres. Double cropped soybean acres contribute substantially to the impact of soybean on Missouri agriculture economy, especially in central and southern Missouri. Few soybean yield data are collected from a double crop system. In an effort to develop appropriate management recommendations, researchers are working to collect data from a system like that which Missouri farmers who double crop use.

This project uses two experiments to determine the best combination of variety maturity, seedling rate, and pest management practices for soybean in a winter wheat-soybean double crop system. Data will be collected in soybean planted after harvested wheat. Combinations of seed treatment, fungicides, and insecticides will be used to determine best practices for pest management.

## ENHANCING SOYBEAN PRODUCTION EFFICIENCY IN NORTHWEST MISSOURI

*Jim Crawford and Wayne Flanary, University of Missouri*

The research goal is to look at various production methods and practices to help producers increase yield and reduce input costs while working to protect the environment. The goal is help determine the most cost effective practices. Growing and management practices are evaluated at the Graves-Chapple Research Center, and the plots are shown during the annual field day at the Graves-Chapple Research Center.

## DEVELOPMENT OF A HERBICIDE INJURY APP FOR MOBILE DEVICES

*Kevin Bradley and Mandy Bish, University of Missouri*

The understandable and initial question when herbicide injury occurs to soybean or any crop is “will this injury result in yield loss?” The University of Missouri Weed Science program is working to address this question in soybean using multiple approaches. Research trials are ongoing that seek to con-elate ALS- and PPO-inhibitor early-season

herbicide injury in soybean to yield loss. As a result of the off-target dicamba injury that occurred to soybean in 2016, a new study was also initiated to con-elate in-field visual dicamba injury symptoms to yield losses. Limited resources are available to address the most basic question asked when investigating possible herbicide injury: “what caused this injury to these soybean plants?”

This project aims to develop an herbicide injury app that growers will find useful when estimating yield loss due to herbicide injury. Having the information on which herbicide caused the injury will help determine what should be done with regard to potential yield losses.

## INCORPORATING COVER CROPS INTO SOYBEAN CROPPING SYSTEMS

*William Wiebold, University of Missouri*

The soybean rotation-cover crop systems study is designed to determine if soybean intensity in a rotation affects soil health parameters and yield. Studies have shown a significant loss in yield from soybean following soybean as compared to following another crop such as corn or grain sorghum. The yield penalty for soybean following soybean is about ten percent. This study is helping to determine if the appropriate cover crop, and appropriate management, will have a positive impact on soybean yield. Another objective of this study is to determine if soybean intensity in a rotation affects soil health parameters. This work is important to Missouri as we have a greater portion of soybean planted after soybean than other states.

## MISSOURI AGRICULTURAL WATERSHED MONITORING PROJECT

*Darrick Steen, Missouri Soybean Merchandising Council*

Measuring the effectiveness of farmer practices and documenting and demonstrating the grower’s continuous improvements remains the goal of the watershed monitoring project. Edge-of-field monitoring allows farmers to measure the runoff leaving their fields. Establishing reliable monitoring stations in producer-owned crop fields gives farmers, collaborating partners, and agencies the ability to collect and monitor water samples and hydrologic data. The impact of management practices can be measured to determine their effectiveness. Edge-of-field monitoring will provide information about the amount of runoff, soil, nutrients and, if desired, crop chemicals moving off a given field into an adjacent waterway. Assessing the water quality impacts from farmland as well as assessing the performance





# NEW PLAN SEEKS TO PREVENT FURTHER DICAMBA-RELATED SETBACKS TO SOYBEAN BREEDING RESEARCH

By Jason Jenkins, Mill Creek Communications

For Pengyin Chen, the 2017 growing season began with both promise and optimism. As leader of the Southern Missouri Soybean Breeding Program at the University of Missouri Fisher Delta Research Center in Portageville, he looked forward to continuing the quest for “better beans,” seeking out new lines with novel traits to benefit soybean producers in the Show-Me State and beyond.

Within those blocks of conventional soybean, the next variety expressing superior yield, soybean cyst nematode tolerance, drought resistance or even greater high-oleic oil content may have been waiting to be discovered.

But Chen wouldn’t get an opportunity to find it in 2017. The first signs that something wasn’t right appeared at the beginning of May. Two weeks later, more symptoms surfaced. By the second week of June, it was clear what had happened: Off-target dicamba exposure compromised the research, evident by the fact that dicamba-tolerant beans planted in the block were flourishing.

“We had symptoms in all of our breeding blocks,” says Delta Center Director Trent Haggard.

“Every single plant was affected. Nothing escaped. The data is not usable because there’s no way to tell if there are genetic

differences or differences caused by dicamba injury,” says Chen, the David M. Haggard Endowed Professor of Soybean Breeding.

## The Dicamba Debacle

Across Missouri, officials estimated that more than 325,000 soybean acres were injured by off-target movement of the herbicide during the growing season.

For soybean producers who experienced dicamba-induced symptoms, the true extent of injury or actual yield loss varied.

Chen says the impact of dicamba exposure on non-tolerant conventional soybean varieties in his breeding blocks went far beyond the cupped leaves that producers likely observed in their fields.

“The dicamba forced the plant to grow a trifoliate leaf at the first node, which is not normal. The first node is supposed to be two leaves, two cotyledon leaves,” he explains. “The plants were forced to branch out sideways, and then the branches were very brittle. You shake it, and they just bent over. The dicamba changed the biology of the plant.”

## Plotting Protections

As the new growing season approaches, concerns still abound regarding dicamba use and avoiding the issues that impacted some Missouri soybean

producers in 2017.

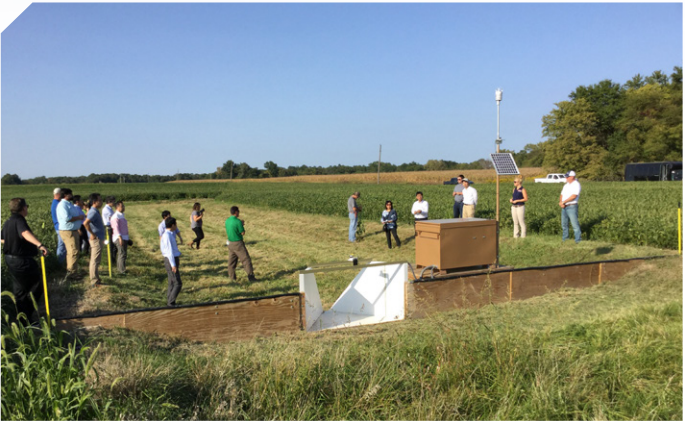
The Missouri Department of Agriculture set state-specific restrictions on dicamba use in 2018. While herbicide formulations containing dicamba will be allowed, their use will be prohibited after June 1 in 10 southeast Missouri counties and after July 15 for the remainder of the state.

The state agriculture department also instituted a new training requirement. Both certified private and commercial applicators applying synthetic auxin herbicides such as dicamba or 2,4-D in 2018 must complete mandatory training provided by University of Missouri Extension.

Haggard says that at the research center, additional steps will be taken to protect the soybean-breeding blocks and the investment of soybean checkoff dollars. “I’m trying to guard the long-term investment in this breeding program, both by the university and by Missouri’s soybean producers through the soybean checkoff,” says Haggard.

“At the same time, I’m also a family farm owner who planted dicamba-tolerant soybean in 2017 and benefitted from effective weed control. I understand the need for the technology. We have to figure out a way to coexist.”

and effectiveness of best management practices (BMPs) in reducing nutrients and sediment helps document and demonstrate the progress that is being made in state, national, and industry stewardship goals. Monitoring will allow producers to measure the value and benefit of their past, current and future conservation efforts.



Darrick Steen at Gottman Farm showing a monitoring station

# INVESTIGATING DICAMBA MOVEMENT AND INJURY TO SOYBEAN

Kevin Bradley and Mandy Bish, University of Missouri

Factors known to contribute to off-target movement of dicamba include physical drift due to wind, surface temperature inversions, vapor drift (herbicide volatility), and spray tank contamination. During the 2017 growing season, the number of Missouri soybean acres planted in dicamba-tolerant soybean increased substantially. The impacts of dicamba drift due to wind and spray tank contamination are believed to be minimized by better education and greater awareness of herbicide applicators.



Brian Dintelmann discussing Dicamba impact on off-target plants at Bradford Research Center in Columbia, MO

The objectives of this research are 3-fold:

- 1 Correlate field-scale observations of dicamba injury to real-world yield losses so that producers and agrichemical industry representatives are better prepared to deal with future office-site dicamba injury issues
- 2 Study the impact of dicamba formulations on temperature inversions
- 3 Initiate development of a mobile app and/or website that will send alerts to herbicide applicators when unfavorable weather conditions are present



Air sampler used to test for Dicamba vapor drift

# MU CERTIFIED STRIP TRIAL (COLLABORATION WITH ISA ON-FARM NETWORK ILeVO TEST)

John Lory, Bill Wiebold, Greg Luce, Peter Scharf, Wayne Flanary and Kent Shannon, University of Missouri

In Missouri, a steering committee including farmer representation through Missouri Soybean Association and Merchandising Council, Missouri Corn Growers’ Association and Merchandising Council and other participating farmer organizations selects and prioritizes the types of trials available in a given year. Initial funding focused on fertilizer management, particularly the environmentally active nutrients nitrogen and phosphorus, and conservation practices such as cover crops. The farmer panel was asked what types of trials, in addition to the current focus, they would prioritize. Seed treatment trials consistently topped these informal surveys.

This study is an integrated research, education, and demonstration project helping Missouri producers validate management decisions on their farm and document efficiency and environmental stewardship. In collaboration with the Iowa Soybean’s On-Farm Network, pursue these goals:

- 1 Provide Missouri farmers access to a trial focused on ILeVO
- 2 Gain insight into how On-Farm Network runs trials as a first step in defining opportunities for closer collaboration between the two programs



# Soybean Breeding

## BREEDING PRODUCTIVE, PEST RESISTANT, CONVENTIONAL AND HERBICIDE TOLERANT GROUP IV AND V SOYBEANS

*Pengyin Chen and Andrew Scaboo, University of Missouri*

The objective of this research is to develop new soybean varieties for the Missouri Delta region and other Mid-South environments. Specific objectives are breeding for higher yields, quality traits, and disease and nematode resistance. This soybean breeding program is housed at the University of Missouri Delta Center in Portageville, Missouri. Key areas of focus include the development of varieties with SCN and Root Knot nematode resistance, frogeye leaf spot resistance and, of course, yield. The Delta Center Soybean breeding program has released multiple varieties over the last two years. An important aspect of the research program continues to be developing soybean varieties with higher oleic acid and linolenic acid content, as well as herbicide resistance and other traits.



*Soybean breeding team sorting seeds at the Bay Farm Research Facility*

## BREEDING AND GENETIC MAPPING FOR FLOODING TOLERANCE IN SOYBEAN

*Pengyin Chen, University of Missouri*

This research aims to develop new flood tolerant soybean varieties for the Missouri Delta region and Mid-South environments.

To accomplish this goal, modern soybean breeding and mapping techniques will be employed as follows:

- 1 Screen a set of soybean varieties and new plant introductions in group III, IV, and V to identify new sources of flooding tolerance.
- 2 Identify new flood tolerance germplasm and identify and map genes for tolerance
- 3 Evaluate the lines aimed at developing new adapted varieties for flood tolerance as well as current cultivars for tolerance.

Further work will be conducted to yield test soybean lines under both flooding and optimum conditions.

## EVALUATION OF OLEIC ACID GERmplasm FOR DEVELOPMENT OF SOYBEANS WITH HIGH OLEIC ACID

*Pengyin Chen and Andrew Scaboo, University of Missouri*

The primary goal of this project is to develop productive group III, IV and V soybean varieties for Missouri with the high oleic and low linolenic traits. The outcome is to deliver soybean oil with a healthier profile and provide a more functional oil for food, feed and industrial applications. High oleic, low linolenic acid soybean oil is similar to olive oil in many ways and can be produced in large quantities and sold more economically than olive oil. This trait has great potential benefit to Missouri Soybean Farmers. This work is being accomplished using the patented, non-GMO, high oleic genes and methods discovered in Missouri by USDA and University of Missouri researchers. This work is conducted at both the Bay Farm Research Facility and Fisher Delta Research Center as a collaborative effort between Dr. Pengyin Chen and Dr. Andrew Scaboo.

## NORTH MISSOURI SOYBEAN BREEDING PROGRAM

*Andrew Scaboo and Pengyin Chen, University of Missouri*

With the focus on yield and agronomic traits important for soybean farmers, this project involves developing new soybean varieties for use in north Missouri maturity zones. Variety development is focused on maturity group III and early group IV varieties.



*Lateral irrigation system at Bay Farm research facility*

The north Missouri soybean breeding program takes place at the Missouri Soybean Association Bay Farm Research Facility, the only soybean research facility owned and operated by a state soybean association. The development of high oleic soybean varieties remains an important aspect of the soybean breeding research. The high oleic trait was discovered and developed by USDA and MU researchers and is a focal point of variety development. The Bay Farm Research Facility is home to a state-of-the-art composition marker and analytical lab to aid in the development of high oleic varieties. This program works closely with the Delta Center soybean breeding program and shares resources and germplasm for testing throughout Missouri.

## WINTER PRODUCTION PROJECT

*Pengyin Chen and Andrew Scaboo, University of Missouri*

Winter nurseries are an essential component of a successful soybean breeding and genetic program. Nurseries in Costa Rica, Puerto Rico are used so crosses can be made in off-season for Missouri and year-round, which greatly enhances the efficiency and timeliness of the Missouri soybean breeding program. These winter nurseries greatly support our breeding programs and are crucial to compete in variety performance and provide productive genetics for Missouri farmers.

Utilizing winter nurseries starts as soon as seed is harvested. Once the seed is harvested in September or October, it is sent to a winter nursery. The first cycle is October through January and a second from February through May. In May or June, the seed is then sent back to Missouri for planting. In the past two years, over ten soybean varieties have been released from our two soybean breeding programs, a feat not possible without the support of winter nurseries.

## GENETIC MAPPING OF A UNIQUE MORPHOLOGICAL TRAIT IN SOYBEAN AND EVALUATION OF THE CORRELATIONS WITH YIELD POTENTIAL AND SEED COMPOSITION

*Andrew Scaboo, University of Columbia, and Jason Gillman, Agriculture Research Service*

This project's main goal is to identify genomic regions controlling a unique branching pattern discovered in wild soybean and evaluate the yield potential and seed composition in experimental lines exhibiting this trait. The specific trait of this project is directed towards the improvement of genetic seed yield potential.

Identification of genomic regions have been located on three different chromosomes that explain a significant portion of the branching results. Also found are the locations which explain a significant portion of the variance for protein and oil.

This promising work is a collaboration between MU and USDA at the Missouri Soybean Association Bay Farm Research Facility.

## GWAS TO GENES: A SYSTEM TO UTILIZE ASSOCIATION ANALYSES TO CLONE GENES AND DEVELOP MARKERS TO IMPROVE SOYBEAN BREEDING FOR VARIETY DEVELOPMENT

*Kristin Bilyeu, Agriculture Research Center; Dong Xu and Trupti Joshi, University of Missouri*

This research is designed to improve bioinformatics tools and systems to enable broad and efficient identification of soybean genes controlling important phenotypes. The strategy is a proof-of-concept approach using a validated data set of cloned genes to test different methods for providing gene information that can immediately be used to develop soybean varieties. The computer science team is working closely with the molecular biology team to determine the desired outcomes for modifying an existing decision tool or building a new one. This project is focusing on mining data to characterize genes that control plant traits and use that information to develop molecular markers to make efficient selections.



## DEVELOPING HIGH-YIELDING, HIGH OLEIC ACID, LOW LINOLENIC ACID SOYBEANS VARIETIES WITH ADDITIONAL VALUE-ADDED COMPOSITION TRAITS (HOLL PLUS)

Kristin Bilyeu, Agriculture Research Service; Andrew Scaboo, University of Missouri

Americans are seeing more cooking oils in the marketplace than ever before. Purchase choices are influenced by many factors, and what appears on the label is an important consideration. Soybean oils are typically sold as vegetable oil, which does not directly link soybeans with the product. If HOLL soybean oil appears in the grocery stores, it could add a new opportunity for consumers to directly choose soybean oil for its positive benefits.

The goal is to create competitive soybean lines with the high oleic and low linolenic traits plus additional seed composition traits to enhance the value of the soybean to producers, processors, and end users alike. Establishing a HOLL plus soybean breeding and molecular selection program dedicated to developing high yielding maturity

group III and IV soybean varieties for Missouri farmers is the specific objective of this proposal.

## IDENTIFICATION AND EVALUATION OF DOMESTICATED SOYBEAN LINES DERIVED FROM WILD SOYBEAN CROSSES WITH INCREASED LEVELS OF PROTEIN AND VALUE-ADDED AMINO ACIDS

Andrew Scaboo, University of Missouri

This project is designed for the development of high yielding domesticated soybean lines of recent wild ancestry with increased protein and high-value amino acid seed content using conventional breeding. Another major goal of the project is the identification of the specific wild soybean genes responsible for improved seed composition of domesticated lines. This research can aid in the diversity of the soybean industry and, specifically, improve measurable quality traits. The unique combination of wild seed composition data, wild type genetic blueprints, and soybean breeding expertise will provide Missouri and U.S. soybean farmers improved soybean selections.

## BENEFITS OF HIGH OLEIC SOYBEAN OIL

### Health:

- High oleic soybean oil can be used at high temperatures in preparing foods **without hydrogenation** or producing harmful **trans fats**.
- High oleic soybean oil contains **less saturated fat** than other commonly used oils.



### Environment:

- High oleic soybean oil has an **extended fry-life**, lowering cost and waste.
- Soybean are a **renewable energy source**, and a **nitrogen-fixing** legume grown across Missouri.

### Industry:

- High oleic soybean oil based motor oils have **better viscosity** and **lower volatility** than their synthetic counterparts, resulting in better performance in high temperature applications.
- Lubricants made with high oleic soybean oil offer **natural detergency**, leaving engines cleaner and reducing deposit on metal surfaces.



## MISSOURI LEADING THE WAY

**Missouri leads the U.S.** in having the only high oleic soybean technology developed through **soybean breeding**.

The patents and applications for high oleic soybean are owned by the Curators of the University of Missouri and the U.S Dept. of Agriculture; and are **exclusively licensed to the Missouri Soybean Merchandising Council**.

## DEVELOPING VALUE-ADDED SPECIALTY SOYBEANS FOR THE SOYFOOD MARKET

Pengyin Chen and Andrew Scaboo, University of Missouri

The main goal of this project is to develop new and improved soybean germplasm varieties adapted to Missouri, with the desired seed quality traits for various soyfood markets.

This project was a new initiative and effort for Missouri soybean research. This research was initiated to increase the visibility and impact of Missouri soybean production with multiple lines of products, marketing channels, increased market shares, and maximum economic returns. Dr. Chen has a track record of success in establishing a new edamame industry in Arkansas with breeding, production, processing, and marketing capabilities. In addition, the PI has developed several natto varieties for two companies that dominate the vast majority of the Japanese natto market.

## BREEDING SOYBEANS RESISTANT TO MULTIPLE NEMATODE SPECIES

Pengyin Chen, Andrew Scaboo and Melissa Mitchum, University of Missouri



Roots of soybean plant infected by soybean cyst nematode

Plant-parasitic nematodes (PPN) are the cause of significant yield losses to Missouri soybean producers each year. Soybean cyst nematode (SCN) is the most economically important nematode species of soybeans and is found throughout the state of Missouri where soybeans are grown. Root-knot nematodes (RKN) cause major yield losses in southeast Missouri and often occur in the same field with SCN. Reniform nematode (RN) is also an increasing threat to soybean production in southeast Missouri particularly in rotation with cotton.

The primary goal of this project is to develop productive soybean varieties for Missouri with resistance to multiple

nematode species. Using SCN, RKN, and RN resistant sources with genes that are most effective against the species prevalent in the state will be the key to accomplishing this goal. The work performed under this project will ensure the continued development of high yielding soybean cultivars with multi-nematode resistance for Missouri.

## BREEDING HIGH-YIELDING SOYBEANS WITH FUNCTIONAL TRAITS

Pengyin Chen and Andrew Scaboo, University of Missouri

This research intends to provide a steady flow of new and improved soybean lines with desirable functional traits for food, feed, oil, and biodiesel production.

Specific Objectives:

- Develop high yielding lines with high protein content (>45 percent) for food, feed, and protein isolate
- Develop high yielding lines with high oil content (> 23 percent) for oil crushing and biodiesel production
- Develop high yielding lines with high sucrose (>8 percent) and low stachyose (<1 percent) for food and feed
- Incorporate high protein, high oil, high sucrose and low stachyose into high oleic lines

## UTILIZING MOLECULAR MARKERS FOR SOYBEAN VARIETY DEVELOPMENT

Andrew Scaboo and Pengyin Chen, University of Missouri

The project's primary goal is to improve the efficiency and quality control of the soybean breeding program, assuring the continuous release of novel soybean varieties for Missouri farmers, while maximizing limited resources.

The specific objectives of this project are:

- 1 facilitate marker assisted selection (MAS) for introgression of quality traits (i.e. high-oleic soybean) and disease resistance traits (i.e. SCN) into the breeding program for variety development
- 2 increase the breeding efficiency for developing new varieties by using genomic prediction of breeding value for experimental lines
- 3 develop and utilize new molecular markers for emerging beneficial traits (i.e. LL55)



# SCN and Crop Physiology

## USING MICROGENOMICS TO IDENTIFY NEW SOURCES OF SOYBEAN CYST NEMATODE RESISTANCE IN SOYBEAN

Melissa Mitchum, University of Missouri

This project will study a new biotech approach to soybean nematode resistance. SCN have been adapting to the current source of resistance and evaluating new approaches to resistance as well as resistant sources, which is of utmost importance for fighting this serious soybean pest. Understanding how resistance genes work on a molecular level is the key to developing broader, more durable resistance in soybean cultivars. Current research aims to understand how plant defense mechanisms work against SCN and exploiting the information through novel or conventional plant breeding approaches.

## IMPROVING HEAT TOLERANCE: IDENTIFICATION AND CHARACTERIZATION OF SOYBEAN GERmplasm

Felix Fritschi and Arun Dhanapal, University of Missouri; Jason Gillman, Agriculture Research Service

Weather conditions prevailing during key parts of the growing season greatly affect soybean yield. Among these weather factors, temperature strongly influences the success or failure of reproductive structures, and therefore yield. Temperature conditions in Missouri can vary considerably and rapidly. The occurrence of episodes of high temperatures detrimental to yield formation is common in our state. In essence, there are no management practices that growers can use to mitigate soybean exposure to high temperature stress, therefore, varieties need to be developed that can yield better when temperatures are elevated. We have characterized a broad range of soybean germplasm including exotic as well as advanced entries for their response to high temperature stress.

The goals of this project are to:

- 1 Identify germplasm with increased heat tolerance by exploiting genetic variability of MG III and IV genotypes
- 2 Develop a more detailed understanding of the mechanisms that protect soybean yield from losses during episodes of high temperature stress

- 3 Initiate incorporation of heat tolerance traits into advanced soybean germplasm and the development of mapping populations.

## HIGH-THROUGHPUT PHENOTYPING TO ACCELERATE SOYBEAN IMPROVEMENT THROUGH AGRONOMY, BREEDING, AND GENETICS

Felix Fritschi, Gary Stacey, Andrew Scaboo, Bill Wiebold, Guilherme DeSouza and Minviluz Stacey, University of Missouri

This research focuses on the implementation and deployment of a phenotyping platform that will accelerate soybean improvement by facilitating repeated, rapid, accurate, non-destructive plant measurements. The optimized platform will be available to Missouri soybean researchers conducting experiments ranging from crop management to fundamental genetics for many years to come.

Yield measurements are the ultimate measure of crop performance. However, while yield improvement is the desired outcome, final yield does not provide sufficient information of crop growth and development differences that led to the improved yield. In-season crop measurements are critical to understand why yield may differ, and what we might want to change within the growing season to improve profitability. Phenotyping platforms combine multiple types of sensors that complement or expand measurements commonly made in agronomic, physiological, and genetic studies. This platform can and will be used by many different researchers at the University of Missouri.



# Feed, Food and New Uses

## OIL DERIVED EPOXY MONOMER FOR STRUCTURAL COMPOSITE APPLICATIONS

Thomas Schuman, Missouri University of Science and Technology

This research aims to develop a monomer into a marketed product and further develop applications toward broader market access. This project is working to further develop application and begin commercialization of a unique soybean oil-derived monomer as a resin system that shows promise for structural composite applications. The resin material is considered 100 percent bio-based. The use of oil monomer material in structural and structural composite application and its unique properties; high strength, higher temperature application window, and improved computability and reactivity when used by itself or with commercial epoxies has been demonstrated. This additional application data will demonstrate increased market value with the potential for Missouri farmers to move new industrial materials into the marketplace via performance and cost.

## DEVELOPMENT OF HIGH VOLUME APPLICATIONS OF HIGH OLEIC SOYBEANS (I) DIELECTRIC LIQUID IN TRANSFORMERS AND OTHER ELECTRIC EQUIPMENT AND (II) COMPOSITION AND FUNCTIONAL PROPERTIES OF ISOLATED PROTEIN FROM HIGH OLEIC SOYBEAN

Shubhen Kapila and Rocha Seemamahannop, Missouri University of Science and Technology; Kristin Bilyeu, USDA Agriculture Research Service; and Bongkosh Vardhanabhuti, University of Missouri

The overall project goal is to demonstrate suitability of high oleic soybean oil as dielectric fluids with superior long-term stability, fire resistant properties and environmental compatibility in electrical transformers and similar devices.

Proposed research will assess suitability of high oleic soybean oil as dielectric liquid in electrical transformers and similar devices.

The research efforts will directed at:

- Formulation of high oleic soybean oil
- Evaluate formulations dielectric properties of formulated soybean oils
- Evaluation of oxidative and aging stability of formulated oils
- Evaluation of compatibility of formulated oils with solid insulators (paper and polymers) used in electrical transformers

## DEVELOPMENT OF SOY PROTEIN-NANOCCELLULOSE COMPOSITES AS FOOD PACKAGING

Mengshi Lin and Azlin Mustapha, University of Missouri

This project aims to develop soy protein/nanocellulose composites containing antimicrobial and antioxidant agents. These nanocomposites can be used as food packaging materials to inhibit the growth of foodborne pathogens in foods and reduce lipid oxidation to prolong the shelf life of foods. This novel nanocomposite is an inexpensive, lightweight, and strong material for food packaging. It can improve food quality due to its barrier properties that can positively influence water vapor transmission and oxygen permeability. This two-year project has the potential to benefit Missouri soybean growers and the industry.

## SUSTAINABILITY ANALYSIS

Doug Whitehead, National Biodiesel Board

This project will improve the lifecycle carbon reduction score for biodiesel and promote biodiesel sustainability benefits in target audiences. Results and expanded awareness will encourage use of higher biodiesel volumes by carbon-conscious consumers and make biodiesel more competitive.

Accurately defining the impacts and benefits of soy biodiesel with regard to GHGs and environmental factors will increase the market acceptance of soy biodiesel. This will result in increased volume use of soybean oil as a feedstock for biodiesel production. It will also result increased market premiums being paid for low carbon fuels.



## COMMERCIAL APPLICATION OF SOYBEAN HULLS/STOVER FOR ELECTRONIC INDUSTRIES

Ram Gupta and Pawan Kahol, Pittsburg State University; and Karthik Ghosh, Missouri State University

Project investigators plan to utilize soybean hulls/stover for electronic applications particularly for battery and supercapacitor industry. Soybean hulls/stover will be converted to high surface area carbon for energy storage applications.

The bio-waste such as hulls and stover from the soybean crops will be used as the starting materials for carbonization.



soybean hulls

These materials will be converted to high quality carbon by:

- 1 Controlled carbonization of soybean hulls and stover using cost effective method
- 2 Activation of these carbonized soybean hulls and stover to produce high quality carbon

The hulls and stover from soybean crop will be washed and dried. The dried hulls and stover will be crushed to get the powder. These powders will be pretreated and carbonized. These materials will be microstructurally and electrochemically characterized using industrial standards. The schematics of the process are given in Figure 1. The inherent porous structure of soybean hulls and stover will provide carbons with high porosity and specific surface area. The additional advantage of using soybean hulls and stover is they contain sulfur and nitrogen (from protein). These sulfur and nitrogen provide additional energy storage capacity and reduce the resistance of the device and thus improve the efficiency.

## Educational Opportunities

### MONSANTO EDUCATION CENTER FOR SUSTAINABLE SOLUTIONS (MECSS)

Darrin Peters

The focus is to recruit schools and other educational groups to tour the MECSS building and partake in the available agricultural and STEM (Science Technology Engineering Math) activities. Participant surveys will be conducted. The results will be used to make the MECSS an educational model the nation can learn from.

The goal of, "Fuel Wash U" will be to educate and demonstrate how soybeans can be used as a renewable fuel without hurting our food supply. To do this we (RSHS Renewable Fuel Project) will collect waste vegetable oil from Washington Universities food service system, blend the waste oil with virgin soybean oil separated from our soybean press, and convert the oil into biodiesel at MECSS (Monsanto Education Center for Sustainable Solutions). Washington University will buy back biodiesel blended at B20 to B50 from RSHS Renewable Fuel Project. The Rockwood School District will expand the use of biodiesel in their diesel fleet to include some school buses. We will need a research assistant to help pick up oil, produce, test, and deliver fuel, and educate groups visiting MECSS.

### UNDERGRADUATE RESEARCH INTERNSHIPS

William Wiebold, University of Missouri

Continued improvements to soybean depend on attracting high-quality students to study agriculture and related disciplines. One goal is to foster the education of new scientists with a focus on soybean.

The Missouri Soybean Center (MoSC) will match two undergraduate students with two appropriate faculty mentors for undergraduate research internships. Students from any discipline may apply for an internship by providing a resume and a letter of application that includes career goals. A small committee appointed by the director of the MoSC will evaluate the applications and contact potential faculty mentors. Research topics for the internship will be determined by the mentor and the student with input from MoSC. The research must focus on soybean.

Students will follow internship rules so that they can obtain university credit in their chosen major. Upon completion of the internship, the student will write a research summary that will be posted on the MoSC web site. The interns will also develop a poster to be displayed at the 2018 US Soybean Symposium.

## Regional Affiliations

### MID-SOUTH SOYBEAN BOARD (MSSB)

Dawn Howe, Mid-South Soybean Board

The MSMC works with several southern soybean states to conduct research that impacts growers in the mid-south growing region. Compared to the Midwest, the delta region has unique needs for management and traits. The states associated with the Mid-South include Missouri, Arkansas, Louisiana, Mississippi, and Texas. The Mid-South Soybean Board was created in 2009 by the soybean promotion boards in Arkansas, Louisiana, Mississippi and Texas to coordinate soybean research in the 4-state area. The goals are to eliminate duplicate research spending and to develop and fund research of importance to our producers. During the fall 2012, the Missouri Soybean Merchandising Council joined the MSSB.



Pat Hobbs - Dudley, MO  
MSSB Board Chair

### NORTH CENTRAL SOYBEAN RESEARCH PROGRAM (NCSRP)

Ed Anderson, North Central Soybean Research Program

The North Central Soybean Research Program (NCSRP) was established in 1992 by state checkoff organizations in the North Central states: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin.

In December, the NCSRP celebrated 25 years of collaborating to improve farmer profitability through research. Rock Port soybean farmer Cecil DeMott, vice president of the group, represents Missouri on NCSRP board of directors and executive committee.

As a farmer-led organization, we invest soybean checkoff funds in university research and Extension programs to better understand and manage plant stressors that reduce soybean yield and farmer profitability.

The NCSRP's mission is to maximize producer returns by coordinating regional research efforts, minimizing the duplication of research, and assuring that regional research

projects are targeted at problems specific to the North Central soybean producer.



Cecil Demott, NCSRP Vice President, at NCSRP field day

### THE SOYBEAN RESEARCH & INFORMATION INITIATIVE

The Soybean Research and Information Initiative, a project funded by the North Central Soybean Research Program (NCSRP), helps make soybean research more accessible. The initiative launched in Spring of 2014 as an effort to build upon the functionality and success of the Plant Health Initiative (PHI) in developing an easy access one-stop shop for soybean research. The site can be found at [www.soybeanresearchinfo.com](http://www.soybeanresearchinfo.com). The Missouri Soybean Merchandising Council, a member of the NCSRP, is a supporter of this project.

Research from thirteen universities across the twelve NCSRP member states, as well as grower-focused information about soybean diseases and pests is featured on the site. The site also houses diagnostic tools for growers and resources on other agronomic issues. The University of Missouri, a contributor to the website, ensures growers in the Show-Me State are well represented within the agronomic and diagnostic tools.

The overview of 24 of the most prolific soybean diseases throughout the region is one of the most beneficial features of the site. Each summary includes the disease's life cycle, agronomic impact and how to manage the disease. To help identify the diseases, many pictures are included in addition to scouting tips and information about how to distinguish diseases that are commonly mistaken for each other. Learn more online through the NCSRP or at [www.soybeanresearchinfo.com](http://www.soybeanresearchinfo.com).





**MOSOY.ORG**  
(573) 635-3819



3337 Emerald Lane, Jefferson City, MO 65109