MISSISSIPPI DEPARTMENT OF
AGRICULTURE
&COMMERCE

Specialty Crop Block Grant Program-Farm Bill FY2014

Final Performance Report
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Introduction

The Mississippi Department of Agriculture and Commerce (MDAC) was awarded $481,130.08 in funding for the Specialty Crop Block Grant Program-FB (SCBGP-FB) in September 2014. MDAC has partnered with six organizations to implement 17 projects to enhance the competitiveness of specialty crops throughout the state. The final report for the project, "Public Relations Campaign to Promote Buying Local Specialty Crops," was approved in the first annual report. The final reports for projects, "Promoting Specialty Fruit Crops by Grafting Workshop Training," "Testing Plastic Mulches for Sweet Potato Seed Bed Performance," and "Training MS Farmers And Ag Professionals Through Annual Food Safety Conferences," were approved in the second annual report.

TABLE OF CONTENTS **PAGE**

PROMOTING SPECIALTY FRUIT CROPS BY GRAFTING WORKSHOP TRAINING

(previously approved in the second annual report)

Partner Organization

Mississippi State University

Project Summary

Production of fruit in the deep-south is a constant battle against insect and disease problems. Even with advanced pesticides and rigorous spray regimes pest control is a challenge. Growing heritage fruit that have originated under these adverse conditions is a necessity for successful production. This project provided 11 workshops to train agricultural extension agents on the use of various grafting techniques used in the propagation of fruit trees. The agents will then teach clients the most productive propagation techniques. Agent knowledge was evaluated before and after training to access knowledge gained.

Project Purpose

The skill of fruit tree grafting is still best conveyed by hands-on practice. It is particularly important that those who will train others should have actual experience in using the correct techniques. Both knowledge of the methods and skill in execution are necessary to ensure a good success rate for the survival of heirloom grafted plants.

This project has two objectives:
1. Provide hands-on training of extension service agricultural agents on various grafting techniques of fruit trees. These agents are expected to have knowledge about a wide range of topics. Without proper training they will not have this knowledge base. Grafting of fruit trees is a hands-on training that the vast majority of the younger agriculture extension agents do not have. Once the agents are trained they can conduct workshops for the cliental in their county.

2. Promote the propagation and use of heritage fruit for homeowners. Heritage fruit trees arose under indigenous growing conditions so they have built in resistance to many of the pests found in the hot, humid south. Trees that are successfully grafted will be planted at research and extension center sites to provide a source of scion wood for interested cliental.

This project does not build in any previously funded SCBGP or SCBGP-FB funded project.

Project Activities

Rootstock material was ordered from Willamette Nursery in Canby, Oregon, in late 2014 and 2015. Various grafting materials, including traditional grafting knives and a professional grafting tool, were also ordered from multiple suppliers.

During the winters of 2015 and 2016, scion wood of heritage apple and pear were collected from various sites in MS. Additional scion wood was collected in south Louisiana and north Florida by workshop participants. All the scion and rootstock material was stored in refrigerators until used in the workshops.

Brochures advertising the workshops were emailed to all 82 MS county extension offices and a newsletter email list of 200 individuals. Some county offices forwarded the announcement to numerous more individuals. Printed copies were also displayed in several counties.

Seven fruit tree grafting workshops promoting the use of heirloom apples and pears were offered in early spring of 2015 at various sites around the state. Four additional workshops were offered in March of 2016. Attendees for the workshops were from Mississippi, Louisiana, Alabama, Tennessee, and Florida. The number of participants for each workshop was limited to 35. All sites except one registered the maximum number of participants in advance.

The participants were given a pre-test to collect prior knowledge of grafting techniques and procedures. Participants were then presented a one-hour PowerPoint training on basic grafting techniques. This was followed by a 20 minute PowerPoint presentation on post-grafting tree care and planting. Participants were then given a post-test to determine knowledge gained.

Before being allowed to graft actual trees, there was a hands-on demonstration of various grafting methods (whip and tongue, cleft, and different grafting tools). Participants were also instructed on how to place the newly grafted tree into a container for growing until they could be planted in the fall. After this, participants were allowed to graft their own plants with supervision. They were instructed to record the fruit tree variety and grafting method used. This information was used to conduct a follow-up survey to evaluate grafting success. The participants were also encouraged to fill out an overall evaluation of the workshop.

During the 2016 workshops, only apples were grafted. In addition, the workshop evaluation was altered to be more effective and accurate.

Goals and Outcomes Achieved

Workshop Evaluation Results – Year 1

The workshop evaluation found that participants rated the program as helpful to them (4.8; 1 being 'no' and 5 being 'definitely'). They felt the material was presented in a clear manner (4.9) and enough detail (4.8). They felt they received the information they came for (4.9) and would attend future extension programs on other topics (4.9). Over 90% of participants rated the workshop handouts as very helpful and the overall program as very helpful. Although these workshops were free, participants said they would be willing to pay an overall average of $19.07 for this type of workshop. The potential economic impact of these workshops would be ($19.07 X 195) = $3,718.65. The participants did not strongly feel they would consider planting an orchard of heirloom fruit (2.6) or would consider growing heirloom fruit trees for sale (2.7).

Workshop Evaluation Results – Year 2

A summary of the workshop evaluation found that participants rated the presenters as knowledgeable of the subject matter (4.8), material related to real-life situations (4.8), the content was relevant to their needs (4.7), at an understandable level (4.8), well-organized (4.8), and based on credible, up-to-date information (4.8). They said attending this workshop was worth their time (4.8) and they would recommend this workshop to others (4.8). Participants increased their knowledge of the topics covered (4.8) and learned new skills (4.7). They will use information learned at this workshop (4.7) and will tell others about what they learned (4.8).

The participants did not strongly feel they would consider planting an orchard of heirloom fruit (2.6) or would consider growing heirloom fruit trees for sale (2.3).

Although these workshops were free, participants said they would be willing to pay an average of $23.27 for this type of workshop. The potential economic impact of the workshops would be ($23.27 X 76) = $1,768.52.

Workshop Pre & Post Test Results – Year 1

The Pre-test acted as the Benchmark and the Target was at least a 50% increase of knowledge gained in fruit tree grafting. Participants were asked the same 5 questions on the pre and post-tests. 1) What is a graft, average scores increased from 33% pre-test to 86% post-test. 2) Name one reason to graft a tree, average scores increased from 51% to 84%. 3) Name the wood grafted onto rootstock, average scores increased from 55% to 98%. 4) What is most common type of graft used, average scores increased from 28% to 84%. 5) What is the most important key to success, average scores increased from 24% to 69%. Overall, scores increased from 40% to 85% between the pre and post-tests, showing a significant gain in knowledge.

Workshop Pre & Post Test Results – Year 2

Participants were asked the same 5 questions on the pre and post-tests. 1) What is a graft, average scores increased from 56% pre-test to 86% post-test. 2) Name one reason to graft a tree, average scores increased from 68% to 97%. 3) Name the wood grafted onto rootstock, average scores increased from 54% to 91%. 4) What is most common type of graft used, average scores increased from 26% to 91%. 5) What is the most important key to success, average scores increased from 17% to 74%. Overall, scores increased from 44% to 88% between the pre and post-tests, showing a significant gain in knowledge.

Workshop Grafting Results – Year 1

Six to 8 weeks after completing the grafting workshop, participants were contacted by email or phone to determine the success rate for their grafting. Because of so many different varieties of apple and pears used, the numbers were pooled together by grafting technique.

The most obvious result is that participants had a greater grafting success rate with apples (78.1%) than pears (56.3%). The apple rootstock was more uniform in size and was not as hard as the pear rootstock, making it easier to splice to make the necessary cuts. Additionally, more pear rootstock died because of root rot.

Successful grafts of apples with whip and tongue, omega-cut grafting tool, and cleft grafts was essentially the same at 81.1, 82.2, and 82.4%. The omega-cut and Scionon® grafting tools were selected because they produce uniform, matching cuts on the scion and rootstock. This translates to greater grafting success with untrained people. In reality, for the Scionon® to be successful, collection of high quality, uniform size plant materials and lots of practice using the tool are imperative.

Overall grafting success of pears (56.3%) was much lower than apples. Whip and tongue and omega-cut methods were 48.4 and 48.3%. The cleft and Scionon® methods resulted in 68.4 and 60.0%, but only 5 participants used the Scionon® method, resulting in a small sample size. These participants had previous experience using this tool. It is of interest to note that the cleft graft method scored highest in both apples and pears.

Workshop Grafting Results – Year 2

Six to 8 weeks after completion of the grafting workshop, participants were contacted by email or phone to determine the success rate for their grafting. Because of so many different varieties of apples used the numbers were pooled together by grafting technique.

Successful grafts of apples with whip and tongue and cleft grafts were essentially the same at 80.3 and 84.6%. The omega graft resulted in a 66% success rate. The overall grafting success rate was 77% for this year.

Research Component Results – Years 1 and 2

Heirloom 'Bean' apple scions, originating from one tree, were grafted in the late winter of 2015 and 2016 by selected MSU employees who had little or no grafting experience. There were four participants in 2015 and five in 2016. All scion, rootstocks, and soilless medium were of the same source. Each participant grafted an apple using the whip and tongue, omega, and cleft graft methods. Results found that the success rate for each grafting method over the two years combined was 77.8%. This was slightly lower than the workshop participant results. This could be due to being done after the planned workshops and potentially past the optimal grafting period.

Extension agricultural agents will be able to take this knowledge and transfer it to clientele in their counties. This will further perpetuate the use of heirloom fruit trees in Mississippi.

Beneficiaries

Availability of locally grown produce is a poplar issue in today's society. Of even more importance is the production of fruit with little or no pesticides used. A third issue is the development of community and forest orchards that are allowed to grow wild. The use of heritage fruit trees would address these concerns. Since it can be difficult for homeowners to purchase Mississippi heritage fruit trees, another potential impact is the development of a cottage industry of producing these trees.

The heirloom fruit grafting workshops were a success, with a total of 271 people being trained, including 54 extension agents. Participants overwhelmingly found the workshops to be helpful, presented in a clear and understandable manner, detailed, well-organized, and they were willing to pay an average of $20.25 for the workshop.

Workshop attendees increased their grafting knowledge in every category of test questions. Over the two years workshops, overall pre and post-test scores increased from an average of 42% to 87%.

With the apple trees, averaged over all workshops, whip and tongue, omega-cut, and cleft grafts were all in an acceptable range of success. With the pears over one year, only the cleft and Scionon® grafts were at an acceptable percentage. For this study, it is recommended that agents use the cleft or whip & tongue grafting methods when teaching their clientele grafting methods. The omega-cut method would be an acceptable third option.

A PowerPoint presentation with a script and a supply list will be made available to Extension agriculture agents in MS for their use in workshops to train clients. Additionally, a publication on fruit tree grafting techniques is being developed. The study has also been submitted to a journal. Trees that were successfully grafted will be planted at research and extension center sites around the state to provide a source of scion wood for interested cliental.

Lessons Learned

It was discovered that clientele across the state are interested in learning fruit tree grafting techniques. They were also very interested in doing so using heirloom trees. This shows that the project had merit and was of high value to its' participants. This program has already been taught further in numerous counties and is expected to be taught throughout the state in the future. It would be best for anyone interested in teaching these workshops to be very selective in choosing fruit varieties that are suitable to their specific region. It would also be important to limit the number of participants to a manageable number.

Contact Person

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Additional Information

Jeff Wilson presenting at the workshop in McComb.

Participants at the workshop in Poplarville, MS, intensely focused on making proper grafts.

Jeff Wilson filling pots with growing media at the Goodman, MS, workshop.

Mississippi State University Extension Service agents practicing the grafting techniques at the Verona, MS, workshop.

Participants at the grafting workshop in Meridian, MS.

MS FRUIT AND VEGETABLE GROWERS ASSOCIATION

Project Partner

Mississippi Fruit and Vegetable Growers Association

Project Summary

Mississippi has had a history of large numbers of family farms tending small acreages. Most of these family farms depended on contract crops such as pickling cucumbers, pimento pepper and cayenne pepper for the major part of their income. These crops and contractors offered security. If the farmer could produce a crop of acceptable quality, the market and price were guaranteed. As a result of changing times, smaller families (meaning less available labor) improved transportation systems and company consolidations, these markets are no longer available. A renewed interest in rural living and small family farms trying to survive has increased the demand for information on growing and marketing specialty crops. This project supported the 2015 Mississippi Fruit and Vegetable Growers Annual Conference to offer growers a wide variety of topics to help boost their specialty crop output available for farmers markets and other direct markets.

This project built upon a previous SCBGP funded previously in FY2011 by utilizing the feedback from attendees' survey evaluations of the last conferences. Based on surveys from the previous conference, growers have overwhelmingly stated that they want to hear from other growers of specialty crops. The goal of this proposed effort is to enhance the grower's conference to better educate new and existing farmers on how to grow specialty crops to be sold at farmers 'markets and other direct markets by bringing in some experienced key speakers and providing a good environment for the meeting.

Project Approach

The Mississippi Fruit and Vegetable Growers Association (MFVGA) board of directors met and outlined the plans for the 2015 Annual Conference. The MFVGA board of directors held planning sessions every two months.

The conference was held December 2-3, 2015, at the Natchez Convention Center in Natchez, MS. This time was chosen because of availability of the convention center, as well as being midweek; allowing producers time to prepare for their weekend markets. Natchez was also chosen because of easy access and being only a one to two hour drive for a large number of present and potential specialty

crop growers. The conference consisted of a two day growers conference and a one day youth conference.

Work began in January of 2015 in preparation for the 2015 Mississippi Fruit and Vegetable Growers Association Conference. David Nagel, Extension Professor and vegetable specialist for the Mississippi State University, and Dr. Bill Evans, Associate Research Professor for the Mississippi Agricultural and Forestry Experiment Station, Truck Crops Branch began working to identify potential specialty crop growers and fruit and vegetable experts to make presentations at the conference.

Speaker selection was based on grower request to hear presentations from local growers that had achieved success in growing and marketing specialty crops. Niche specialty crops and topics applicable to most growing systems were considered. Changes in fruit and vegetable production in Mississippi over the last 30 to 40 years have changed the crops and the way produce is marketed. In the past, most small acreage growers' crops, such as pickling cucumbers, cayenne pepper and pimento pepper, were under contract for large processors. If the grower could produce the crop of acceptable quality, the market and price were guaranteed. All of these processors are no longer operating in Mississippi.

Growers Conference: The keynote speaker for the growers conference was Dr. Gilbert Miller, Extension agent and Researcher for Clemson University. Dr. Miller was chosen for his knowledge of water needs of vegetable crops utilizing irrigation. Dr. Miller's experience growing watermelons, a popular crop in Mississippi, made Dr. Miller a good choice for this conference.

Other speakers and their topics for the conference were: Don Kazery, Figs; Dr. Rebecca Melanson and Dr. Allen Henn, Fruit and Vegetable Diseases; Mr. Willie Sims, Mayhaws; Mr. Steve Richardson, Tomatoes; Anthony and Leilani Rosenbaum, Mushrooms; Dr. Scott Cagle, Marketing; Mr. Harvin Hudson, Peas; Dr. Bill Evans, Sustainable High Tunnel Production; Mr. Rodney Johnson, USDA Small Farm Programs; Dr. David Nagel, Crop Sequencing; Dr. Jac Varco, Soil Health and Productivity; Dr. Jeff Wilson, Grafting Fruit Trees; Dr. Rick Snyder, Starting Seed and Plant Care; Mrs. Gerri Ellis, Home Canning as a Cottage Industry; Mrs. Rebecca Bates, Starting a Farmers Market; and Mr. Purvie Green, Electronic Payments and Vouchers.

Youth Conference: Felicia Bell was responsible for selecting the speakers for the youth conference.

A total of 90 specialty crop growers and potential growers attended the growers conference and 26 youth attended the youth conference.

There was a delay is surveys conducted, this was completed in early 2017 to satisfy requirements of the grant.

Goals and Outcomes Achieved

Educate existing, new and potential farmers, on how to grow specialty crops to be marketed at farmers markets and other direct marketing outlets. Expectations are that attendees will gain knowledge from all speakers and will leave the conference with more knowledge and perceived abilities than when they came to the conference.

Short Term Outcomes: The project proposal showed an expectation for growers to learn from the speakers. One year after the conference, a survey and evaluation was sent to those attending the conference. The response was 15.5%.

Things learned from speakers by participants from the conference.
Learned how to keep irrigation lines clean
Learned need to check quality of irrigation water
Learned about soil acidity and fertilization
Learned you don't cure plat diseases, you prevent them
Learned how to scout for insect presence and damage and when to apply control measures
Learned that social media is a great way to advertise the local farmers market
Learned about cost share programs to help put up high tunnels
Learned how and when to graft fruit trees
Learning to grow your own transplants can save you money

Long Term Outcomes:
One of the expected outcomes of the Mississippi Fruit and vegetable Conference was to see an increase in membership and participation in association activities. This has not happened. Sixty four percent of those responding to the evaluation said that they would attend another conference. Fifty seven percent suggested subjects for a future conference.

One year after the conference there was positive feedback from attendees.
I learned about growing transplants. I am now growing my own transplants and saving money doing so.

I learned you have to be proactive not reactive when it comes to disease and insect prevention and control. Scouting my crops and using control and preventive measures has improved my yield and the market quality of my produce.

Beneficiaries

Direct beneficiaries of the conference were the 90 growers and potential growers that learned practices and procedures and took them home and made improvements to their operations. Indirect beneficiaries are their customers that can enjoy quality produce.

Lessons Learned

The timeline to secure the speakers and update the website combined with the board members' lack of time and knowledge in website building resulted in contracting using MFVGA funds for updating the site. The MFVGA also reached out to our board advisors at MSU to help secure expert speakers for conference topics of interest. The need exists for more training and research from experts in the field of growing small and medium vegetable farmer's capacity in the state. In addition, MFVGA recognizes it is important to identify new outreach methods to build more capacity for its members. The pre-registration numbers for the conference of attendees are down, the board members understand that outreach and communication using technology is needed. It is important to build upon the relationships from both our state ag universities to help enhance all small farmers.

There was a delay in the surveys that were to be conducted after the conference; this was completed in early 2017. The board learned that this should be completed at the conference instead of waiting to mail out separately. It is likely that more surveys would have been completed at the conference.

The information needed by participants varies, with those just getting started needing the basics while experienced growers need more advanced and technical information. Individual initiative will determine the end results.

Contact Person

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PUBLIC RELATIONS CAMPAIGN TO PROMOTE BUYING LOCAL SPECIALTY CROPS

(Previously approved in the first annual report)

Partner Organization

Mississippi Farm Bureau Federation

Project Summary

Farm Families of Mississippi has been created for the specific purpose of promoting Mississippi agriculture to the general public.

We are dedicated to educating those who are not actively engaged in farming about the real benefits we all get from agriculture, because without an appreciation of what it takes to provide the food, fiber, and energy that we all use, many people tend to dismiss agriculture as unimportant.

The Specialty Crops grant is used to create a specific message that promotes the buying of products from farmers growing specialty crops in Mississippi. Because the message is distributed with the other Farm Families of Mississippi messages, it receives much wider recognition than it would on its own. Since the beginning of this partnership, surveys have shown a more than 12% increase in the public's awareness and purchase of locally produced specialty crops.

Less than two percent of the public is actively engaged in production agriculture today. Many people are three or four generations removed from the farm and consequently have less of an appreciation for the benefits of a locally-produced food source. A well-designed, professional campaign is needed to educate the public about the benefits of agriculture in general. The Farm Families of Mississippi campaign addresses many of the issues that have been identified through surveys that the public is misinformed about or needs further information. We saw the Specialty Crops Grant Program as a way to educate the public about the benefits of buying locally produced foods which was one of the identified messages of the overall campaign.

This specialty crops promotion project was designed to run in concert with another public relations effort being run by the Farm Families of Mississippi. The larger project is the Ag Image Campaign for all agriculture. The specialty crop promotional effort was specifically directed to promote buying locally produced specialty crops. Many of these small specialty crop growers cannot afford the high cost of a media campaign. With this campaign, however, the specialty crops had their own TV spots, radio spots, and billboards that had the same look and feel of the larger campaign but targeted specialty

crops. This specialty crop promotion was the only portion of the overall campaign promoting specialty crops.

This project was previously funded by the 2011, 2012, and 2013 Specialty Crop Block Grant Program. Our program for FY2014 built on the name recognition that was achieved in the past. We also pushed the specialty crops in our cooking segments that ran on several of the TV stations and highlighted them in our social media posts. These segments highlighted the use of locally grown products and gave interesting facts about the commodities while the dish was being prepared.

Project Approach

The TV spot promoting the availability of specialty crops ran in equal rotation with the rest of the spots in our Farm Families of MS campaign. They ran on WLBT in Jackson, WLOX in Biloxi, WABG in Greenwood/Greenville, WTVA in Tupelo, WTOK in Meridian, and WDAM in Hattiesburg, plus Comcast cable systems throughout the northern third of the state and the Jackson metro area. This gave us statewide coverage. These spots generally ran during morning, noon, and evening news programming but we also picked TV shows, especially on cable, which fit our demographics and ran some spots in them. We ran approximately 950 TV spots featuring specialty crops. In addition to the paid TV ads, specialty crops were featured on several cooking segments at no charge.

The radio spot ran on the SuperTalk radio network statewide. This network of nine stations multiplied our coverage tremendously. For every spot we ran, it was played on nine stations for a fraction of the cost of doing that individually. The specialty crop ad was run over 880 times.

There were 14 billboards that featured a specialty crop that were displayed in Jackson, on the Gulf Coast, Tupelo, Meridian, Hattiesburg, and in the Greenwood/Greenville area.

We contracted with Market Research Insight to do our scientific survey to measure our impact of the campaign. We surveyed the public just prior to the campaign to get a baseline number and then again immediately following the campaign. The survey results show that our ads had the desired effect on consumers. The number of respondents saying they frequently try to find and purchase locally grown specialty crops remained high at 73% in May 2015. Respondents saying they recall the promotional ads increased from 49% in 2012 to 55% in 2013 to 60% in 2014 to 61% in 2015.

Farm Families of Mississippi is a group of approximately 240 organizations, companies, and individuals committed to educate and improve the image of agriculture among the state's consumers and the list is still growing. This is not a short-term project. The partners in this organization, spearheaded by Farm Bureau, have committed to an ongoing, multi-year campaign. To influence public perception, a consistent, sustained communication program is required and should keep in focus the long-term goal of creating positive public perception of agriculture in Mississippi.

Even though the specialty crop ads were branded and had the same look and feel as Farm Families of Mississippi ads, they had their own message that was not mixed with any of the other messages. The scripts specifically stated that specialty crops were being promoted.

Goals and Outcomes Achieved

The goal of the project was to raise the level of awareness among the public about the benefits of buying locally produced specialty crops. By raising awareness, the demand for these specialty crops will potentially enhance the viability and profits for the farmers producing them. TV spots, and billboards were used in the Jackson, Meridian, Hattiesburg, Tupelo, Greenwood/Greenville, and Gulf Coast media markets and radio spots were used statewide. The survey company stated, *"Those recalling ads continued to respond significantly higher in their ability to name Mississippi's specialty crops compared to those who do not recall ads. There is no question that the advertising program increases awareness of Mississippi's specialty crops and clearly provides benefits of purchasing them."* Public opinion concerning the importance of buying locally grown specialty agriculture products should be considered at universal levels, well over 90%. Because the numbers are so high already, the focus now should be maintaining that awareness. We attribute some of that awareness to a carryover effect from previous years' advertising. The numbers are pretty high already so that shows the ad campaign is having its desired effect. But we have seen that when advertising is stopped, public perception of your message goes down.

Four years of the Farm Families of Mississippi campaign (our FY2011 – FY2014) have included the specialty crops promotion that was funded through this grant. TV and radio spots featuring honey, sweet potatoes, sweet corn, pecans, and other specialty crops ran along with our regular Farm Families of Mississippi spots. Our plan for FY2015 is to feature those crops being sold at local Farmers' Markets. Continuing the messaging that has been started is crucial to the continuation of the awareness and support of specialty crops in Mississippi.

Beneficiaries

The groups that will benefit from this public relations effort will be the local farmers that raise these specialty crops and market them locally. Mississippi is the number two sweet potato producer in the nation with over 100 farmers growing sweet potatoes on approximately 20,000 acres. There are more than 2,000 acres of sweet corn produced in Mississippi by approximately 40 growers with most of the crop being consumed locally. Mississippi ranks between 23rd and 25th in the nation in honey production and produces about from 1.1 to 1.5 million pounds of honey each year. Mississippi contains between 14,000 and 16,000 acres of pecan orchards and thousands of yard trees. Orchards range in size from 25 to 500 acres. Pecans are sold directly to consumers, accumulators, or by mail-order.

While we don't have sales figures from all of the local farmers, the increase in the awareness of the benefits of buying locally produced foods should increase local sales especially when you combine that with the responses from the survey showing that the public realizes that buying locally helps the local economy. The benefits of an advertising campaign fade with time if it is not continued. Long term economic impact of a project such as this will be continued as long as the advertising campaign continues. The campaign highlighted the fact that most people try to find and buy fresh produce including specialty crops locally grown rather than a brand that they may be familiar with and accustomed to buying.

Lessons Learned

An interesting insight came as a result of our long-term campaign. We have taken a much larger interest in social media this year. We hired a social media marketing firm to raise the profile of our Facebook page, Twitter feed, and all other social media outlets. Our Facebook page has more than increase 5-fold this year. Conversations about how and where your food is grown are abundant and continue to expand.

We feel like this was a very worthwhile effort because it showed that the public really does want to buy locally produced food and understands the benefits of doing that. The challenge is reminding them of it enough so that they are motivated to take the extra step to find and purchase the locally produced food.

It's important to make sure that your message is continued on year after year or the public will forget they ever heard it. Reminding people of what they already know is just as important as having them learn it in the first place.

Contact

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Additional Information

To see the TV spots, go to the URL listed below.

http://www.growingmississippi.org/tv-spots/

MISSISSIPPI FARMERS MARKET CERTIFICATION PROGRAM

Partner Organization

Mississippi Department of Agriculture and Commerce

Project Summary

The Mississippi Certified Farmers Market Program is a marketing initiative designed for true farmers markets across the state; it has become important to the preservation and promotion of Mississippi agriculture. This voluntary branding program is offered and administered by the Mississippi Department of Agriculture and Commerce (MDAC) to identify and promote markets for Mississippi grown fruits, vegetables, plant materials, and other specialty crops products made and/or processed in Mississippi. This project allowed those certified markets to promote the specialty crops at their market to increase sales of specialty crops and in turn to also increase the number of specialty crop vendors selling at these markets as a result.

MDAC received FY 2007 Specialty Crop Block Grant Program funds to begin the Mississippi Certified Farmers Market Program. The purpose was to create brand recognition to farmers markets with Mississippi farmers selling their produce directly to the public. Due to the success of this program, MDAC received FY 2008 and FY2012 SCBGP funds to continue the program. Funding was sought again with the 2014 Specialty Crop Block Grant to further continue this program. Markets deemed 'Certified' must have at least two Mississippi farmers and at least 51% of products sold have to be grown in Mississippi. The objectives of the project were to:

1) Continue to identify which farmers markets in the state are operating as a true 'farmers' market with Mississippi growers selling their specialty crops directly to the public.
2) Expand and increase the number of markets participating in the Mississippi Farmers Market Certification Program.
3) Highlight each of the Mississippi Certified farmers markets and Mississippi's specialty crops through promotional efforts.

It is important that MDAC continued to offer this program to Mississippi's Farmers Markets as they continue to boom across the state of Mississippi. The number of markets rose significantly from about 20 markets in 2006 to a total of 80 markets in 2013. At the conclusion of this grant, there were a total of 92 known markets in Mississippi.

As the number of markets grows, the variation in operating structure among the markets also grows. Sometimes the term 'farmers' market is used to describe produce markets that sell fruits and vegetables from 'peddlers' and wholesalers rather than directly from farmers.

Farmers markets have begun to rely on the benefits of this program. By implementing this program and branding markets that operate as true 'farmers markets,' participating markets gained recognition and credibility among their shoppers. Consumers are now able to identify what 'certified' markets are and understand the benefits of shopping at certified markets. Consumers shopping at these markets can be confident that they are buying locally-grown produce that they desire. This program has allowed MDAC to establish greater contact with these markets so they can be made aware of educational programs, grant funding, and technical assistance opportunities. Many market managers need assistance with promotion of their markets. Varying constraints include lack of funds, knowledge, and time. Numerous managers have expressed this concern and the desire to increase their customer base in previous surveys conducted by MDAC. This program has been successful in creating awareness of specialty crops available to consumers at farmers markets; there was vital need to continue with this program. Mississippi lawmakers and other state agencies have recognized this as a legitimate program with merit and have established exemptions for these markets and their vendors.

Project Approach

Each year of the grant program, a Farmers Market Manager Workshop, hosted by the Mississippi Department of Agriculture and Commerce, was held in Spring 2015, 2016, and 2017. The Certified Farmers Market applications and grant packets were given to each farmers market present; those unable to attend were mailed packets. Various topics were discussed including the Certified Farmers Market Program and the benefits of this program. This was a great time for new market managers to learn about this program and promotional opportunities available through the specialty crop grant.

In 2015, there were 86 known farmers markets, of these 29 became certified (34%). In 2016, there were 88 known farmers markets in Mississippi, of these 30 became certified (34%). In 2017, there were 92, known markets with 36 being certified (39%).

Markets that sought certification were done so by MDAC's Consumer Protection Division Inspectors. MDAC staff created press releases for each market once they passed inspection; these were dispersed to each market's news outlets. MDAC also notified the Department of Revenue and the Mississippi Department of Health to inform them of which markets have passed certification. Certified Farmers Markets are listed on the MDAC website: http://www.mdac.ms.gov/bureaus-departments/farmers-market/certified-markets-mississippi/ and are also listed in the summer month editions of the *Mississippi Market Bulletin* (which reaches over 42,000 subscribers).

Once markets passed certification, they received an award packet that detailed the mini-grant program available. In 2015, Certified Farmers Markets were eligible to apply for up to $250 to promote the specialty crops sold at their market. This amount was chosen so each market certified could theoretically apply and take advantage of the program. However, only one market took advantage of the specialty crop assistance. Due to the lack of participation in 2015, MDAC revised the grant to offer larger grants on a first-come, first-serve basis. MDAC requested a budget modification to raise the grant amount certified markets could apply for specialty crop promotional activities. Certified markets could apply for up to $1,000 to promote specialty crops sold at the farmers market. Only specialty crops could be promoted and reimbursed with the grants funds. Five markets were awarded the grant in 2016 and six in 2017.

Results of surveys, conducted my MDAC, showed there was an average increase of 12% in the number of specialty crops vendors in 2015, an increase of 56.5% in 2016 and an increase of 16% in 2017. The average of all three years was a 28% increase in specialty crop vendors, surpassing our goal of 20%.

The Mississippi Department of Agriculture conducted and oversaw all aspects of the specialty crop certified farmers market grant program.

Goals and Outcomes Achieved

Although the Mississippi Certified Farmers Market Program is seasonal, MDAC continually works on this program throughout the entire year. Database updating, budgetary concerns, contacting farmers' market managers, and fielding calls and questions from those who might need assistance in starting a new farmers market are a regular occurrence.

Some farmers markets are open year-round, but most do not open for business until mid-spring and close around the end of September or October. The Mississippi Certified Farmers Market Program officially began in March/April with application packets mailed out to managers of all known farmers markets across the state or handed out at the statewide Farmers Market Manager Workshop each Sping. Once applications were returned to the Market Development Division, inspectors from the agency's Consumer Protection Division made an appointment with the manager of each of the applicant for the inspection of the market to become certified.

Once markets passed certification, they received an award packet that detailed the mini-grant program available. In 2015, Certified Farmers Markets were eligible to apply for up to $250 to promote the specialty crops sold at their market. This amount was chosen so each market certified could theoretically apply and take advantage of the program. However, only one market took advantage of the specialty crop assistance. Due to the lack of participation in 2015, MDAC revised the grant to offer larger grants on a first-come, first-serve basis. MDAC requested a budget modification to raise the grant amount certified markets could apply for specialty crop promotional activities. Certified markets could apply for up to $1,000 to promote specialty crops sold at the

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The goal of this project was to increase the number of specialty crop vendors at certified farmers markets across the state. The target to have an increase of 20% in the number of specialty crop vendors was achieved.

Through this program, we expected specialty crop sales to increase at certified farmers markets. Due to the difficulty of obtaining sales figures directly from growers, this was measured by the number of farmers selling fresh Mississippi produce at these markets. The target was to increase the number of farmers selling fresh produce sold at certified farmers markets by 20%. Surveys were conducted to Certified Farmers Markets that received the grant only in order to determine the growth in the number of specialty crop growers at their respective market. From 2014-2017 Certified Farmers Markets saw an average increase in specialty crop vendors over three years by 28%.

Overall, the goal of the project was reached with variability from year to year. The weather plays such a significant role for farmers markets and the past few years, each part of the state has seen extreme conditions of rain, drought, late frost, etc. This can detriment a farmers total crop for the year, despite these challenges, we still saw an increase in specialty crop producers selling at markets, therefore adding to our state's specialty crop industry.

Beneficiaries

At least 36 markets benefited from this grant, while only 7 markets and specialty crop growers truly directly took advantage of the program. We continue to see to the number of farmers markets increase in addition to the number of specialty crop producers selling at these markets.

Lessons Learned

The Mississippi Department of Agriculture and Commerce revised the grant to increase the amount given to markets to have a larger impact on the market's specialty crop products. Certified farmers markets could apply for funds up to $1,000 to promote the specialty crops sold at the market. This slight change increased participation for the grant program in 2016 and 2017 market years. Yet it is still hard to get the markets to understand the ease and potential this

program has to offer. MDAC has tried to provide as much information and assistance to the markets in order to get them to take advantage of this program to promote specialty crops sold at farmers markets, however, there is some disconnect that must be overcome.

Contact Person

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DEVELOPING A MS-SPECIFIC MODERN STRAWBERRY PRODUCTION SYSTEM

Project Partner

Mississippi State University

Project Summary

Mississippi has a smaller strawberry industry than surrounding states. This project sought to increase local production and local knowledge supporting strawberry production in the state. We conducted two years of cultivar and timing trials, and trained more than 150 people at two successful field days. We taught growers, industry supporters, and extension workers about strawberry production, disease and pest management, post-harvest handling, and marketing. Following the project, we can document two new growers raising more than 25,000 plants with an estimated annual crop value of $25,000 to $75,000. We can document significant changes in the skills of the research staff to grow and manage a strawberry trial. We can document over 90% of field day participants reporting positive changes in their knowledge of the crop from the material presented at the field days. We documented increased knowledge among extension and service workers about fresh market strawberry production that should translate into quality service to growers for years to come. We can document at least two follow-on proposals for outreach, research and teaching that were in preparation at the end of this project's performance period that should provide continued support to strawberry growers for several years to come.

Project Approach

In the early part of the 20th century, Mississippi had hundreds of acres in strawberry production. Remnants of this industry remain today, with strawberry buildings still in place in Madison Co. and in the history of MSU's Crosby Arboretum near Picayune, MS. Before it was an arboretum preserving rare pitcher plants, it was a pine plantation. Prior to that, much of it was one of the largest strawberry farms in the southeast. Today, the U.S. strawberry industry is dominated by California, with Florida a distant second in production. States like North Carolina have maintained a regional presence through regional wholesale and direct marketing of high quality fruit. It is this avenue that holds promise for Mississippi. We have thousands of acres of land with air and water drainage needed for quality strawberry production. What we have lost is a foundation of information on high-quality production and the infrastructure to do the high-end production needed to produce a quality crop. What we have also lost, is a system that takes the best of production systems in other areas and adopts it for Mississippi conditions. For instance, if we take the North Carolina

system, it is possible that we could have even higher yields than they do because we have a warmer winter in most years. This warmer average temperature can allow us to set flowers and fruit nearly continuously through December and January, when it becomes too cold in North Carolina to produce fruit. Unfortunately, no matter what we do, we cannot bring in fruit before the fruit matures in Florida. Therefore, we cannot compete in the wholesale arena early in the season. By the time we can enter the wholesale arena in March, prices have declined from December and January highs. This leaves us the local and regional retail and high-end wholesale markets to build into; this is what Louisiana does. Indeed, most of the "local" strawberries sold in Mississippi each spring are Louisiana berries. After discussions with an expert from North Carolina, we believe that Mississippi is a viable location to build a local/regional strawberry system. Such a system will need to use the very best production strategies and commitment to excellence to produce yields needed to be profitable. The rise in farmers markets, community supported agriculture, higher end restaurant trade, and farm-to-institution outlets have created ready outlets for any berries produced, outlets that to date are underserved by local production.

This project is not a continuation of a previously funded SCBG project. This project has not been submitted to any other agency, Federal, State or private, for funding.

Overview: Using the guidance of a national strawberry expert and an experienced local grower, we built a two-year strawberry cultivar evaluation project. In this project, we evaluated more than ten cultivars over two seasons. We tested several varieties at a local farm, too. We also hosted two field days Crystal Springs.

Field Cultivar and Timing Trials: Using the recommended practices presented at a strawberry short course in Choctaw, MS in May 2014, we established cultivar timing and cultivar trials at the MSU Truck Crops Branch at Crystal Springs. We worked with Barkley Poling, the Executive Director of the North Carolina Strawberry Growers Association on design and execution of various parts of the project. We tested ten June bearing types and two transplanting dates in 2015-2016. Plants were planted on raised beds, set in twin rows, with plants and rows 12 inches apart centered on the bed. Each plot had 20 plants. During the flowering period, row covers were used for frost protection, deployed three times in winter 2016 and twice in winter 2017. Additional irrigation was supplied as needed from establishment through harvest.

Berries were harvested two or three days each, graded and weighed. This provided information on earliness, yield, quality (size and variance in size), and length of harvest period. Samples were taken of marketable fruit and frozen for later evaluation of color, sugars, and acidity

Field Day: In spring 2016 and spring of 2017, the MSU Truck Crops Branch hosted a commercial strawberry production field day. The field day featured a tour of the plots, discussion of data gathered to date, production training by extension professionals, and meetings with potential market partners. We displayed the strawberry bed shaper in 2017 and discussed why it is advantageous to use when compared to a standard vegetable bed shaper. Pre- and post- event surveys indicated significant changes in knowledge and increased interest in strawberry production by many growers in attendance. Significant networking and partnership discussions occurred over lunch and during breaks, too.

Twelve strawberry cultivars were evaluated in three years of trials at Crystal Springs. This resulted in several cultivars being eliminated from consideration for recommendation. It also resulted in significant understanding and training about disease control and crop management for the staff at MSU's Truck Crops Branch and growers.

The project completed its purchase of a bed shaper mulch layer which was displayed and discussed at the April 2017 field day. The demonstration trained growers on the importance of land preparation and proper planting bed geometry for commercial strawberry production. The machine will be used to continue demonstration and training activities for years after the project termination.

Follow up Funding: The project has informed a large regional strawberry production grant application made in winter 2017, just after this project's performance period ended. At least one other proposal to USDA to support regional strawberry education is in preparation as of the submission date of this final report.

This project did not directly benefit commodities other than specialty crops.

Goals and Outcomes Achieved

Original Proposal Introduction: To grow an acre of fresh strawberries, it can cost over $18,000, based on budgets from North Carolina. Average yields can be over 1.0 lbs./plant, with very good growers achieving yields of over 2.5 lbs./plant. This can mean yields of 20,000 to 50,000 lbs./acre. At a retail price of $1.50/lbs., this works out to $30,000 to $75,000/acre. If this project can help generate 20 new acres of production in three years, that would be $600,000 to $1,500,000 in annual sales. Additional impact would come from improving yields on existing acres. We estimate that the project could improve yields on ten to twenty existing strawberry farms and result in ten to twenty additional farms starting to grow strawberries. Each of the existing farms would have annual net sales increases of $3,000 to $15,000. The new berry farms would have net sales of $2,000 to $114,000 based on one or two acres per new grower, and the costs and returns per acre described above. In addition to helping berry growers, impacts of the project on planted acreage and yield will allow consumers and local restaurants would have access to more locally-grown berries, benefiting the former by providing more local, healthy alternatives in the market, and the latter by improving menus and marketability due to the local and fresh nature of local berries. Conservatively, it is estimated that more than 100 local restaurants would buy Mississippi strawberries if they were more available. That works out to a modest 1.2 new restaurant accounts/county. We estimate that more than 100,000 consumers would be new purchasers of Mississippi strawberries if our modest acreage and yield increases our met. At the low end of our yield and acreage estimates, that works out to somewhat less than 2 pounds per new consumer if half of the estimated new yield goes to new customers and half goes to wholesale and to existing retail customers buying more from the in-state acreage.

Our original goals of this project were to increase planted acreage of strawberries, increase strawberry yield on existing acreage, and to increase the farmer and local service worker knowledge about cultivars and modern production practices in strawberries. We can document that the project contributed to more than 27,000 plugs set in new strawberry plantings for the 2017-2018 season in Mississippi, with a potential retail value of fruit production in the $27,000 to $75,000 range. We cannot easily measure changes in production or impacts on most existing farms. However, our surveys grower conversations at the field days indicated that growers left the events with more information about disease and insect control, and cultivar selection and management. Several had not been using frost protection and indicated they would now consider it. Our misfortune with anthracnose (See Lessons Learned) became an educational tool during the field tours we provided. We also provided a great forum for our extension and research team to work with and learn from each other in strawberry production support. Thus, we believe the goal of increasing local service worker knowledge has been met.

Our proposed performance measures included planted acreage, reported yield per acre, and changes in self-reported knowledge during field day pre- and post-testing. The proposed benchmarks included estimated acreage at the start of the project by the cooperating growers. Currently, Mayhew Tomato Farms plants around two acres of strawberries. They have not shared yield data with us for now, nor any increase in acreage. We collaborated with Foot Print Farms in Jackson and they have a 500-plant berry patch planned for the 2017-2018 crop year. Choctaw Farms is in a transition period and will not have any new strawberry plantings in 2017-2018, but their total fruit and vegetable crop production continues to increase, in part because of support from this and other efforts to serve specialty crop growers through the SCBG program. The original targets of the project were to increase strawberry acreage by 10-20 acres across the state; increase yield on existing acreage by 5-10%, and increase self-reported knowledge of modern strawberry production and cultivars in 75% of participants at our field days. We have at least 1.5 new acres for the 2017-2018 season, do not have numbers on yield increases, and increased self-reported relevant knowledge in over 90% of field day participants in both 2016 and 2017.

In terms of some other specific impacts and outcomes, our project influenced new plantings on at least three farms in the state. One has small plantings of less than 1,000 plants, with yields of nearly 1.0 lb./plant. These retailed berries are generating approximately $3,500 in sales for the grower. As of late 2017, just after the project ended, another grower set out nearly 25,000 plants on over an acre in the Mississippi Delta. This planting was the farmer's first use of a bed shaper/mulch layer with drip irrigation. The berries will be Good Agricultural Practices (GAP) compliant. They are pre-sold and the original project PI will continue to mentor the grower through the 2018 picking season.

The lead PI continues to field questions about new plantings and production through and beyond the termination date of the project.

In terms of recommendations, we showed that late September and early October plantings performed better than mid-October or later plantings. Frost protection can be beneficial. Quality planting stock is critical as is appropriate and diligent management. New growers with capital or experience challenges would

likely benefit growing smaller numbers of plants well than skimping to grow larger patches with less than optimal inputs and attention. We would also recommend that industry support professionals maintain formal and informal lines and webs of communication and joint edification for the benefit of the industry.

Beneficiaries

The project hosted three field days and trainings, reaching nearly 300 direct contacts. Another 5,000 + people were exposed to the effort through visits and the Fall Flower and Garden Fest at the Truck Crops Branch Experiment Station in Crystal Springs. Between six and twelve farmers reported that they would begin or increase strawberry acreage because of trainings received. Nearly 50% of all direct contact participants were limited resource and/or minority farmers.

Over seventy people attended the strawberry production field day in April 2017. All participants responding to pre-and post-activity surveys indicated that the training would likely change their production or farming methods. Several indicated that the program would increase the likelihood that they would start growing strawberries. In fall of 2017, two farms reported new plantings of strawberries, representing nearly 2 new acres of berries, with a potential value of over $50,000, and over 200 hours of total employment for the farmer and labor.

The project trained new, beginning and established farmers, NRCS staff, university staff and faculty, and the public about strawberry production. The project included the first significant strawberry trials at any unit of Mississippi State University in decades.

Lessons Learned

Strawberries can be grown successfully and profitably in central Mississippi and surrounding areas, especially if they can be sold at or near a retail price. They are difficult to grow and they grow in what is normally an off-season in a summer vegetable area. It can be difficult to convey to skilled staff, colleagues, and even administrators the day-to-day demands of this crop compared to less intense vegetables, row crops or other more traditional agricultural enterprises in the area. It was easy to train staff to pick and grade the berries, though one does see differences among pickers that must be accounted for and managed.

The project PI left the university in early summer 2017. This may reduce the continuity of the program after the end of the project. However, the PI remains in state and continued working with new and existing strawberry growers past the termination date. The crew at the research station was trained in strawberry production and operation of the bed shaper and will have the ability to execute demonstration and research as needed in the future.

The project had great success in its field days. Agendas were well planned and speaker recruitment and scheduling was done in a timely manner. The timing of the field day in 2017 corresponded well to the crop peak, whereas in 2016 some other priorities pushed it beyond the crop peak and attendees did not get to see the best of the berries. Attendee recruitment was good, though a stronger partnership with Extension during project development and from before the entire performance period began may have helped even more by providing access to mailing lists, websites, and traditional/social media feeds to improve publicity.

We did modify our cooperator list as it became difficult to manage cooperators distant to the Crystal Springs. Choctaw had some personnel changes that kept them from participating, too.
We were not able to develop a local plug production system based on North Carolina methods as proposed. We ended up buying in plugs due to some local logistical issues with greenhouse space and labor availability to properly root tips in August and September
We substituted regional meetings for the Southeastern Strawberry Expo in North Carolina for training and networking by the PI. We maintained communication with the NC Strawberry Growers Association throughout the project.

We were able to acquire the strawberry bedder late in the project performance period. Though we ended up not having it for our planting dates, we were able to demonstrate it at our 2017 field day and it will be available for future trainings and field work at Crystal Springs.

Sprinkler irrigation was not available, and our frost protection fabrics proved more than adequate for the dates we used them. We saw no significant frost damage on flowers open or fruit set prior to the nights we protected the crop with frost protection fabric.

Social media site Twitter was used occasionally for casual communication during the project. Most that reacted to the posts were scientists or professional support workers, though occasionally a grower (usually out of state) would “like” or retweet a post.

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Additional Information

Below are some photographs related to activities in the project:

Fig. 1 Strawberry plugs ready for transplanting into a Crystal Springs cultivar trial, fall 2015.

Fig 2. Flier used to advertise 2016 field day.

Fig. 3. Crystal Springs field day layout, spring 2016.

Fig. 4. Mississippi State University Associate Extension Fruit Specialist Eric Stafne speaking at the 2016 Commercial Strawberry Production
Workshop at Crystal Springs.

Fig. 5. Mississippi State University Assistant Extension Plant Pathologist Rebecca Melanson speaking at the 2017 Commercial Strawberry Production Workshop at Crystal Springs.

Fig. 4. Strawberry fruit sample being prepared for freezing.

MISSISSIPPI SWEET POTATO PROMOTION/MARKETING CAMPAIGN

Partner Organization

Mississippi State University

Project Summary

Per capita sweetpotato consumption in the United States and certain European nations continues to increase as more consumers seek health conscious foods. As a result, more sweetpotato acreage is being planted in European and Central American nations. Sweetpotato production is an important part of the Mississippi economy. As more sweetpotatoes are grown domestically (especially in North Carolina) and internationally, competition increases and price decreases. In order for Mississippi sweetpotato producers to remain competitive, it is imperative that the state's producers maintain buyer contacts, acquire new business, and market the superior quality of their product. This project enhanced Mississippi's sweetpotato industry through promotion of "Mississippi Sweetpotatoes" to domestic and international produce buyers at the Produce Marketing Association (PMA) Fresh Summit Trade Show. This activity enhanced Mississippi's sweetpotato industry by increasing sales and brand loyalty.

Project Purpose

The purpose of the proposed project was to influence purchasing decisions of produce buyers by promoting "Mississippi Sweetpotatoes" at the Produce Marketing Association's annual trade show. The overriding objective was to create brand awareness for Mississippi-grown sweetpotatoes among produce wholesalers and distributors. In previous years, the Mississippi Sweet Potato Council (MSPC) has obtained Specialty Crop Block Grant Program (SCBGP) funding to promote "Mississippi Sweetpotatoes" through various activities with one being participation in the PMA tradeshow. Marketing studies show brand awareness requires long term commitments over several years. With the current consumption trend ticking upward for sweetpotatoes, it is vital that the MSPC continue with the marketing/promotion program proposed in this project. This project highlighted the availability and quality of "Mississippi Sweetpotatoes" to a targeted audience of national and international produce industry executives. The timing of this proposed project was perfect to raise awareness and increase sales of "Mississippi Sweetpotatoes".

Project Activities

Four Mississippi sweetpotato farms represented the MSPC at the PMA Fresh Summit Trade Show in Atlanta, GA October 23-25, 2015. Those farms were C&W Farms, Edmondson Farm, N&W Farms, and Topashaw Farms. Additionally, Sylvia Clark, Secretary of the MS Sweet Potato Council participated in and helped to coordinate the event.

The budget and timeline for the project were revised in spring 2016 to make funds available for promotional brochures. 25,000 brochures were purchased and used at the 2016 PMA Fresh Summit Trade Show and for broader marketing efforts throughout the state.

All funds and efforts were used to solely enhance the competitiveness of specialty crops.

With the Executive Director of the Mississippi Sweet Potato Council resigning in April 2015, Dr. Stephen Meyers and incoming secretary Sylvia Clark handled the planning and coordinating of all project activities.

Goals and Outcomes Achieved

The goal was to participate in the PMA Trade Show in order to attract new buyers to purchase Mississippi sweetpotatoes in order to increase sales. At the 2010 PMA Show, Mississippi grower/packers were able to attract several new buyers totaling over 14,000 cartons of sweetpotatoes valued at $224,000 (Benchmark). The target for this project was to increase this by 10%.

Of the four participating Mississippi sweetpotato farms in the 2015 PMA show, three reported increased sales. The fourth reported that their attendance ensured they maintained sales by interacting with existing clientele. Though sales directly associated with attendance at this event are difficult to determine, those farms in attendance believe that their participation in the tradeshow did result in meeting the increased sales target of 15,400 cartons put forth in the original proposal. Producers credit trade shows like the PMA Fresh Summit and other promotions of Mississippi Sweetpotatoes with the increase in demand and subsequent 12.7% increase in planted acreage between 2015 (25,200 acres) and 2016 (28,400 acres).

Printed promotional brochures were distributed across the state of Mississippi, including all the state's welcome centers. Welcome centers report that the Mississippi Sweetpotato brochures are a favorite of visitors and many centers have requested additional copies. Furthermore, consumers have contacted MSPC representatives for additional copies.

As a result of success from past PMA Fresh Summit Trade shows, additional sweetpotato farms now participate in the Mississippi Sweetpotato booth. Six farms participated in the 2017 tradeshow. Also

as a result of demonstrated success, the participating farms have agreed to invest their own money into securing booth space.

Beneficiaries

Participating sweetpotato packers in the project represent approximately 50% of the 28,100 planted sweetpotato acres in the state of Mississippi. Increased sales from participating in this project benefit the participating farms directly by increasing revenue and all Mississippi sweetpotato farms indirectly by contributing to broader "Mississippi Sweetpotato" brand awareness.

Lessons Learned

The Executive Secretary of the MSPC and Co-PI on this project, Benny Graves, resigned from the Council in April of 2015. This placed more responsibility on Dr. Meyers and incoming Secretary, Sylvia Clark.

From an administrative perspective, the greatest lesson learned from this project is that collaboration among competing sweetpotato farms in Mississippi is possible with proper guidance and leadership. Sweetpotato producers in Mississippi believe they offer a superior product, but would benefit from greater organizational structure and cohesiveness to market their Mississippi Sweetpotatoes collectively.

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Additional Information

A letter of appreciation from one of the participating farms, Topashaw Farms, is included with this report.

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Fax: 662-682-7736

WORLD CLASS QUALITY
Topashaw Farms Packing, a General MS Partnership
826 HWY 341 S, Vardaman, MS 38878
www.topashaw.com

To whom it may concern,

Because Topashaw Farms has had the opportunity to participate in the PMA Fresh Summit Convention each year, we have experienced a steady growth in sales. This growth comes not only from established customers, but also from the opportunity of meeting new people that we would otherwise not cross paths with.

The PMA provides a "store-front" in which to market our sweet potatoes. It also provides customers a way to "put a face with a familiar voice". There is no better feeling in the world than to be able to speak proudly about what the State of Mississippi has to offer when someone comes up to you and says, "Man, those are some beautiful sweet potatoes! I didn't even know Mississippi *had* sweet potatoes!" We've not only increased the sales of our business, we've also utilized the opportunity to educate those who are not familiar with our products, and have seen tremendous growth in the demand for Mississippi sweet potatoes both nationally and internationally.

We appreciate the opportunity to proudly represent our state each year.

Sincerely,

Joe and Melissa Edmondson
Topashaw Farms

ASSISSTANCE FOR GAP/GHP

Partner Organization

Mississippi Department of Agriculture and Commerce

Project Summary

The Mississippi Department of Agriculture and Commerce (MDAC) implemented a cost-share program to help offset some of the costs to acquire the Good Agricultural Practices/Good Handling Practices (GAP/GHP) certification and seek additional markets for growers to sell their products. Due to growing food safety concerns, many large buyers in the marketplace such as grocery stores, wholesalers, food service providers, schools, and other institutions are requiring this certification from their growers. This credential ensures stakeholders in the supply chain that the product they are receiving is of a predetermined quality standard. In addition to the cost share program, MDAC also created an informational video to educate growers on food safety practices they should implement on their farm in order to help them pass a certification such as GAP/GHP.

Project Purpose

The objective of this proposal was to increase the number of Mississippi farmers possessing the GAP/GHP certification. By increasing the gross number of Mississippi farmers with GAP/GHP credentials, the market for fresh local produce will be expanded within the state. Expanding available supply capacity within the marketplace will provide institutional buyers with additional outlets for a fresh local supply of produce to meet their operational needs.

Our local farmers in Mississippi have the desire to grow into large scale producers who can supply the needs of institutional buyers; a program to obtain the necessary credentials must be offered to receive GAP/GHP certification so they may compete with regional whole suppliers.

Project Activities

The program requirements and application for cost-share reimbursement was developed early in 2013 (through the FY2012 Specialty Crop Block Grant Program). Information and application instructions

can be found at the MDAC website: https://www.mdac.ms.gov/bureaus-departments/market-development/gapghp-certification-cost-share-program/.

Additional announcement avenues and locations including several press releases; articles and reminders about the program in the Mississippi Market Bulletin; numerous conferences and workshops including a GAP/GHP training workshop; and MS Fruit and Vegetable Growers Association (MSFVGA) Annual Conference and Tradeshow.

To coincide to the cost-share program, MDAC worked with Mississippi State University Ag Communications to create an informational video for those farmers interested in acquiring certification such as GAP/GHP. Many farmers have heard of the program, yet there are many reservations about being able to comply with regulations. However, many farmers are already practicing food safety and may fail to realize it, that is why we created this video to go through some important practices to implement and record on a farm. MDAC filmed different aspects of packaging on various Mississippi farms including practices for packing product in the field and packing house. A link to the video is at the end of the report. DVDs were also duplicated for those without internet access and those have been mailed out to growers upon request.

MDAC reimbursed a total of 50 growers over the past three years for a percentage of their GAP/GHP certification costs. The overall number of MS GAP/GHP operations has increased from 32 to 39 according to the latest USDA GAP/GHP report. In order for growers to receive reimbursement, they have to submit an application, W9, a copy of their audit bill, score sheet to show completion, and documentation of the payment. Only Mississippi producers are eligible, and the farm must be located within the State of Mississippi. Only audits for specialty crops are eligible for reimbursement.

Goals and Outcomes Achieved

The goal of this project to increase the number of Mississippi farmers with the necessary credentials to participate in large scale distribution of fresh, local produce by a minimum of 50 percent was achieved. Our target of assisting at least 16 additional growers (from 32) by providing financial assistance was not quite met. While we had 50 reimbursements over the course of the three years, the total number of operations benefiting from this program was 37. However, some growers have pursued other food safety audits besides GAP/GHP that we are not aware of.

Beneficiaries

A total of 37 specialty crop operations benefitted as a result of the GAP/GHP cost share reimbursement program. This certification opened new market opportunities and avenues to sell their products. Growers that sell to our Farm to School program have benefitted from this program by being able to

sell directly the school system. This has been a great opportunity to link our projects together to further enhance both programs. We expect this number to increase as with the new federal produce rule becomes effective in addition to the increased awareness of our program and informational video.

Lessons Learned

This has been a successful project with many thanks to outside parties publicizing this opportunity. Grower organizations, workshops, meetings, and emails have included information about this funding cost-share program in their agendas and newsletters. Since someone in our agency serves as a GAP/GHP Certifier for USDA, we have a close working relationship to have a checks and balances system to ensure this program is not abused.

This video has proved very useful when speaking to growers to give them a better understanding of the importance of food safety and the audit program. Copies of the video have been requested by growers so that they can also show their workers.

Contact Person

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Additional Information

The information and application instructions can be found at the MDAC website: http://www.mdac.ms.gov/departments/marketing/gap_ghp.htm.

The video is also on the MDAC YouTube channel: https://www.youtube.com/watch?v=HBuNL_SdI6o&t=9s.

A FIELD-LEVEL SURVEY OF THE PRESENCE OF PATHOGENIC BACTERIA IN SWEET POTATO FIELDS AMENDED WITH POULTRY LITTER

Partner Organization

Mississippi State University

Project Summary

Mississippi is the second largest producer of sweetpotatoes in the United States. Many Mississippi sweetpotato growers utilize poultry litter as a soil amendment because it is a cost-effective means of maintaining soil fertility and is readily available. However, human pathogenic bacteria (especially *Salmonella)* are known to exist in poultry litter and can be persistent. This is potentially problematic, as consumption of raw and minimally processed sweetpotatoes may not inactivate *Salmonella*. Field studies were conducted at the Pontotoc Ridge-Flatwoods Branch Experiment Station to determine if pathogenic bacteria from poultry litter persist under field conditions in sweetpotato production systems in Mississippi. Fields were treated with 0, 1, or 2 tons/acre of non-composted poultry litter, sampled throughout the production season, and tested for the presence of pathogenic bacteria. Additionally, harvested roots, bins, and storage houses were tested for the presence of pathogenic bacteria. *Salmonella* was recovered from fields, sweetpotato roots, and the storage environment. It was, however, not recovered from the poultry litter. Findings suggest that *Salmonella* is present in sweetpotato fields at low levels, but that its origin may be from wildlife visiting the fields rather than poultry litter applied to fields as a soil amendment.

Project Purpose

Poultry litter is a common soil amendment in Mississippi used by row crop and specialty crop producers to supplement synthetic fertilizer applications. It is estimated that 15 to 20% of sweetpotato growers utilize poultry litter on a portion of their fields each year. In addition to essential plant nutrients, poultry litter often contains food-borne pathogens, including strains of *Salmonella*. Research shows that *Salmonella* and *E. coli* have been recovered from litter or manure for up to 120 days after the removal of poultry flocks that were raised on the litter, or produced the manure. *Salmonella* and *E. coli* have also been shown to survive in litter or manure-treated soils for up to two months. Other studies show that *Salmonella* and *E. coli* can survive in litter or manure-treated soils for

up to 90 days (Ekperigin 2000). Work conducted by Kim (unpublished data) found that litter in poultry houses were highly contaminated with *Salmonella*.

Poultry litter used for sweetpotato production must first be subjected to a composting process intended to kill pathogenic bacteria as both the Food Safety and Modernization Act and Good Agricultural Practices requirements prohibit the use of raw manure in crops for fresh consumption. Only certain composting procedures are effective in inactivating pathogens (FDA 2014). However, preliminary data suggest that windrow composting of poultry litter may not allow for litter to reach a temperature high enough to kill pathogenic bacteria. There is a degree of likelihood that surviving pathogenic bacteria are transferred to the sweetpotato production field and distributed during the spread of poultry litter. To date no sweetpotato grower has reported food-borne illnesses related to poultry litter use. Although most sweetpotatoes are consumed cooked, potential pathogen-containing sweetpotato roots could still pose a threat to individuals who consume raw sweetpotatoes or allow for cross-contamination with other produce consumed raw.

The objective of the proposed research was to determine the persistence of pathogenic bacteria in sweetpotato production fields and harvested sweetpotato roots and to educate growers of the best practices to avoid pathogenic bacteria contamination when utilizing poultry litter.

This proposal is developed in a manner that enhances the competitiveness of the sweetpotato and has not been funded or submitted to any other state or federal granting agency. This research was a new proposal and has not been funded through previous Specialty Crop Block Grants.

Project Activities

Field surveys were conducted at three sweetpotato fields at the Pontotoc Ridge-Flatwoods Branch Experiment Station (Pontotoc, MS).

Samples from the sweetpotato farming environment (n=260) included poultry litter (n=9), swabs of soil from fields fertilized with 0 (n=48), 1 (n=111), and 2 (n=71) tons/acre of poultry litter, environmental samples from a sweetpotato storage house (n=13), and sweetpotato roots (n=8).

Poultry litter was tested for the presence of pathogenic bacteria prior to spreading. *Salmonella* was not isolated from poultry litter applied to sweetpotato fields (Table 1).

Fields used for the study were tested for the presence/absence of *Salmonella*, *E. coli*, and total aerobic bacteria counts once a month by swabbing the soil surface at five locations throughout each field.

Table 1. *Salmonella* spp. incidence in sweetpotato fields and a packing house by sample type and season.

Sample Type	Incidence (%)	Season	Incidence (%)
Soil, 0 Ton poultry litter	0.18[b]	Winter	0.24[ab]
Soil, 1 Ton poultry litter	0.19[b]	Spring	0.21[b]
Soil, 2 Tons poultry litter	0.04[b]	Summer	0.48[a]
Poultry litter	0.00[b]	Fall	0.34[ab]
Roots	0.44[ab]	-	-
Box	0.98[a]	-	-
SEM	0.02	SEM	0.02

Incidence of *Salmonella* was greater (p≤0.05) on the sweetpotato storage boxes than on the 0, 1, 2 ton soil and the poultry litter, but it was similar to the sweetpotato roots (Table 1). Incidence of *Salmonella* was greater in the summer than in the spring, but similar in the winter and fall.

Additional data was collected to try to identify the different serotypes and their prevalence. In total, 54 *Salmonella* isolates, representing seven different serotypes, were recovered from the sweetpotato farming environment (Table 2). Overall, *Salmonella* ser. Newport (46%) and *Salmonella* ser. Javiana (30%) were the most frequently isolated serotypes. In this study, *Salmonella* (n=54) was isolated from sweetpotato fields fertilized with 0 (20%), 1 ton (50%), and 2 tons of poultry litter (13%), and from sweetpotato roots (6%) and storage house areas (11%). *Salmonella* ser. Newport and *Salmonella* ser. Javiana were the most frequently isolated serotypes in this study, and their isolation was greater during the warmer months. These serotypes were isolated on almost all types of soil regardless of the amount of poultry litter applied, and they were the only serotypes isolated from sweetpotato roots.

Table 2. *Salmonella* spp. serotypes isolated from the sweetpotato farming environment.

Sample type	Infantis	Javiana	Mississippi	Newport	Norwich	Saintpaul	Typhimurium	N/A	Total
0 Ton soil	1	2	0	5	2	1	0	0	**11**
1 Ton soil	0	10	1	14	0	0	0	2	**27**
2 Ton soil	1	0	4	2	0	0	0	0	**7**
Roots	0	1	0	2	0	0	0	0	**3**
Others*	0	3	0	2	0	0	1	0	**6**
Total	**2**	**16**	**5**	**25**	**2**	**1**	**1**	**2**	**54**

At harvest, a sample of sweetpotato roots from each sampled portion of the field were tested for the presence of *Salmonella*, *E. coli*, and total aerobic bacteria. The incidence of *Salmonella* on sweetpotato roots was 0.44% (Table 1).

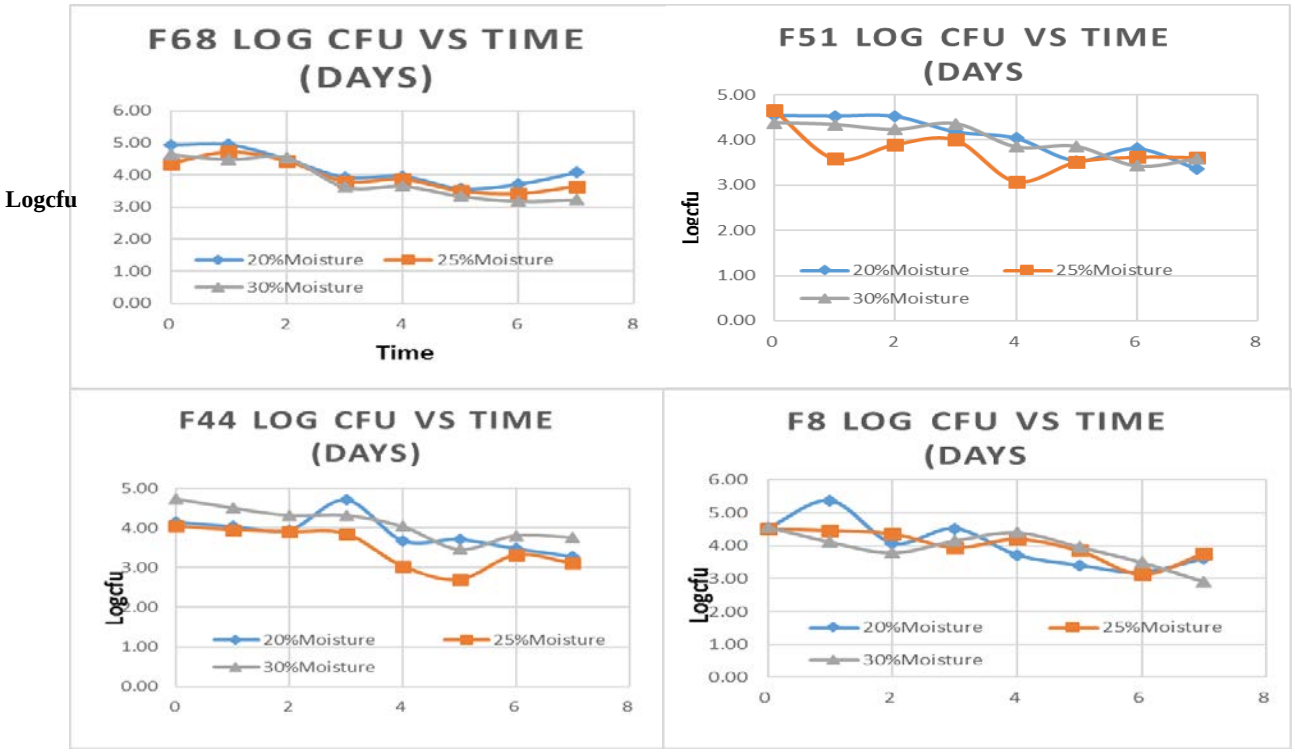
Additional data was collected to try to identify the different serotypes, their prevalence and possible sources of *Salmonella*. This data is described below:

- Genetic similarity values between fingerprints were calculated based on the Dice coefficient at a 1.5% band position tolerance, and dendrograms were generated by the unweighted pair group method using the arithmetic average (UPGMA). The 54 isolates resulted in 32 different XbaI PFGE patterns. Seven clusters (I to VII) were identified with a genetic similarity ≥ 90%, suggesting that they represent the same strain isolated from different samples.
- PFGE analysis of *Salmonella* spp. isolates from the sweetpotato farming environment identified three clusters with ≥ 90% of genetic similarity, where a possible path of contamination could be established. The isolates could be traced back from sweetpotato bin boxes or sweetpotato roots to the three-different environment-sampling sites treated with 0, 1, or 2 tons of poultry litter. This suggests a path of contamination of *Salmonella* from the environment to the final product.
- This data suggests that *Salmonella* ser. Newport was prevalent throughout the fields, regardless of the amount of poultry litter applied, and that this pathogen can contaminate sweetpotato bin boxes and harvested roots. This serotype was also persistent during the course of this study, which took place from the summer of 2015 through the fall of 2016. Since *Salmonella* was not detected in the poultry litter itself, it is likely that this serotype is prevalent in the soils due to possible prior use or persistent use of manure, and/or presence of *Salmonella*-carrying wildlife in the area.

Additional data regarding poultry litter source, cultivation, soil temperature, rainfall, soil pH, soil fertility, and pest management practices were collected and will be used to determine the potential influence of cultural management and environment growing conditions on the survival of pathogenic bacteria.

In a lab, poultry litter (dried and pre-moistened) and different soil types were inoculated with *Salmonella* to determine the effect of soil type, pH, and soil moisture on *Salmonella* persistence. Results (Figure 3) showed that *Salmonella* tended to decrease over time regardless of soil type/pH and moisture content.

Figures 3. *Salmonella* behavior in different soils and soil moistures.



Goals and Outcomes Achieved

Goal 1: To generate new knowledge pertaining to the potential existence of pathogenic bacteria in sweetpotatoes.

The results of this project indicate that *Salmonella* is endemic to agricultural fields and/or is placed there by wildlife, leading to contamination of the roots upon harvest. The harvest bins were also identified as possible carriers of the pathogen.

Sweetpotato farmers and handlers should be aware of the possibility that their product could be contaminated with *Salmonella*. Sweetpotatoes marketed as ready-to-eat (as in salads) should be screened for *Salmonella* in addition to adding intervention measures to decrease the possibility of contaminated product reaching the consumer.

More work is needed to try to identify sources and strategies to mitigate *Salmonella* from contaminating roots.

Goal 2: Each sweetpotato grower registered with the Mississippi Sweet Potato Council will be made aware of the results of this project.

Data generated from this study was presented to growers at one Winter Sweetpotato Production Meeting, two GAPs/GHPs trainings, one Produce Safety Rule Training, and one Sweetpotato Field Day. Additionally, a summary of findings were presented to the Mississippi Sweet Potato Council Board of Directors at a quarterly council meeting. Through these meetings, the data was presented to approximately 127 stakeholders, although some of these interactions included the same producers. Given this engagement and the fact that there are approximately 100 sweetpotato farmers in the state of Mississippi, the investigators believe that the vast majority of sweetpotato growers registered with the Mississippi Sweet Potato Council have been made aware of our findings.

Goal 3: The investigators believe that a minimum of 30% of the state's growers who use poultry litter will incorporate a portion of the recommendations generated from this research in their production practices.

Given that the present research yielded little correlation between poultry litter soil amendment and the presence of human pathogenic bacteria, the investigators recommend producers use the currently accepted best management practices for poultry litter which include using only aged/composted litter and applying litter to fields at least 120 days before harvest, the current standard for crops that are grown in contact with the soil. While the investigators believe that few growers verify the composting requirements from their poultry litter trucking service, 100% apply litter at least 120 days before harvest.

Beneficiaries

This research was a proactive approach to address what could potentially be a health concern for sweetpotato consumers. Addressing this potential risk proactively protects consumers and allows for production practices to be altered, if necessary, ensuring safe sweetpotatoes reach consumers. Results from this research will not only be of benefit to Mississippi, but results will also be applicable to other sweetpotato producers throughout the United States. Although only a portion of Mississippi's sweetpotato producers use poultry litter as an amendment, the potential of food-borne illness associated with sweetpotatoes would be devastating to the entire industry in the state including the 100 farmers, 26 packing facilities, and more than 1,000 full time equivalent employees associated with the industry.

An addition to benefiting the sweetpotato producing community, the greater sweetpotato and food safety scientific community benefits from this research as well. Below are the **deliverables** so far (numbers in parenthesis reflect the number of attendants to the meeting/training):

Siberio, L., T. Kim, J.L. Silva, S. Meyers, and J. Main. 2018. Incidence of *Salmonella* in sweetpotato fields by improved detection methods (poster and abstract). National Sweetpotato Collaborator's Group Annual Meeting. Wilmington, NC.

Siberio, L. 2017. Incidence of *Salmonella* in sweetpotato fields by improved detection (presentation). Mississippi Sweetpotato Field Day. Pontotoc, MS. (~60)

Siberio, L. 2017. Incidence of *Salmonella* spp. in farming environments and food facilities by improved detection. Ph.D. Dissertation, Mississippi State University.

Siberio, L. 2016. *Salmonella* collection methods from sweetpotato production and harvest environments (presentation). Mississippi Winter Sweetpotato Production Meeting. Pittsboro, MS. (~20)

Main, J.L., T. Kim, S.L. Meyers, L. Siberio, J. Silva. 2016. Validation of sample collection methods for *Salmonella* isolation from sweetpotato production and harvest environments (poster and abstract). National Sweetpotato Collaborators Group Annual Meeting. 34:19. (~65)

Silva et al. 2016. Good Ag Practices and the PSR including data on *Salmonella* in sweetpotato fields. Pittsboro, MS. (16)

Silva et al. 2017. Good Ag Practices and the PSR including data on *Salmonella* in sweetpotato fields. Pittsboro, MS. (22)

Silva JL, Meyers, S, Siberio, L and Abdallah, A. 2017. Produce Safety Rule training including findings on Salmonella and sweetpotatoes. Verona, MS. Sept. 8, 2017. (9)

Lessons Learned

The presence of pathogenic bacteria in production fields is a sensitive topic. This limits, to some extent, the efforts of the scientists to promote the work and its findings in public outlets (namely university press releases and agricultural and general popular press).

The presence of pathogenic bacteria does not necessary imply an unsafe production system. Further research is needed to determine what, if any, threat exist based upon the findings in this study.

The original proposal was to conduct screenings on-farm. While the sweetpotato producers in Mississippi support food safety research and provide a safe and nutritious product to their consumers, they were uncertain of the ramifications of allowing researchers to test their fields and post-harvest

environments for pathogenic bacteria. This is, in part, due to the lack of research-based information on what corrective actions should be taken if/when a positive sample is reported.

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SPECIALTY CROPS EDUCATION OF MS'S GREENHOUSE VEGETABLE PRODUCERS

Project Partner

Mississippi State University

Project Summary

Potential specialty crops producers learn of the possibility of raising greenhouse tomatoes or other vegetable crops hydroponically from a number of sources. Some have seen newspaper or magazine articles, some have seen posts, pictures, or videos on social media, some may have purchased tomatoes from a greenhouse and thought that this might be a good opportunity.

However, people first learn about this crop, one thing is universal. They tend to know very little about the technical aspects and work requirements to succeed. This is a problem. The misconception is far too often that this would be an easy crop to grow and that a person can become rich in a very short time. Nothing can be further from the truth.

For this reason, we were motivated to implement the Greenhouse Tomato Short Course (GHSC). The GHSC is a university sponsored, non-biased delivery system for current, research-based information that will help potential and new growers succeed in this business. Speakers from MSU Extension as well as experts from other states around the U.S. are invited to give presentation to the growers.

Specialty Crop Block Grant funding was used to educate producers in the successful production of greenhouse vegetable specialty crops. The 25th, 26th, and 27th annual Greenhouse Tomato Short Courses (GHSC) were implemented in March of each year. This training for greenhouse hydroponic vegetable growers was held at Eagle Ridge Conference Center in Raymond, MS, just outside of Jackson. About 110 participants benefited from this educational program each year, including about 10 exhibitors. Twelve speakers were on the program, with about 13 educational seminars each year.

In addition to the speaking part of the program, a greenhouse tour was held in the latter part of the afternoon on the first day of the conference. The tour was at Salad Days, a diverse greenhouse in Flora, MS (Madison County). This "hands on" portion of the Short Course was a valuable addition to the program, especially for newer growers, as it gave them an opportunity to see production methods that were discussed at the Short Course in practice.

Project Purpose

The goals of this project were to:
1) Train more producers in greenhouse vegetable technology than the previous year so that they have the tools to succeed,
2) Train more Extension Agents than the previous year so that they can be a valuable resource for producers, and
3) To increase the level of knowledge of both producers and Agents.

About 20 more growers attended in 2015 than the previous year. This represented a 22% increase which more than doubled the 10% goal.

Although all attempts were made to attract 20 MSU-ES Agents to receive Agent Training in 2015, only 6 signed up. This number, however, is still much higher than the previous year in which 0 Agents were trained. Many Agents in MS had already been trained in previous years so they may not have needed additional training. Also, some Agents do not have any greenhouse vegetable growers in their county or counties so have no need for training in these specialty crops.

In both 2016 and 2017, there were 100 to 110 growers, and very few agents trained due the reasons stated above.

The level of knowledge was clearly increased. Evaluations were very positive and complementary. Many growers mentioned that they will be back next year and look forward to continuing their learning from the resources provided. PowerPoint presentations were posted on the GHSC website each year so that they could be accessed later. All Extension publications relating to greenhouse vegetable production were made available at the GHSC so growers could pick them up and take home to use later.

The project did not benefit any non-specialty crop commodities.

Hydroponic production of greenhouse vegetables is steadily climbing in the U.S., as it is in the rest of the world. This project was very timely in that it addressed the need for growers to learn how to grow these specialty crops, increasing their success and profitability.

This project built on previously funded SCBGPs by bringing in more growers and agents than before to get trained in these specialty crops.

Project Activities

During the first year of the grant period, the 25th annual Greenhouse Tomato Short Course (GHSC) was implemented. This training for greenhouse hydroponic vegetable growers was held at Eagle Ridge Conference Center on March 3 and 4, 2015. About 110 participants benefited from this educational program, including 9 exhibitors. Twelve speakers were on the program, and presented a total of 13 educational seminars.

In addition to the speaking part of the program, a greenhouse tour was held in the latter part of the afternoon on the first day of the conference. The tour was at Salad Days, a diverse greenhouse in Flora, MS (Madison County). This "hands on" portion of the Short Course was a valuable addition to the program, especially for newer growers, as it gave them an opportunity to see production methods that were discussed at the Short Course in practice.

Many favorable comments were received from growers, speakers, and exhibitors.

Promotion for the Short Course was with two national magazines (American Vegetable Grower Magazine and Small Farm Today), an email blast, websites, as well as social media, primarily Facebook and Twitter. Both a press release and a radio show were done to increase public awareness of the Short Course. Calendar information was sent to national, regional, and state media so they could list the event for their clientele. The GHSC website is at http://greenhousetomatosc.com. An experiment using Facebook marketing was able to attract over 6,000 page likes before the Short Course dates to broaden the audience reached beyond methods used in previous years. This number makes the GHSC Facebook page the largest page of all MSU Extension Facebook pages. The value of this page will continue into future years since those who have "liked" the page already will receive information about greenhouse tomato production and future GHSC events on their timelines. This page is located at https://www.facebook.com/GreenhouseTomatoShortCourse.

Agents were solicited to participate and informed of the availability of complete scholarship funding via this grant project to pay for their travel expenses. The training was listed on the MSU-ES intranet for inservice training credits. Although the goal was to train 20 Agents, only 6 signed up in 2015 for the scholarship in spite of several reminders and assistance from administrators. Remaining funds were carried over to use for the 2016 Short Course.

In July 2015, I participated in the American Society for Horticultural Science Conference in New Orleans to network with other faculty / specialists in the field of greenhouse technology and share outcomes. I presented an academic paper about the various methods of promoting an Extension event and evaluating which were best, using the Short Course as a model. See abstract at the end of this report.

Conclusions from the promotion methods tried are that I will continue to use American Vegetable Grower but drop Small Farm Today Magazine in future years due to the significant differences in

number of people who noted where they learned about the Short Course in the evaluations. Although I will keep the Facebook page, I will not invest more funds into marketing it (note: funds were not paid out of this grant but another source was used). As for the program itself, the tour was very popular among the growers and all attempts will be made to include a greenhouse tour in the future.

During the second year of the grant period, the 26th annual Greenhouse Tomato Short Course (GHSC) was implemented. This training for greenhouse hydroponic vegetable growers was held at Eagle Ridge Conference Center on March 1 and 2, 2016. About 110 participants benefited from this educational program, including 8 exhibitors. Twelve speakers were on the program, and presented a total of 13 educational seminars.

In addition to the speaking part of the program, a greenhouse tour was held in the latter part of the afternoon on the first day of the conference. The tour was at Salad Days, a diverse greenhouse in Flora, MS (Madison County). This "hands on" portion of the Short Course was a valuable addition to the program, especially for newer growers, as it gave them an opportunity to see production methods that were discussed at the Short Course in practice. This was the 2nd year we toured Salad Days as part of the Short Course. Many favorable comments were received from growers, speakers, and exhibitors.

Promotion for the Short Course was with a national magazine, American Vegetable Grower Magazine, an email blast, websites, as well as social media, primarily Facebook and Twitter. Both a press release and a radio show were done to increase public awareness of the Short Course. Calendar information was sent to national, regional, and state media so they could list the event for their clientele. The GHSC website is at http://greenhousetomatosc.com.

Facebook was again used and attracted over 6,300 to the page which helped to broaden the audience reached beyond methods used in previous years. This number makes the GHSC Facebook page the largest page of all MSU Extension Facebook pages. The value of this page will continue into future years since those who have "liked" the page already will receive information about greenhouse tomato production and future GHSC events on their timelines. This page is located at https://www.facebook.com/GreenhouseTomatoShortCourse.

Agents were solicited to participate and informed of the availability of complete scholarship funding via this grant project to pay for their travel expenses. The training was listed on the MSU-ES intranet for inservice training credits. Four signed up for the scholarship. Remaining funds were carried over to use for the 2017 Short Course.

Conclusions from the promotion methods tried are that I will continue to use American Vegetable Grower in future years due to the high number of people who noted where they learned about the Short Course in the evaluations. Although I will keep the Facebook page, I will not invest more funds into marketing it. As for the program itself, the tour was very popular among the growers and all attempts will be made to include a greenhouse tour in the future.

In 2017, the Greenhouse Tomato Short Course was held March 7 & 8 at Eagle Ridge Conference Center in Raymond, MS. About 100 participants from 20 states, as well as 3 producers from Canada, were trained in the production of specialty crops in greenhouses during this two-day national conference.

In advance of the Short Course, advertising in American Vegetable Grower Magazine, a national publication, was done in the January 2017 issue. Also, a mailing to the list of growers went out using the services of Campus and City Mail.

The new Facebook page (https://www.facebook.com/GreenhouseTomatoShortCourse) continues to share information about greenhouse tomatoes and the Short Course to growers and enthusiasts, currently with 6,430 page likes. The value of this page will continue after this grant expires since those who have "liked" the page already will continue to receive information about greenhouse tomato production as well as GHSC events in future years. It is hoped that these numbers will convert into people attending in the future.

There were no project partners.

This project is now complete. Spending of the budget has been completed as well.

Goals and Outcomes Achieved

The goals of this project were to

1) Train more producers in greenhouse vegetable technology than last year so that they have the tools to succeed,
2) Train more Extension Agents than last year so that they can be a valuable resource for producers, and
3) To increase the level of knowledge of both producers and Agents.

About 20 more growers attended in 2015 than the previous year. This represents a 22% increase which more than doubles the 10% goal.

Although all attempts were made to attract 20 MSU-ES Agents to receive Agent Training, only 6 signed up. This number, however, is still much higher than the previous year in which 0 Agents were trained. Many Agents in MS have already been trained in previous years so they may not need additional training. Also, some Agents do not have any greenhouse vegetable growers in their county or counties so have no need for training in these specialty crops.

The level of knowledge was clearly increased. Evaluations were very positive and complementary. Many growers mentioned that they will be back next year and look forward to continuing their learning

from the resources provided. PowerPoint presentations were posted on the GHSC website so that they can be accessed later. All Extension publications relating to greenhouse vegetable production were made available at the GHSC so growers could pick them up and take home to use later.

The project did not benefit any non-specialty crop commodities.

There were no problems or delays in the implementation of this Short Course. Having coordinated this event for 25 years, the methods used are tried and true and have led to a successful program for our specialty crops growers in Mississippi.

As mentioned above, only 6 Agents signed up in 2015. While fewer than hoped for, 6 Agents trained was still much better than 0 Agents trained in the previous year. Remaining funds were used for the 2016 Short Course to extend specialty crop education to a new batch of growers and Agents.

Only 4 Agents signed up for training in 2016. While fewer than hoped for, 4 Agents trained was still much better than 0 Agents trained in 2014. Remaining funds were used for the 2017 Short Course to extend specialty crop education to more growers and Agents.

Beneficiaries

Beneficiaries of the project were commercial producers, Extension Agents and Specialists, and business who exhibited during the program.

About 330 people directly benefited from the program. However, this number was certainly extended by the Agents and Specialists who received training.

Growers, Agents, Specialists, and Exhibitors benefited by learning the latest techniques for successful production of greenhouse tomatoes and other specialty vegetable crops in the greenhouse. By coming to the three Short Courses funded with this project, they are much better prepared to better decision making during the greenhouse business careers, leading to higher success and profitability.

Lessons Learned

Program promotion cannot be overemphasized. To bring potential specialty crops growers to a program like this, it must be advertised in venues that growers will see. This is why the Greenhouse Tomato Short Course was promoted with its own domain name, website, press releases, email list, hard copy mailing list, via County Agent lists, national and regional e-lists, Facebook, Twitter, radio shows, and national magazines and newsletters. In addition, *paid advertising* was used in American Vegetable Grower Magazine, Tomato Magazine, Small Farm Today Magazine, Facebook advertising,

and some other outlets. Without excellent promotion, participation can be very disappointing, and success of the goal of educating growers diminished.

Contact Person

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Additional Information

http://greenhousetomatosc.com

https://www.facebook.com/GreenhouseTomatoShortCourse

Abstract 2015
American Society for Horticultural Science

Snyder, Richard G. 2015. Using Real Money to Promote Extension Horticulture Programming

Extension professionals have a long tradition of promoting their educational programming efforts via a variety of creative outlets, the majority of which are at no real cost to the Specialists other than their time. Many of these include newsletters (hard copy and online), trade magazine listings, email lists, direct emails, calendars of events, and more recently blogs, websites, Facebook, Twitter, and a great myriad of other social media platforms. What would happen if actual dollars were spent to market Extension horticulture events to the public? The Greenhouse Tomato Short Course (GHSC) was used as an example and has been promoted over the years in an assortment of free and paid methods. The GHSC is a national conference held in Jackson, Mississippi each March, which is designed to train commercial growers of greenhouse tomatoes and other hydroponically grown vegetables (http://greenhousetomatosc.com). Having just completed 25 years, the methods of promotion will be examined. The free promotion techniques utilized include those avenues mentioned above. While helpful, the reach of free methods to new audiences are currently limited. However, by spending real dollars, new clientele can be accessed. Paid advertising in trade magazines was the first attempt to reach a wide circulation of subscribers. Magazine advertising is often augmented by online versions of the publications which may or may not include an extra fee. Newer fee-based Facebook marketing strategies can be a sophisticated instrument for reaching a new, targeted audience. The specific audience can be selected with a series of keywords, geographic locations, and various population demographics (age, education level, etc.). Furthermore, by using well designed ads and posts, clientele who would most likely benefit from the program can be enticed to become engaged. The GHSC

Facebook page (https://www.facebook.com/GreenhouseTomatoShortCourse) attracted over 6,000 page likes in a four-month period. Additionally, marketing promotional items have been carefully selected and distributed at the GHSC so that producers will enjoy them when they return home, yet also continue to promote the program to others in the community for years into the future. Costs to be incurred need to be incorporated into grant proposals to insure that they are allowable charges. The caveats of navigating this path will also be addressed.

Appendix:

Agendas for 2015, 2016, and 2017 are attached.

25th annual GREENHOUSE TOMATO SHORT COURSE

March 3 - 4, 2015
Eagle Ridge Conference Center
Raymond, Mississippi

Agenda

Tuesday, March 3

8:30 - REGISTRATION and COFFEE

9:00
Kickoff GHSC 2015!

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:10
Welcome from Central MS R&E Center

Dr. Sherry Surrette, Head, Central Mississippi Research & Extension Center, Mississippi State University

9:20
Welcome from Mississippi State University

Dr. Bill Herndon, Associate VP for Ag, Forestry, & Vet-Medicine, MSU

9:30
So, You Want to Grow Greenhouse Tomatoes?

Dr. Richard G. Snyder, Professor & Vegetable Specialist, Mississippi State University

10:15
The Job of the Plant: Environment Basics

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

11:00
Break -- Visit Exhibitors

11:15
Greenhouses: The Ins and Outs

Dr. Richard Harkess, Professor of Horticulture, Mississippi State University

12:15
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:30
Exhibitor Show & Tell
Exhibitors Present Their Products

2:00
Mastering Fertility & Nutrition for Greenhouse Tomatoes

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

2:45
Learn Valuable Lessons From Other Growers' Experiences

Leigh Bailey and Jamie Redmond, Salad Days, Flora, MS.

3:30
Depart for Tour of Salad Days.

- Pick up directions at Registration Area.
- We will Carpool / Caravan to the greenhouse.

4:30
Arrive at Salad Days, 256 First St., Flora, MS.

6:00 Supper

Depart greenhouse for supper (on your own) at --

Bill's Creole and Steak Depot
471 Railroad Ave, Flora, Mississippi
0.7 miles north of Salad Days.

2015 Greenhouse Tomato Short Course

Wednesday, March 4

8:30 - REGISTRATION and coffee

8:50
Day #2 -- Be Ready!

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:00
So, What's it Cost to Grow Greenhouse Tomatoes?

Dr. Alba Collart, Extension Agricultural Economist, MSU Department of Agricultural Economics

9:45
Marketing 101: The Adventure Learned

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

10:30
Break -- Visit Exhibitors

10:45
Using Social Media To Help With Your Business

Ellen Graves, Social Media Strategist, MSU Extension

11:30
Using Social Media to Grow Your Business: Evidence from Rural Mississippi

Dr. James Barnes, Extension Agricultural Economist, MSU Department of Agricultural Economics

12:15
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:30
The Benefits of Using Grafted Tomatoes

John Jackson, General Manager Grafted Growers

Pest Management Workshop

2:15
Insect Pests of Greenhouse Tomatoes

Dr. Blake Layton, Extension Entomologist, Mississippi State University

3:00
Break -- Visit Exhibitors

3:15
Disease Identification, Prevention, and Management

Dr. Rebecca Melanson, Extension Plant Pathologist, Mississippi State University

4:00
Understanding All of the Other Problems With Tomatoes – Abiotic Disorders

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

5:00
Panel Discussion - General Discussion: Questions and Answers – Speakers who are still present will participate

Leigh Bailey, Dr. Joe Kemble, Steve Froehlich, John Jackson, Ellen Graves, Dr. Blake Layton, Dr. James Barnes, Dr. Rebecca Melanson, Dr. Alba Collart, Dr. Richard Harkess, and Dr. Rick Snyder

Greenhouse Tomato Short Course 2015
Sponsored by
Central Mississippi Research & Extension Center
Mississippi State University Extension Service
USDA Specialty Crops Block Grant

2015 Greenhouse Tomato Short Course

26th annual GREENHOUSE TOMATO SHORT COURSE

March 1 - 2, 2016
Eagle Ridge Conference Center
Raymond, Mississippi

Agenda

Tuesday, March 1

8:30 - REGISTRATION and COFFEE

9:00
Kickoff the GHSC!

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:10
Welcome from Central MS R&E Center

Dr. Sherry Surrette, Head, Central Mississippi Research & Extension Center, Mississippi State University

9:20
Welcome from Mississippi State University

Dr. Gary Jackson
Director, Mississippi State University Extension

9:30
Greenhouse Tomatoes and YOU

Dr. Richard G. Snyder, Professor & Vegetable Specialist, Mississippi State University

10:15
Why Grow In A Controlled Environment?

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

11:00
Break -- Visit Exhibitors

11:15
Understanding Your Greenhouse Design and Environmental Control

Gregg Short P.E., Greenhouse Engineer

12:15
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:30
Exhibitor Show & Tell
Exhibitors Present Their Products

2:00
It's all about Nutrition – Greenhouse Tomatoes and Lettuce

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

2:45
Cultural Practices for Tomato and Lettuce Growers

Maxwell Salinger, Horticulture Sales, Crop King

3:30
Depart for Tour of Salad Days

- Pick up directions at registration area.
- We will carpool / caravan to the greenhouse.

4:30
Arrive at Salad Days, 256 First St., Flora, MS. *Leigh Bailey and Jamie Redmond, Salad Days, Flora, MS*

6:00 Supper

Depart greenhouse for supper (on your own) at --

Bill's Creole and Steak Depot
471 Railroad Ave, Flora, Mississippi
0.7 miles north of Salad Days.

2016 Greenhouse Tomato Short Course

Wednesday, March 2

8:30 - REGISTRATION and coffee

8:50
Day #2 -- Be Ready!

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:00
What You Will Learn In Your First Year

Dr. Natalie Bumgarner, Extension Specialist, University of Tennessee

9:45
Launch Your Business with Planned Market Development

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

10:30
Break -- Visit Exhibitors

10:45
Social Media For Greenhouse Growers

Dr. Roberto Gallardo, Extension Community Development Specialist

11:30
Know Your Greenhouse Varieties!

Dr. Natalie Bumgarner, Extension Specialist, University of Tennessee

12:15
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:30
Cost Analysis for Greenhouse Tomatoes

Dr. Alba Collart, Extension Agricultural Economist, MSU Department of Agricultural Economics

Pest Management Workshop

2:15
Disease Identification, Prevention, and Management

Dr. Rebecca Melanson, Extension Plant Pathologist, Mississippi State University

3:00
Break -- Visit Exhibitors

3:15
Insect Pests of Greenhouse Tomatoes

Dr. Blake Layton, Extension Entomologist, Mississippi State University

4:00
What Happens when Fertility Levels Aren't What They Should Be?

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

5:00
Panel Discussion - General Discussion: Questions and Answers – Speakers who are still present will participate.

Dr. Natalie Bumgarner , Dr. Joe Kemble, Steve Froehlich, Gregg Short, Max Salinger, Dr. Blake Layton, Dr. Roberto Gallardo, Dr. Rebecca Melanson, Dr. Alba Collart, and Dr. Rick Snyder

Greenhouse Tomato Short Course 2016
Sponsored by
Central Mississippi Research & Extension Center
Mississippi State University Extension Service
USDA Specialty Crops Block Grant

2016 Greenhouse Tomato Short Course

27th annual GREENHOUSE TOMATO SHORT COURSE

March 7 - 8, 2017
Eagle Ridge Conference Center
Raymond, Mississippi

Agenda

Tuesday, March 7

8:30 - REGISTRATION and COFFEE

9:00
Kickoff the GHSC!

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:10
Welcome from Central MS R&E Center

Dr. Sherry Surrette, Head, Central Mississippi Research & Extension Center, Mississippi State University

9:20
Welcome from Mississippi State University

Dr. Gary Jackson, Director, Mississippi State University Extension

9:30
Greenhouse Tomatoes? Listen Up!

Dr. Richard G. Snyder, Professor & Vegetable Specialist, Mississippi State University

10:15
Design Your Greenhouse for Success

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

11:00
Break -- Visit Exhibitors

11:15
Life Cycle for Your Greenhouse Crop

Dr. Richard Harkess, MSU Horticulture Professor

12:15
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:30
Exhibitor Show & Tell
Exhibitors Present Their Products

2:00
Grower's Perspective

Steve Reynolds, Tomato Farm, Magnolia, MS

2:45
When Bad Things Happen to Good Growers – Part 1

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

3:30
Depart for Tour of Salad Days

- Pick up directions at registration area.
- **Limited parking = do not drive alone! We will carpool as much as possible to the greenhouse.**

4:30
Arrive at Salad Days, 256 First St., Flora, MS. *Leigh Bailey and Jamie Redmond, Salad Days, Flora, MS*

6:00 Supper
Depart greenhouse for supper (on your own) at --

Bill's Creole and Steak Depot
471 Railroad Ave, Flora, Mississippi
0.7 miles north of Salad Days.

2017 Greenhouse Tomato Short Course

Wednesday, March 8

8:30 - REGISTRATION and coffee

8:50
Day #2 – Ready for More Learning?

Moderator: Dr. Richard G. Snyder, Professor & Vegetable Specialist, MSU

9:00
Why Are My Plants Unhappy?

Steve Froehlich, Engineer, Hydrosun Hydroponics, Inc., Grasston, MN

9:45
7 Reasons Why Your Agri-Business Should Master Social Media Advertising

Dr. James Barnes, Associate Extension Professor, Department of Agricultural Economics

10:30
Break -- Visit Exhibitors

11:00
Understanding Grafting

Ben Hinson, Tri-Hishtil Sales Coordinator

12:00
LUNCH -- Eagle Ridge, lower level
Visit Exhibitors after lunch!

1:15
Cost Analysis for Greenhouse Tomatoes

Dr. Elizabeth Canales, Extension Agricultural Economist, MSU Department of Agricultural Economics

Pest Management Workshop

2:00
Disease Management: Are YOU Prepared?

Dr. Rebecca Melanson, Extension Plant Pathologist, Mississippi State University

2:45
Break -- Visit Exhibitors

3:00
Insect Pests of Greenhouse Tomatoes

Dr. Blake Layton, Extension Entomologist, Mississippi State University

3:45
Complying With New Worker Protection Standards

Gene Merkl, MSU Pesticide Safety Coordinator

4:15
When Bad Things Happen to Good Growers – Part 2

Dr. Joe Kemble, Extension Vegetable Specialist, Auburn University

5:00
Panel Discussion - General Discussion: Questions and Answers – Speakers who are still present will participate.

Dr. Joe Kemble, Steve Froehlich, Ben Hinson, Dr. Blake Layton, Gene Merkl, Steve Reynolds, Dr. Richard Harkess, Dr. James Barnes, Dr. Rebecca Melanson, Dr. Elizabeth Canales, and Dr. Rick Snyder

Greenhouse Tomato Short Course 2017
Sponsored by
Central Mississippi Research & Extension Center
Mississippi State University Extension Service
USDA Specialty Crops Block Grant

2017 Greenhouse Tomato Short Course

ELEVATING BUNCH AND MUSCADINE GRAPE EDUCATION IN MS AND THE GULF COAST REGION

Project Partner

Mississippi State University

Project Summary

There is a shortage of grapes in Mississippi for use in fresh markets and for processing. Demand from Lazy Magnolia Brewing Company (Kiln, MS) and others lead to our efforts to educate local grower. Since it can take 3 years for grapevines to being producing, the importance of starting now to hopefully satisfy a pent-up demand was critical. Short courses and workshops were held in Mississippi for grape and muscadine growers, fruit growers, and winemakers to encourage the growth of a promising specialty crop industry. Over several programs, 100 students learned how to produce grapes and make wine. They reported large gains in knowledge from the material (>50%) and high satisfaction with workshop presentations and material (94%). A new publication was created to assist those who could not attend learn grape growing techniques at their own pace. Surrounding states have vibrant grape and wine industries that stimulate the local economy. The same opportunity is available in Mississippi with the proper direction. Overall the short courses and workshops on grape growing and winemaking provided attendees with baseline knowledge to further their aspiration in creating a growing, dynamic industry in Mississippi. This project was new and did not build upon previous SCBGP projects.

Project Purpose

The purpose of this project was to address the dearth of fresh grapes that are available in the local marketplace. Grapes have long been a viable crop in Mississippi, but little has been done in the last 25 years to introduce new, advanced education for current and potential grape growers. Throughout much of the United States, as well as in surrounding states, the grape and wine industries are quickly expanding. This expansion has led to increased agritourism, tax revenue, jobs, and business prosperity in those states. Existing businesses in Mississippi have interest in purchasing fruit, but cannot find it. This project used in-depth workshops taught by experts in southern grape production and also produced a new publication to foster improved decision making that will sustain, enhance, and add value to the Mississippi grape industry, as well as engage others on a regional and national basis. Although just an initial first step, this project acted as an instrument for addressing the needs of the

Mississippi bunch grape industry which could become an important component of the state's economy.

Project Activities

In the reporting period for this project, several activities related to the development and implementation of the grape and muscadine short course were accomplished. In January 2015, Dr. Stafne attended the Southeast Fruit and Vegetable Conference in Savannah, GA and gave a presentation entitled "Observations on bunch grapes in south Mississippi". Within the presentation he outlined the short course on bunch grapes and muscadines and encouraged anyone to attend the program or interact with him on ways to produce better grapes in the region. The PI and collaborators developed several PowerPoint presentations that informed students of appropriate vineyard practices. The agenda was developed, advertised on various venues (MSUcares.com, Twitter, Facebook, msfruitextension.wordpress.com, press, etc.), and the first class was held in Hattiesburg at the MSU Forrest County Extension office on February 19, 2015. In all there were 29 participants. The purpose of the workshop was to introduce concepts of viticulture related to both muscadines and bunch grapes to growers who are already growing these crops or may potentially grow them on a commercial scale. Muscadines are widely grown on a small scale, but larger scale production could be done to satisfy existing in-state and out-of-state markets. Bunch grapes are difficult to produce in Mississippi due to environmental conditions. However, intensive management can yield crops useful in the process and fresh markets, especially for wineries. Few wineries exist currently in Mississippi, but those that do are limited by the dearth of commercial quality fruit and thus the course is targeted at bringing together growers and processors.

A pre-test and post-test were administered to understand baseline viticulture knowledge as well as acquisition of knowledge after the class. The tests consisted of 12 questions related to the topics covered during the class. Pre-test student scores averaged 5.6 out of 12 and post-test scores averaged 8.3. This is an increase, on average, of 2.7 correct answers per student. The change in score was normally distributed ($p=0.2608$) as validated by the Shapiro-Wilk W test. From there, t-test score was 7.31, $P<0.0001$, thus indicated that the knowledge gained was statistically significant from pre-test to post-test.

The second class was held in Pontotoc at the MSU Pontotoc County Extension office on March 10, 2015. In all there were 33 participants. A pre-test and post-test were administered to understand baseline viticulture knowledge as well as acquisition of knowledge after the class. The tests consisted of 12 questions related to the topics covered during the class. Pre-test student scores averaged 5.9 out of 12 and post-test scores averaged 9.5. This is an increase, on average, of 3.6 correct answers per student. The change in score was normally distributed ($p=0.7731$) as validated by the Shapiro-Wilk W test. From there, t-test score was 8.65, $P<0.0001$, thus indicated that the knowledge gained was statistically significant from pre-test to post-test.

The second half of each class was held in Hattiesburg/Richton and Verona/Pontotoc on August 13 and August 20, 2015, respectively. In all there were 63 participants. The purpose of the workshop was to build on concepts of viticulture introduced in the first class as well as to present topics related to post-harvest processing. At each class guest speakers from local vineyards, wineries, Mississippi State University, and Mississippi Alcohol Beverage Control presented topics related to grape and muscadine harvest, processing, and regulation.

Satisfaction surveys were administered to discover if the material presented was useful and if more educational opportunities are warranted. The survey consisted of 13 questions related to the topics covered during the class. In summary, for the Verona course respondents self-reported an average increase in knowledge of 52% while further requesting specific information on wine processing. Hattiesburg students reported an average increase in knowledge of 53% and requested that the course become an annual program.

Following these programs a new publication was produced entitled "Fruit and Nut Review: Bunch Grapes" (http://extension.msstate.edu/sites/default/files/publications/information-sheets/is1608_0.pdf). This publication covers the basics of producing bunch grapes in Mississippi. A grape pruning workshop was held at the MSU Beaumont Horticulture Unit in January 2016 as well to reinforce topics from the short course.

Two winemaking workshops were held in Starkville, MS in October 2016 and September 2017. There were 25 attendees for the workshop held in 2016. Attendees drove an estimated total of 3,198 miles for the workshop equaling an investment in this workshop of (3198 miles x 0.535 federal mileage rate) = $1710.93.

A survey was given at the end of the workshop as well. Respondents indicated that their knowledge of winemaking increased by 67% by taking this course. Other responses indicated that 78% strongly agreed they would use the information they learned, 89% strongly agreed that they increased their knowledge of the topics, and 94% strongly agreed that attending this workshop was worth their time.

The second workshop, attended by 22, was held in 2017 also well received. Participants rated the overall program a 4.86 on a 1-5 scale. Specific comments included "I was happy with all aspects"; "I could do an entire week of this"; "Excellent training. I learned so much. Thanks so much"; and "Everything in the seminar has helped me to improve my knowledge and now I don't have to convince my husband what not to do".

The need for this type of programming was apparent. Overall, 100 individuals participated in the short courses and wine workshops. More effort needs to be given to these programs in order to encourage industry growth.

Goals and Outcomes Achieved

The GOAL of this proposal was to deliver workshops and create Extension publications to educate future and current growers on how to effectively grow bunch grapes and muscadines in the Gulf Coast region. Outcomes from this project were: (1) 4, 1-day workshops in MS. Participants will be encouraged to attend both to see grape production during different times of the year (winter and summer); (2) revise existing grape Extension publications; and (3) utilize student assessments of workshops for planning of future field days/workshops/short courses/publications and research. In gauging grape industries in other states, we believe that a latent industry likely exists in Mississippi and only needs nurturing to gain momentum.

All workshop attendees will be given a pre-test and post-test to gauge knowledge gain from the course (performance measure). The pre-test will act as the BENCHMARK and the TARGET will be at least a 50% increase in knowledge of southern grape production. Uploaded online materials will be monitored for pageviews, number of visitors, shares, and other quantifiable metrics to establish reach, engagement, and impact. These PERFORMANCE MEASURES will establish project results and provide incentive for continuation in this area.

The workshops were completed. One publication was written with another still in process. Student assessments were used to understand the learning that was accomplished. As stated in the previous section, we achieved the >50% knowledge increase. During the time period of this project, approximately 41 blog posts were written that garnered 9,536 page views. These are still available and will continue to be access well past the funding period at msfruitextension.wordpress.com.

Beneficiaries

Beneficiaries of this project include grape and other fruit growers who are interested in fresh market and process market production. At least 100 current and potential fruit growers and winery operators benefited from the short courses and workshops. They learned how to effectively grow grapes and muscadines in all regions of Mississippi. Workshop participants also learned the basics of wine making to get them started on a journey to commercial production. In 2014 there was only 1 active winery in Mississippi. In 2017 there are 4, with more in the works to open in the future.

Lessons Learned

One lesson we learned was that the knowledge level of the interested students was at a lower level than anticipated. We were forced to spend time on remedial material that led to longer sessions and less in-depth teaching than we would have liked. In the future, it will be preferable to hold basic and advanced classes to tailor the material better to the student needs.

The expectations of the students is very high. While we were able to meet and exceed those expectations in this project, going forward upgrades in facilities where conferences are held and bringing in more outside speakers will be necessary. The grape and wine crowd is demanding of certain amenities which cannot be provided while holding classes in county Extension facilities.

Contact

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Additional Information

The 2017 wine workshop was covered by Farmweek TV. A segment can be found in this video http://extension.msstate.edu/farmweek/video/2017/season-41-show-16 3:35-5:49.

Fruit and Nut Review
Bunch Grapes

Bunch grapes reside in the Vitaceae family of plants and within the subgenus Euvitis. They have fruit that forms clusters and can be harvested as a uniformly ripe unit.

The South does not have the ideal climate for bunch grapes. Bunch grapes prefer long, warm, dry summers and mild winters; however, with proper cultivar selection and management practices, growing bunch grapes in the South is possible.

The primary threat to successfully growing bunch grapes in Mississippi is Pierce's disease, a bacterial disease vectored by sharpshooter insects, which shortens the life or kills the plants. Muscadine grapes have a natural resistance to Pierce's disease. Some bunch grape cultivars have resistance to this disease.

Soil and Climate

Bunch grapes grow best in deep, well-drained, sandy loam soils. Soils that impart too much vigor can lead to excess vegetative growth and reduced fruit yields and quality. Shallow, heavy clay soils will not produce the vine vigor, tonnage, or fruit quality of better-drained soils. In general, bunch grapes require a long growing season, relatively high summer temperatures, low atmospheric humidity, a ripening season free from rain, and mild winter temperatures.

Planting and First Year's Growth

Plant the vines in January or February, 7 to 8 feet apart in rows spaced 10 to 12 feet apart. Set the vines the same depth they grew in the nursery. If vines are grafted, the graft union should be 2 inches above the final soil level. Spread the roots in all directions in the planting hole.

After planting, cut back the vine to leave two or three buds. Place posts, bamboo stakes, or string at each plant to train and support the vine. When the new shoots begin to grow, select the most vigorous and tie it loosely to a stake. Remove all the other shoots. In some cases, it may be possible to train the vine onto the trellis in year one. If not, cut back the vine to a point where substantial growth has occurred, then retrain in the following year. Spindly growth will likely be killed during winter months, so it should not be retained.

Second-Year Training

During the second growing season, train the vines on the trellis if not done in year one. Use 9- or 12-gauge smooth galvanized wire for the trellis wire. There are many trellis options. The easiest is to use two horizontal wires on the trellis at 12 and 72 inches above the ground. Large support posts are needed every 12 vines down the row, with T-posts at every one to two vines. The ends of the trellis must be well anchored.

If the vine (trunk) is long enough, loosely secure it to the top wire and cut it off about 2 inches above the wire. Tie a cane to the upper wire on each side of the trunk.

Pruning Mature Vines

Prune according to the vigor of the vine and its production potential. You should do this in the dormant season. Remove canes that bore fruit the previous year except for one or two buds. These are called spurs. Spurs are canes that will produce fruit the following year. Remove all other canes close to the trunk.

The properly pruned grapevine will have a trunk, two arms (cordons), and eight to ten one- or two-bud spurs (depending on vine vigor) on each arm. Proper pruning may remove 90 percent of the wood.

Aggressive pruning is necessary in grapevine culture. Allowing too much growth by not pruning enough will inhibit fruit production and fruit quality because of resource allocation and excess shading.

Cultural Practices

Fertilizer is not a serious limiting factor in young vines. Apply ½ pound of complete fertilizer (such as 13-13-13) per vine, split into two equal applications 6 weeks apart. Make the first application when vines begin to grow (budbreak) in spring.

Drip irrigation is excellent for grape culture. The irrigation line should be attached to the 12-inch wire. Apply 1 gallon of water a day per vine per year of age until you are applying 5 gallons of water per day for young plants. Mature vines can tolerate some dry conditions.

Grapes will begin to acclimate for the cold winter by slowing growth in August after harvest. This is in response to shorter daylengths and cooler temperatures. Stop using the drip system in early August to help with this natural process.

Harvesting

Grape harvest usually begins in mid-July and continues into August in much of Mississippi. Mature bunch grape vines can produce as much as 25 pounds or more per year.

Color is a poor indicator of maturity in bunch grapes. Many cultivars change color long before they are fully

ripe and become sweeter and less acid as they mature. Maturity can be determined by taste or by the color of the seeds, as they change from green to brown. If the fruit will be used for processing (juice, wine, jam, jellies, etc.) testing the sugar and acid levels will help in deciding the best time to harvest.

If vines are allowed to overproduce, the sugar content of the fruit will be low, the color will be poor, and the maturity of both fruit and wood will be delayed. Immature wood is susceptible to freeze damage, and the next year's crop may be reduced. In the case of severe overcropping, the entire vine may be winter-killed; therefore, balancing the reproductive to vegetative growth of the vine is important. This is typically done through proper pruning techniques.

Cultivars

The choice of cultivars is important and complicated. The cultivars listed below are best for growing in Mississippi and are resistant to or tolerant of Pierce's disease. Many of the cultivars listed here are difficult to find in the nursery industry. Seek out other bunch grape growers to obtain plant material. Although this is not the best practice, it may be the only option in some cases.

Black Spanish (Lenoir) — A red wine grape. Grown in Texas. Likely lacks the highest fruit quality for wine production but can be an important piece of a wine or juice product portfolio. Susceptible to black rot and downy mildew.

Blanc du bois — A high-quality white wine grape that is grown extensively in the Gulf Coast region of Texas. It is highly susceptible to anthracnose and only constant spraying will keep this disease at bay. Extremely vigorous vine growth. Harvest from late July to early August.

Conquistador — A multipurpose bunch grape that yields well but has problems with uneven ripening. Recommended for wine, juice, and jelly, as well as table use. Susceptible to anthracnose and root-knot nematodes.

Cynthiana (Norton) — A deep red wine grape. Slow to get established and has light production early in life, but this will improve with age. Tolerant of Pierce's disease but will do much better in north Mississippi. Resistant to most diseases. Later harvest than most cultivars listed here.

Daytona — A pink bunch grape recommended for fresh fruit consumption. The large clusters of grapes cling to the vine clusters, allowing handling without losing berries. Susceptible to anthracnose and root-knot nematodes.

Favorite — Very similar to Black Spanish and managed in the same manner. May have higher fruit quality.

MidSouth — Resistant to Pierce's disease but highly susceptible to root-knot nematodes when grown in infected soil. Dark-blue grape good for eating fresh and making jellies. Fruit has high acid levels when not fully ripe. Harvest dates are from late July to mid-August.

Miss Blue — A dark-blue grape with open clusters. Highly susceptible to anthracnose. Harvest dates are from late July to mid-August. Recommended for juices and jellies.

Miss Blanc — White to green in color, sweet, mild, and pleasantly flavored. Fruit may be suitable for blending for juice and wine production. Fruit ripens in late July to mid-August.

Orlando Seedless — A seedless bunch grape that has good flavor, large attractive bunches, early ripening, and vigorous vines. Very difficult to find sources for this cultivar. It is the only seedless bunch grape cultivar for the Deep South. It is susceptible to anthracnose and root-knot nematodes.

Suwannee — A vigorous, early-ripening cultivar with large berry size. Good for wine or for fresh fruit. It blooms later, but its large berries ripen early. Susceptible to anthracnose and root-knot nematodes.

Victoria Red — A new table grape that produces large clusters. Non-slipskin with a neutral flavor. Susceptible to anthracnose. Appears to be tolerant of Pierce's Disease. Ripens in early to mid-August.

Villard Blanc — A good, all-purpose white bunch grape cultivar. It can be consumed fresh or used in wine production. It tolerates Pierce's disease but, with time, will succumb to the disease. However, areas of north Mississippi will find this a suitable cultivar.

Information Sheet 1608 (POD-01-16)

By **Dr. Eric T. Stafne**, Associate Extension/Research Professor, Coastal Research & Extension Center.

Produced by Agricultural Communications.

Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. GARY B. JACKSON, Director

Agreement #14-SCBGP-MS-0028

CONSUMER DEMAND FOR FROZEN AND VALUE-ADDED MS GROWN BLUEBERRY FOOD PRODUCTS

Partner Organization

Mississippi State University

Project Summary

Blueberry production in Mississippi has significantly increased in the past decades due the compatible soil and climate conditions in the state. However, production was down dramatically in 2013 due to freeze and torrential rains, bringing profitability down and impacting the state's value of blueberry production. An opportunity to increase profits for Mississippi blueberry producers is to consider value-added alternatives for blueberries, particularly alternative food products that use substandard fruit known as juice berries, i.e., blueberries that have been damaged and are not suitable for direct sale to the consumer in the fresh market. This project sought to estimate consumer's WTP for locally grown and/or organic fresh blueberries and for value added food products made with MS-grown organic blueberries (such as blueberry jams, jellies, and ice creams, produced using Mississippi-grown juice blueberries), and to support blueberry growers by presenting these and other research results at a free, one day long Blueberry Education Workshop.

Project Approach

The first part of the project involved assessing consumer preferences by conducting an economic experiment using alternative blueberry products. In collaboration with MSU's Department of Food Science and Nutrition, we developed both organic and non-organic versions of five different food products made with MS-grown juice blueberries, for a total of ten new food products. Then, we conducted nine 1-hour long experimental sessions during two days to gather data on consumer preferences and willingness-to-pay for each product. Each session included between 16 and 18 consumers of blueberry food products, with a total of 150 participants.

The second part of the project involved conducting a one day long Blueberry Education Workshop in Hattiesburg, MS, with content targeted towards blueberry growers. Participation was free of charge and all participants received a 3-ring binder with information on the latest research being presented on blueberry production and marketing, including the results of our economic experiment on consumer demand for the new value-added blueberry food products.

Significant Results

- Willingness-to-pay (WTP) estimates for each food product at two different expiration dates into the future:

	Expires 7 days later			Expires 15 days later		
	Mean WTP	Range WTP		Mean WTP	Range WTP	
		Min 95%	Max 95%		Min 95%	Max 95%
Blueberry juice, Conventional	$2.57	0.09	4.86	$2.51	-3.09	7.91
Blueberry ice cream, Organic	$2.44	0.02	4.71	$2.38	-3.22	7.74
Frozen blueberries, Conventional	$2.40	-0.01	4.69	$2.35	-3.28	7.70
Frozen blueberries, Organic	$2.36	-0.05	4.64	$2.30	-3.32	7.66
Blueberry juice, Organic	$2.35	-0.07	4.63	$2.30	-3.31	7.67
Blueberry muffins, Organic	$2.31	-0.11	4.60	$2.25	-3.33	7.64
Blueberry muffins, Conventional	$2.19	-0.20	4.48	$2.13	-3.46	7.50
Blueberry preserves, Conventional	$1.96	-0.45	4.23	$1.90	-3.70	7.27
Blueberry preserves, Organic	$1.87	-0.57	4.16	$1.81	-3.82	7.17
Blueberry ice cream, Conventional	$1.45	-0.98	3.75	$1.39	-4.23	6.76

Accomplishments

- Using an economic experiment, we tested consumer preferences for organic and non-organic versions of five different new food products made with Mississippi-grown juice blueberries.
- Estimated consumers' willingness-to-pay for each new food product (table shown above).
- Presented the results at Southern Agricultural Economics Association Annual Meeting.
- Hosted the Blueberry Education Workshop, for which we doubled the attendance from the previous year (from about 50 to almost 100 participants).
- Presented the results of the economic experiment at the Blueberry Education Workshop.
- The Blueberry Workshop Education was featured on the TV Segment Farmweek Focus, Season 40, Show#28, which aired via Mississippi Public Broadcasting on February 2017.
- Submitted various reports to MDAC/USDA.

Conclusions and Recommendations

- Notably, the same ranking of mean WTP holds for all products regardless of expiration date.
- The product that was valued the highest was the 12 oz. juice bottle made with conventional blueberries, which had mean WTP values of $2.57 and $2.51.
- The product that was valued the lowest was the 6 oz. ice cream container made with Conventional blueberries, which had mean WTP values of $1.45 and $1.39.
- Blueberry ice cream made with organic blueberries, however, had the second-highest WTP values of $2.44 and $2.38.

- These numbers could be used in projecting revenue or cash flows, and in estimating cost-benefit analyses. It should be noted that they don't necessarily translate into the price that should be charged. Other factors such as competition affect pricing and should be considered as well.

Favorable or Unusual Developments

- None.

Significant Contributions and Role of Project Partners

- Both Co-PIs contributed equally to the successful completion of every step of this project. Drs. Collart and Interis both have expertise on market and non-market valuation.

Goals and Outcomes Achieved

Short-Term Outcomes

As proposed, consumer WTP estimates were calculated for the 10 new value-added blueberry food products made with Mississippi-grown juice berries. Moreover, blueberry growers were expected to become more knowledgeable about blueberry research, and become aware of consumer preferences for new value-added opportunities for Mississippi-grown blueberries. Participants' increase in knowledge can be assessed by looking at the results of the post-workshop attendee evaluation:

- 94.6 % of participants strongly agreed or agreed that "attending this workshop was worth my time"
- 97.3% of participants strongly agreed or agreed that "I would recommend this workshop to others"
- 100% of participants strongly agreed or agreed that "I increased my knowledge of the topics covered"

They also became somewhat interested in consumer preferences for value-added opportunities, as stated in participants' comments:

- The most important thing I learned or gained through this workshop was "SWD and marketing by Alba."

Long-Term Outcomes

Long-term outcomes include an increase in the number of blueberry producers and/or an increase in the number of growers producing new value-added opportunities for commercial purposes. Estimating the true impact of the project on these factors is challenging. However, about 94.6% of workshop participants indicated that they will actually use the information learned and will share this information with others. They also indicated that as a result of the workshop they will make use of new technologies available (such as the chill hours app), and improve production and marketing practices (such as IPM and SWD management, and customer service), which are factors that can attract more growers to the industry.

A longer-term approach to tease the true impact of the project could be to re-estimate the economic impacts for the Mississippi Blueberry industry and compare these to the most recent 2012 estimates. Collart et al. (2014) estimated the total economic impacts for the Mississippi blueberry industry in 2012 at $39.02 Mn in output/sales, $23.70 Mn in labor income (wages and salaries), 320 jobs, and $22.10 Mn in value added (the residual value of a sector's output after it pays for its inputs), and $3.75 Mn in taxes paid to state/local and federal governments. If any differences arise after re-estimating these statistics, at least part of that difference could be attributed to interventions to support the state's blueberry industry.

Timeline of Activities Completed to Achieve Goals and Outcomes

Timeline	Activity Performed
Dec 10, 2014	IRB initial application package was submitted to MSU's Office of Research Compliance for initial review.
Dec 15, 2014	Project was granted 118 Designation (Developmental Approval).
Dec 17, 2014	University Account number was assigned.
April 29, 2015	Revised IRB application with survey instrument was submitted.
April 30, 2015	Revised IRB application with survey instrument was approved.
May 1, 2015	Initial inquiry on budget changes request was initiated with MDAC.
May 29, 2015	USDA approved Budget change request.
August, 2015	Experimental design draft was initiated.
September 8, 2015	Abstract was submitted for consideration for the 2016 Southern Agricultural Economics Association (SAEA) Annual Meeting (to take place on February 2016).
September 25, 2015	Co-PIs planning meeting with MSU's Department of Food Science and Nutrition (Dr. Juan Silva).

September 25, 2015	Contract with MSU's Department of Food Science and Nutrition (Dr. Juan Silva) completed. Agreement covered the acquisition, processing, packaging, labeling, and storage of 10 new food products using frozen and value-added blueberry food products made with Mississippi-grown organic and non-organic blueberries.
Oct, 2015	Experimental design completed.
Nov 1, 2015	Final IRB application submitted.
Nov 11, 2015	Final IRB application approved. Participant recruitment began.
Nov 13-17, 2015	New food products received from MSU Food Science and Nutrition Lab.
Nov 16-17, 2015	Experiments conducted.
Nov 2015 – Jan 2016	Data cleaning, coding and initial analysis conducted.
Feb 8, 2016	Initial results presented at 2016 Southern Agricultural Economics Association (SAEA) Annual Meeting.
Aug 17, 2016	One-time no-cost time extension request (to June 30, 2017) and budget change request submitted to MDAC.
Mar 2016 – Sep 2016	Additional analysis conducted, manuscript presenting results written.
Sept 30, 2016	One-time no-cost time extension request and budget change request approved by MDAC/USDA.
Dec 16, 2016	Contract with workshop venue (Lake Terrace Convention Center) was signed.
Jan 31, 2017	Blueberry Education Workshop took place in Hattiesburg, MS. Experiment results were shared with blueberry growers during the workshop. All participants received a 3-ring binder filled with the latest research on blueberry production and marketing.
June, 2017	Researchers attended the AERE annual meeting.
August, 2017	Final report submitted.

Actual vs Proposed Goals and Outcomes

Proposed goals and measurable outcomes	Actual goals and outcomes accomplished	Major successful outcome? (Yes/No)
Goal: To investigate consumer preferences for value-added blueberry food products. *Completed*	Willingness-to-pay values were estimated, and the results were presented to academic and non-academic audiences.	Yes
Goal: To increase knowledge of blueberry growers, relative to their current level of knowledge. *Completed*	Knowledge was increased among workshop participants. Survey results indicated that 100% of participants in the Blueberry Education Workshop strongly agreed or agreed with the statement: "I increased my knowledge of the topics covered". Moreover, the majority (83.3%) of participants initially knew none, only a little, or some about the topics covered.	Yes
Outcome: At least **70%** of workshop participants will find the information useful to their decision-making processes. *Completed*	Workshop participants found the information useful and relevant to their needs. Survey results indicated that **87%** of workshop participants strongly agreed or agreed with the statement: "The [workshop] content was relevant to my needs". And, the majority (**95%**) strongly agreed or agreed with the statement "Attending this workshop was worth my time".	Yes

Outcome: At least **50%** of workshop participants will express an intent to enter these markets. *Completed*	Workshop participants expressed that they learned new skills and that they plan to use the information learned in the future. About **92%** of participants strongly agreed or agreed with the statement "I learned new skills related to the topics covered". And, about **95%** of participants strongly agreed or agreed with the statement "I will use the information learned in this workshop." We expect that at least a portion of these growers may choose to enter new markets.	Yes

Beneficiaries

The consumer WTP estimates estimated in this project can be used by blueberry growers in projecting revenue and estimating cost-benefit analyses. Investigating these alternative potential sources of additional profit can increase the competitiveness of blueberry growers by helping them enter into related markets such as those for ice creams, for juices, and for jams. Opportunities in the frozen market, for instance, would alleviate concerns related to shelf life, as blueberries will keep for up to two years if frozen. Also, Mississippi consumers can benefit from increased availability of healthy and tasty blueberries.

Importantly, blueberry growers who participated in the Blueberry Education Workshop benefited from increased knowledge on consumer demand for local blueberry food products, upcoming food safety regulations, breeding and genetics, the unveiling of a new website and mobile app to help growers manage the plants' growth, and the latest on Spotted Wing Drosophila (SWD), important and timely topics for blueberry growers in Mississippi. Growers, vendors, and researchers also benefited from networking opportunities with other workshop attendees.

Number of beneficiaries

We conservatively estimate a minimum of 335 beneficiaries. The 150 participants of experimental auctions benefited from learning more about the new blueberry food products; the 40 attendees to presentation of results at the Southern Agricultural Economics Association benefited from learning about the WTP estimates and methodology used; the 95 attendees to the Blueberry Education Workshop benefited from learning more about blueberry production and marketing; since some members of the Miss-Lou Blueberry Coop learned about the results of the study at the Blueberry Education Workshop, potentially 50 active members of the Coop benefited from learning about new

value-added opportunities for Mississippi-grown blueberries. Moreover, 95% of workshop attendees indicated that they will "tell others of the content of the workshop". Finally, the Blueberry Workshop Education was featured on the TV Segment Farmweek Focus, Season 40, Show#28, which aired via Mississippi Public Broadcasting on February 2017. We can't measure the extent of MPB's audience, but their audience also benefited from learning about the Blueberry Education Workshop.

Lessons Learned

In the economic experiment, one challenge was the process from initial IRB Developmental approval to final approval. Since the economic experiment involved human subjects, all survey instruments needed to be approved before any contact with potential participants can be made. Recruiting and events thereafter were postponed until final IRB approval was received on Nov, 2015.

Moreover, statistical analysis for the type of data collected (choice data among a discrete number of alternatives) is currently advancing at a very rapid pace. In particular, it is becoming cutting edge to estimate individual-level model parameters which provide insight into consumer behavior at a more individual level compared to the aggregate inferences from more traditional analysis methods. To implement this analysis, we had to learn to program the statistical procedures from scratch as no statistical software currently has these procedures built in.

Finally, the incentive of an improved location, vendors, and free registration, lunch, and workshop materials, increased participants to the Blueberry Education Workshop significantly to 95 this year, almost double from last year. The out-of-state speaker at the workshop helped bring the latest research on SWD closer to Mississippi growers.

Contact Person

Alba Collart, Ph.D.
(662) 325-0413
alba.collart@msstate.edu

Additional Information

Attached separately:

- Economic experiment product images
- Workshop agenda
- Workshop promotional flyer
- Workshop photos
- Workshop attendee evaluation results

PRODUCT IMAGES


BLUEBERRY
PRESERVES
NET WT. 8 oz.


BLUEBERRY
PRESERVES
Made with USDA certified
organic blueberries
NET WT. 8 oz.


BLUEBERRY
JUICE
100% Juice
NET WT. 12 oz.


BLUEBERRY
JUICE
100% Juice
NET WT. 12 oz.


BLUEBERRY MUFFINS
1 Pack of 3 Muffins
PACKAGE NET WT. 12 oz.


BLUEBERRY MUFFINS
1 Pack of 3 Muffins
PACKAGE NET WT. 12 oz.

AGENDA

2017 MISSISSIPPI BLUEBERRY EDUCATION WORKSHOP

Hattiesburg, MS, January 31st, 2017

9:00-9:30am **Registration**

9:30-9:45am **Consumer Demand for Selected Food Products Made with Mississippi-Grown Blueberries**
Dr. Alba Collart, Dr. Matthew Interis, and Dr. Juan Silva, Mississippi State University

9:45-10:15am **Fruit Quality Evaluations in Southern Highbush and Rabbiteye Blueberries**
Dr. Rachel Itle, University of Georgia

10:15-10:35am ***Xylella fastidiosa* in Rabbiteye Blueberry: What to Know**
Dr. Mary Helen Ferguson, Louisiana State University

10:35-10:50am **Blueberry Stem Blight – Symptoms and Control**
Dr. Melinda Butler, USDA-ARS Thad Cochran Southern Horticultural Laboratory, Poplarville, MS

10:50-11:30am **SWD Management in Blueberry: Optimizing Available Tools and Ongoing Research**
Dr. Lauren Diepenbrock and Dr. Hannah Burrack, North Carolina State University

11:30-12:30pm **Lunch**

12:30-1:00pm **Identifying Blueberry Germplasm and Traits Resistant to Spotted Wing Drosophila**
Dr. Blair Sampson, USDA-ARS Thad Cochran Southern Horticultural Laboratory, Poplarville, MS

1:00-1:20pm **Update on Southern Highbush Blueberry Production in High Tunnels**
Dr. Guihong Bi, Dr. Tongyin Li, and Judson LeCompte, Mississippi State University

1:20-1:35pm **New Activities from the Blueberry Breeding and Genetics Program at the USDA-ARS in Poplarville**
Dr. Stephen Stringer, USDA-ARS Thad Cochran Southern Horticultural Laboratory, Poplarville, MS

1:35-2:00pm **Update on Regulations That Can Impact You – FSMA and Produce Safety**
Dr. Juan Silva, Mississippi State University

2:00-2:15pm **A New Chill Hours Website and Smartphone App**
Dr. Eric Stafne and Kelli Alexander, Mississippi State University

2:15-2:30pm **Program Evaluation**

2:30-3:00pm **Q & A, Wrap-up**

PROMOTIONAL FLYER

MISSISSIPPI STATE UNIVERSITY.
DEPARTMENT OF PLANT AND SOIL SCIENCES
pss.msstate.edu

MISSISSIPPI STATE UNIVERSITY.
DEPARTMENT OF AGRICULTURAL ECONOMICS
agecon.msstate.edu

2017 BLUEBERRY EDUCATION WORKSHOP

JANUARY 31, 2017

LAKE TERRACE CONVENTION CENTER
EXHIBIT HALL B/C
•
1 CONVENTION CENTER PLAZA
HATTIESBURG, MS 39401

Program

9:00-9:30 am	Registration and Welcome
9:30-11:30 am	Morning sessions
11:30 am-12:30 pm	Lunch (provided to registered attendees)
12:30-2:30 pm	Afternoon sessions
2:30-3:00 pm	Wrap up, Q&A

Near By Hotels:

★★★ Holiday Inn Hotel & Suites Hattiesburg-University, 601.296.0302

★★ Sleep Inn & Suites, 601.268.1722

Hattiesburg visitor's guide for hotel and local eatery information:
Click here

To Register:

- By email or phone:

Eric Stafne, Ph.D.
Associate Extension/Research Professor
Mississippi State University
Department of Plant and Soil Sciences
eric.stafne@msstate.edu
P. 601.403.8939

or

Alba Collart, Ph.D.
Assistant Extension Professor
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Funds for this workshop were provided through the Mississippi Department of Agriculture and Commerce, USDA Specialty Crop Block Grant Program.

PHOTOS


Background

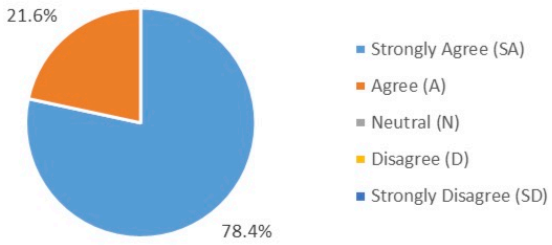

IRRIGATION MART


MISSISSIPPI DEPARTMENT OF
AGRICULTURE
&COMMERCE

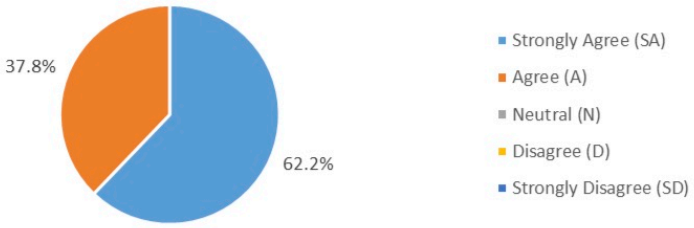
ATTENDEE EVALUATION RESULTS

Surveys completed: 37

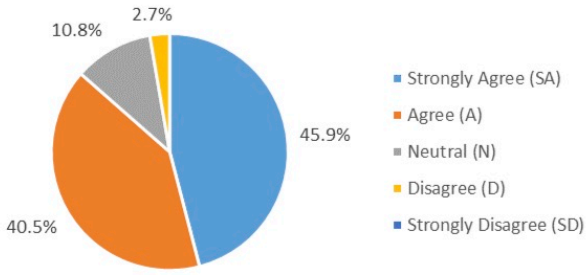
1. SPEAKERS WERE KNOWLEDGEABLE ABOUT THE SUBJECT MATTER



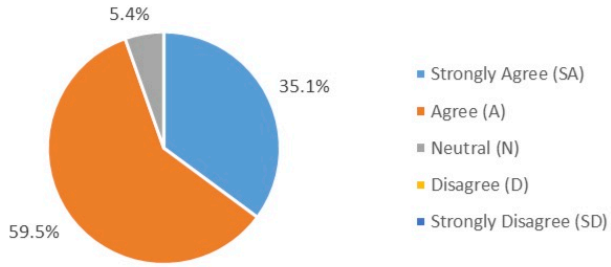
2. SPEAKERS RELATED PROGRAM CONTENT TO REAL-LIFE SITUATIONS



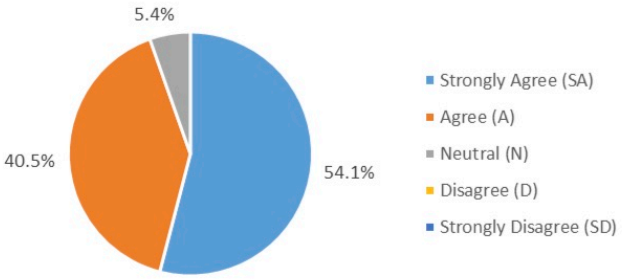
3. THE CONTENT WAS RELEVANT TO MY NEEDS



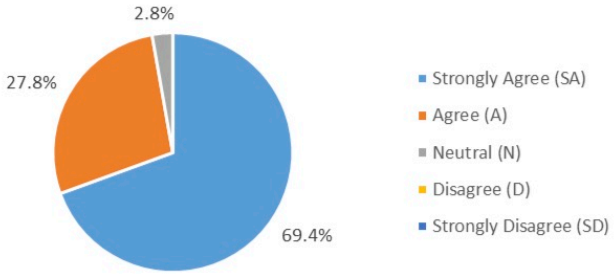
4. THE CONTENT WAS AT AN UNDERSTANDABLE LEVEL



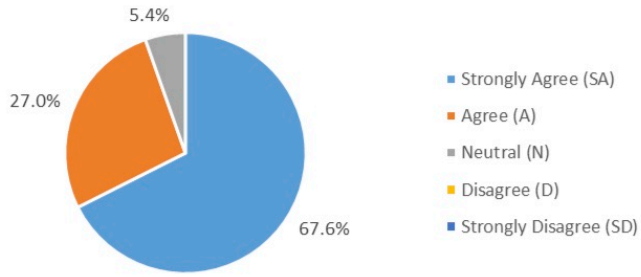
5. THE CONTENT WAS WELL-ORGANIZED



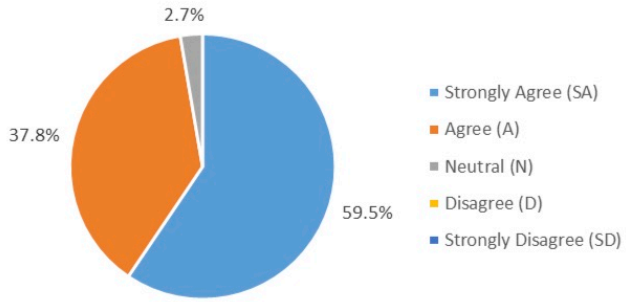
6. THE CONTENT WAS BASED ON CREDIBLE, UP-TO-DATE INFORMATION



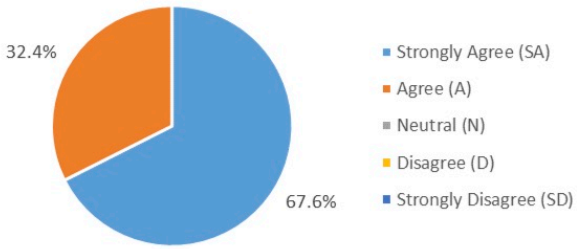
7. ATTENDING THIS WORKSHOP WAS WORTH MY TIME



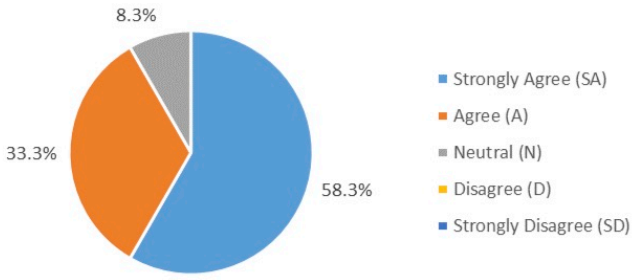
8. I WOULD RECOMMEND THIS WORKSHOP TO OTHERS



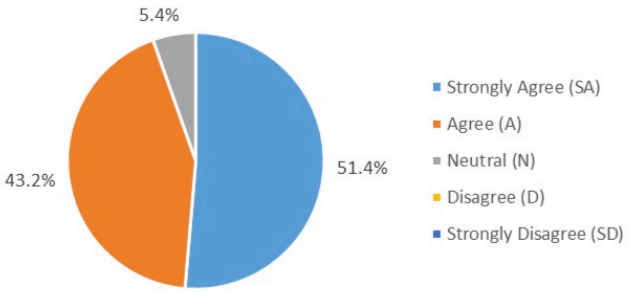
9. I INCREASED MY KNOWLEDGE OF THE TOPICS COVERED



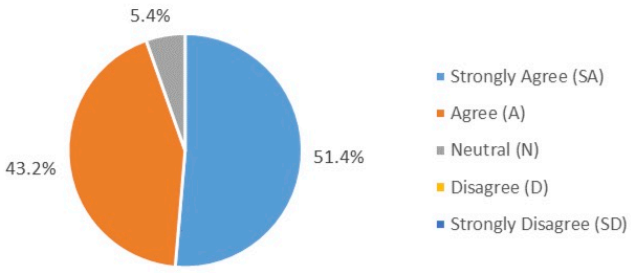
10. I LEARNED NEW SKILLS RELATED TO THE TOPICS COVERED



11. I WILL USE INFORMATION I LEARNED IN THIS WORKSHOP



12. I WILL TELL OTHERS ABOUT WHAT I LEARNED IN THIS WORKSHOP



13. THE MOST IMPORTANT THING I LEARNED OR GAINED THROUGH THIS WORKSHOP WAS:

New updates

Info on SWD, Consumer study

Lower ploidy blueberries were less likely to have SWD damage than the polyploidy blueberry

My wife and I enjoyed it

Knowledge of identifying stem blight, Rabbiteye information, Bluesfest and Gumbo, new blueberry

Overview of cultivars, susceptibility to pests

New blueberry varieties

Meeting people that can help

Connections with other farmers

High tunnel info

High tunnel info

Handy cultivars for growing

SWD Management

SWD and the marketing by Alba

Dr. Ferguson's presentation helped me identify this in a few of my bushes

Disease/blight; varieties

Difference between SHB & RE - Size of berries, chill hrs.

Information on stem blight

Insect, disease, as they affect production

Pesticide treatments and pruning times

I know which blueberry crops I have and what their firmness, strength and seeding is

Info on food safety

Latest info on SWD

Networking, Different cultivars

What to look for re: SWD

Updated research on blueberry

Pruning techniques

14. ONE SPECIFIC THING I PLAN TO USE AS A RESULT OF THIS WORKSHOP IS:

Help customers to better shill on my part. Improve.

New chill hour's app

Website and smartphone app and information on stem blight and rabbiteye

Compare characteristics to narrow possible effects from planting

Better IPM

SWD management

HT Usage

SWD Info and Chill hours

Observation for pathogen detection

Experiment with alternate varieties

Chilling app

Be on alert for SWD flies

When to prune and treat

George county work on 40 acres of blueberries

Meet requirements for food safety

Rework spray schedule

Tea, plants research, high tunnels

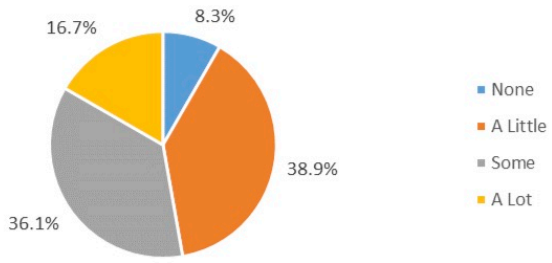
All info with Master Gardener Group

Ideas for additional cultivars

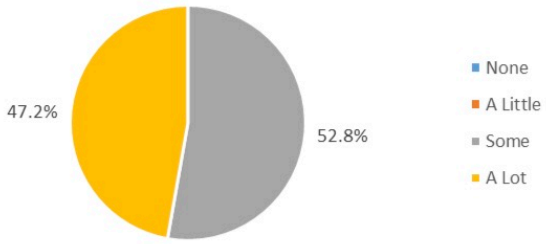
Quality aspect to investigate fruit quality

Plant selections (I will be planting new bushes this year)

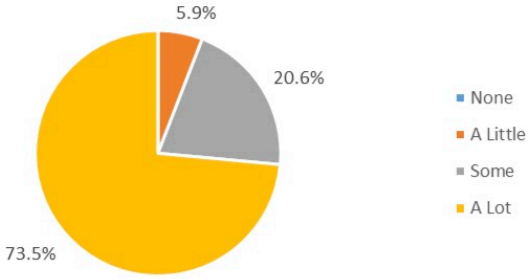
15. HOW MUCH OF THE CONTENT COVERED DID YOU ALREADY KNOW?



16. HOW MANY OF THE RESOURCE MATERIALS WILL YOU USE?



17. HOW WELL DID THE INFORMATION PRESENTED MEET YOUR EXPECTATIONS?



18. OTHER TOPICS THAT WOULD BE OF INTEREST TO ME IN FUTURE WORKSHOPS ARE:

Ponds, small lakes, and more muscadines

Small lakes and large ponds, muscadines

More on pesticides, weed control

New varieties

Soil treatments, fertilization techniques

Beekeeping (apiculture), organic pest control, organic fertilizers

Growing tea plants

Exobasidium

Market trends, market options (u-pick), market safety (in part covered this), market regulations

More economic data

19. ADDITIONAL COMMENTS:

Request slide info to be available on soft copy to view later. Charts are informative but not readable on hard copy.

Great job! Good variety of speakers from around the country.

During Dr. Stafne's tenure these workshops have improved each year due to: The facility this year provided a better environment than previous years. The speakers were well-prepared and knowledgeable in their subject matter. The workshop was well-organized and followed the agenda. Food was excellent. Atmosphere was different, in a good way.

A separate entry level, Blueberries 101, would be helpful for people exploring blueberry farming for home gardening and/or small commercial applications like local farmers' markets etc.

The economic impact (of the workshop) for me will be preventing problems that could be expensive.

Please make all handouts available - even by email is ok.

CONTAINERIZED ORGANIC BLUEBERRY PRODUCTION IN HIGH TUNNELS

Partner Organization

Mississippi State University

Project Summary

In recent years, many small- to medium-sized farmers in Mississippi have adopted high-tunnel systems for season-extending production of specialty crops. These growers seek high-value crops to increase profit and diversify their produce to meet consumer demands. In addition, an increasing number of local growers are looking toward organic production to become more ecologically and economically sustainable. Consumer demand for organically-produced specialty crops also continues to grow each year. Blueberries have become an increasingly important crop in recent years, with both production and consumption increasing dramatically due to the increased awareness of its health benefits. Local growers have requested information on the potential of growing blueberries, including organic, in high tunnels. With high tunnels, growers have the potential to gain an edge on the market by having their berries ripen a month or more early, which will offer a tremendous price advantage. The objective of this project is to develop and promote practices for sustainable organic blueberry production using high-tunnel systems in MS.

This project was initiated in spring 2015 and data were taken through 2017. One-year old liners of ten southern highbush cultivars ('Emerald', 'Farthing', 'Georgia Dawn', 'Gupton', 'Jewel', 'Meadowlark', 'Pearl', 'Rebel', 'Star', and 'Sweetcrisp') were transplanted in spring 2015 into 15-gal plastic containers and grown under a high tunnel. Plants were evaluated for the date of first ripe berry, fresh yield, single berry weight, and soluble solid content in 2016 and 2017. In general, ripened berries started from late March to early April and peaked from mid-April to mid-May. 'Meadowlark' and 'Georgia dawn' were the earliest fruiting cultivars. 'Emerald', 'Farthing', 'Meadowlark', 'Jewel', 'Rebel', and 'Star' produced comparable yield about 2000 g or higher. 'Sweetcrisp' produced berries with the highest soluble solid content (>14% Brix). 'Pearl' produced berries with the highest single berry weight (>2.5 g). In general, there was no difference in fresh yield, single berry weight, or fruit soluble solid content between blueberry plants fertilized organically or conventionally. High tunnel increased temperature about 5-10°F and reduced risk of frost damage on southern highbush blueberry cultivars at Zone 8a. Results indicated that there is great potential to produce early season blueberries in high tunnels using early fruiting southern highbush blueberry cultivars. However, there still might be potential risk of cold

damage on flowers and fruits at freezing temperatures. The project's activities and preliminary results have been shared during grower workshops, field days, and national conference.

Project Purpose

Blueberries (*Vaccinium* sp.) are perennial shrubs that are native to North America. Research has shown that a diet rich in blueberries has a variety of positive health benefits given its high antioxidant and other health beneficial contents. The United States is the world's largest producer of blueberries. Around 60% of blueberries harvested in the U.S. were sold as fresh berries. The U.S. also imports fresh blueberries every year to meet the demand of the fresh markets during the winter months and early spring. There has also been an impressive increase in national per capita consumption of blueberries. In MS, there are about 1600 acres of commercial blueberry production in 2015, and most of the production areas are located South of I-20. The main reason for lacking of field blueberry production North of I-20 is because the colder winter and late spring frost in the region pose a high risk for field production of blueberry. High tunnels have been adopted by many local growers in recent years to extend growing seasons, reduce environmental variability, increase crop yield and quality, and increase income. There is a great potential of integrating high tunnel with blueberry production in regions with low winter temperature and late spring frost.

As an Ericaecous plant, blueberries need a low soil pH between 4.5 to 5.5. Blueberry plant growth will be reduced at pH ≥ 6.5 and plants will likely develop chlorosis due to nutrient deficiencies, primarily iron and manganese. In regions with high soil pH and poor soil conditions, container blueberry production is an alternative with the flexibility of utilizing different substrates and easily adjusting substrate pH to meet plant's needs. In addition, container production in high tunnels provides the flexibility of moving the containers out if needed to free the tunnel space for other crops, and the containers can be moved back into high tunnels during winter months.

During several recent meetings and discussions, local growers have requested information on the potential of growing organic blueberries in high tunnels. However, limited information is available in Mississippi. The objective of this project was to investigate the potential of growing organic blueberries in high tunnels in MS. We proposed to evaluate different blueberry cultivars for early fruiting in high tunnels and develop the appropriate production techniques. The information generated from this project benefits specialty crop growers in MS, and contributes to the long-term economic, social, and environmental sustainability. The funding from this project allowed us to conduct detailed testing to contribute to the development of high tunnel blueberry production in MS.

Project Activities

This study was conducted in a high tunnel located at the Mississippi State University R. R. Foil Plant Research Center (North Farm) in Starkville, MS. The high tunnel was 96 ft. long by 30 ft. wide, placed in full sun and oriented north to south. One-year old liners of ten southern highbush blueberry cultivars ('Emerald', 'Farthing', 'Georgia Dawn', 'Gupton', 'Jewel', 'Meadowlark', 'Pearl', 'Rebel', 'Star', and 'Sweetcrisp') were transplanted into 15-gal plastic containers in April 2015. Pine bark (100%) was used as growing substrate. Blueberry plants were fertilized with either a conventional slow-release fertilizer Osmocote® Plus (15-9-12 (15N-2P-10K), Scotts Miracle-Grow Co., Marysville, OH) or an organic fertilizer (5-3-4 (5N-1P-3K), McGreary Organics, Lancaster, PA). Plants were drip irrigated as needed.

Cultivars were evaluated for the date of first ripe berry, fresh berry yield, single berry weight, and soluble solid content in 2016 to 2017. Ripe berries were harvested on a weekly basis. Single berry weight was calculated by recording the weight of 50 berries and divided by 50. Peak harvest is the largest harvest from each bush during a growing season. Date of peak harvest for each cultivar with a certain fertilizer type was defined as the date when the majority of bushes produced their peak harvest. The study was conducted in a randomized complete block design with five replications. Each replication contained two single-plant subsamples. All statistical analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC).

In general, there was no difference in total fresh yield, single fruit weight, or fruit soluble solid content between blueberry plants fertilized organically or conventionally. Berries started to ripe from late March to early April and peaked from mid-April to mid-May. 'Meadowlark' and 'Georgia dawn' were the earliest fruiting cultivars. 'Emerald', 'Farthing', 'Meadowlark', 'Jewel', 'Rebel', and 'Star' produced comparable yield about 2000 g or higher per bush. 'Sweetcrisp' produced berries with the highest soluble solid content (>14% Brix). 'Pearl' produced berries with the highest single berry weight (>2.5 g). High tunnel increased temperature about 5-10°F and reduced risk of frost damage on Southern highbush blueberry cultivars at Zone 8a. Results from this project indicated that there is great potential to produce early season blueberries in high tunnels using early fruiting southern highbush blueberry cultivars. Compared to traditional field production in MS using Rabbiteye cultivars, the use of early-fruiting southern highbush cultivars in combination with a high tunnel growing system provides the potential of serving early blueberry market, about 4-6 weeks earlier.

The increased air temperature of 5 to 10°F in a high tunnel reduced risk of frost damage on southern highbush cultivars. However, there is still potential risk of cold damage on flowers and fruits at freezing temperatures. We observed mild cold damage in Jan. and Feb. 2016 but no observable cold damage in 2017. In addition, blueberries grown under a high tunnel were excluded from rain. As a result, we observed less cracking and diseased berries during harvest season compared to blueberries grown outside the high tunnel.

The significant contributions and role of project partners in the project: Drs. Bi and Li set up all the experiments in the high tunnels and collected data, hosted tours that showcased the studies being done under this grant, presented the project results at grower workshops, field days, and national conference, and prepared the progress reports and final report.

Goals and Outcomes Achieved

The goal of this project is to select suitable early fruiting cultivars and develop appropriate management practices for high tunnel organic blueberry production in Mississippi. We tested 10 southern highbush blueberry cultivars: 'Emerald', 'Farthing', 'Georgia Dawn', 'Gupton', 'Jewel', 'Meadowlark', 'Pearl', 'Rebel', 'Star', and 'Sweetcrisp' in a high tunnel containerized production system. We collected data on timing of peak harvests, yield, single berry weight, and soluble solid content in both 2016 and 2017. Among the ten cultivars tested, 'Meadowlark' and 'Georgia dawn' were the earliest fruiting ones, 'Sweetcrisp' produced the sweetest berries, and 'Pearl' produced the largest berries. In general, there was no difference in total fresh yield, single fruit weight, or fruit soluble solid content between blueberry plants fertilized organically or conventionally. The peak harvest was from mid-April to mid-May, about 4-6 weeks earlier that the traditional field blueberry production in MS using Rabbiteye cultivars. Preliminary findings and recommendations were delivered to growers and scientific community through workshops, field days and conferences including 2017 MS Blueberry Education Workshop, Beaumont Horticultural Unit Annual Field Day, Poplarville Horticulture Field Day, and American Society for Horticultural Science Annual Conference. The project site has been showcased in several formal and informal grower tours, student tours, and gardener tours. Multiple emails and phone conversations are ongoing between PIs and growers interested in adopting the results from this project. The number of clientele reached by presentations, workshops, and field days was over 300, exceeded the original target of 200. This research was also highlighted in an article published in Mississippi State University Agricultural and Forestry Experiment Station Discovers Magazine. We are in the process of preparing one peer-reviewed journal article and one experiment station bulletin based on the results obtained from this project.

Since blueberries are perennials and the optimum yield will be reached after 3-5 years, we will continue to monitor plant growth and collect yield data beyond the project period to give growers better information on long term yield and economics. The project site will continue to serve as a demonstration site to growers and professionals.

Beneficiaries

Beneficiaries of the project have included new and existing specialty crop growers in MS and surrounding states. More than 300 growers and gardeners have toured the research site over the life

of the project. Knowledge gained from this project has supported grower and agent trainings in Mississippi.

Lessons Learned

Using high tunnels for extended season production of specialty crops are of great interest to small- and medium-scale farmers and marketers because they provide added income for producers and increase the availability of produce to consumers during traditional off-season periods. Results from this project suggested that there is great potential to produce early season blueberries in high tunnels using early fruiting southern highbush blueberry cultivars. Further research on economic analysis is needed to justify the investment of a high tunnel. Considering that there still might be risk of cold damage at freezing temperatures, further research might look into other environment-modifying technology in combination with high tunnels to temper the environment and reduce the environmental and economic risks of season extension production.

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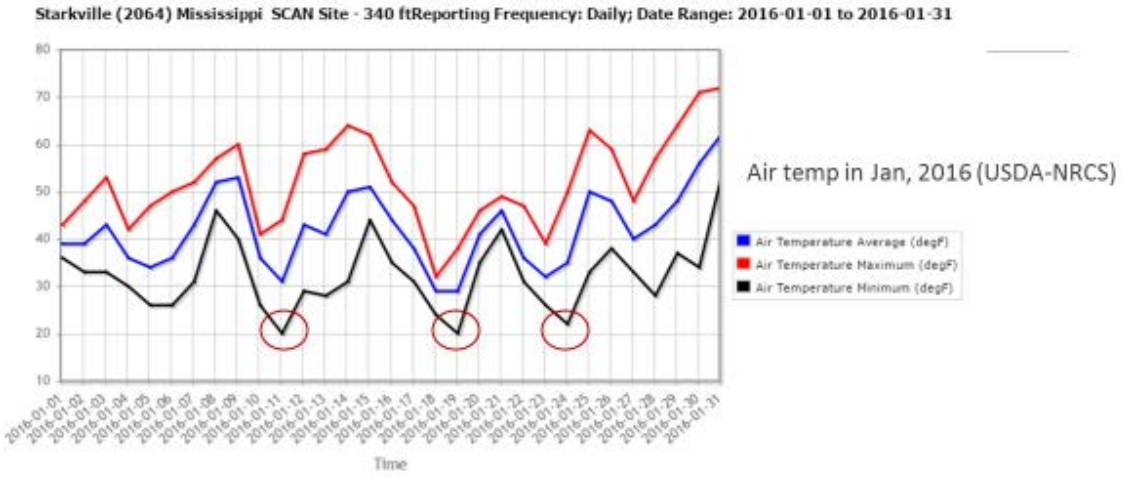
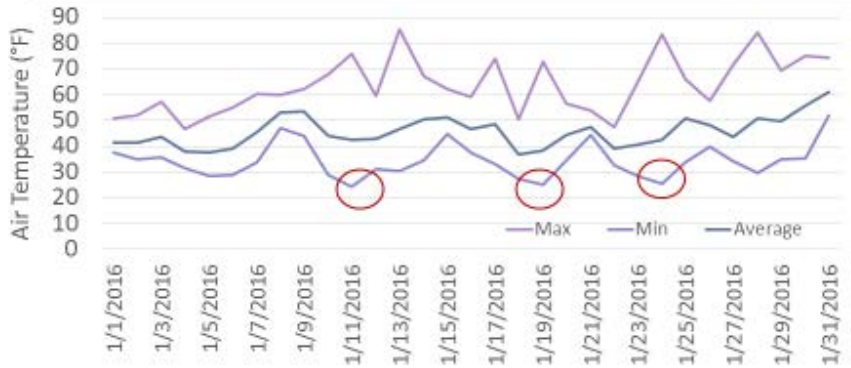
Additional Information

Photo #1. Blueberry plants grown in containers under a high tunnel at Mississippi State University in Starkville, MS.

Starkville Air Temperature



Air Temperature in High Tunnel



- High tunnel raised air temperature of 5-10 °F

Date of First Ripe Berry (2016)

EMR	EMR	RBL	RBL	SWC	SWC	FAR	FAR	MDL	MDL
Org	Slr	Org	Slr	Org	Slr	Org	Slr	Org	Slr
Dec 27	Dec 10	Dec 15	Dec 15	Dec 27	Dec 19	Jan 3			Dec 24
Apr 13	Apr 14	Apr 16	Apr 1	Apr 13	Apr 11	Apr 14	Mar 30	Apr 3	Apr 1
50%	60%	60%	50%	20%	30%	20%			10%
GAD	GAD	STR	STR	JWL	JWL	PL	PL	GPT	GPT
Org	Slr	Org	Slr	Org	Slr	Org	Slr	Org	Slr
Mar 30	Mar 28	Apr 17	Apr 4	Apr 15	Apr 15	Apr 25	Apr 19	Apr 28	Apr 25

Cultivar	
'Emerald'	EMR
Farthing'	FAR
'GA Dawn'	GAD
'Gupton'	GPT
'Jewel'	JWL
'Meadowlark'	MDL
'Pearl'	PL
'Rebel'	RBL
'Star'	STR
'Sweetcrisp'	SWC

- 'Emerald', 'Rebel', 'Sweetcrisp', 'Farthing' and 'Meadowlark' produced first ripe berry from Dec 2015 to Jan 2016.

*Org-Organic fertilizer; Slr-Slow release fertilizer.

Date of First Ripe Berry (2017)

EMR	EMR	RBL	RBL	SWC	SWC	FAR	FAR	MDL	MDL
Org	Slr	Org	Slr	Org	Slr	Org	Slr	Org	Slr
Apr 3	Mar 25	Mar 26	Mar 25	Apr 12	Apr 12	Apr 8	Mar 29	Apr 3	Mar 25
GAD	GAD	STR	STR	JWL	JWL	PL	PL	GTP	GTP
Org	Slr	Org	Slr	Org	Slr	Org	Slr	Org	Slr
Mar 28	Mar 24	Apr 16	Mar 29	Apr 6	Apr 11	Apr 11	Apr 16	Apr 23	Apr 18

Cultivar	
'Emerald'	EMR
Farthing'	FAR
'GA Dawn'	GAD
'Gupton'	GPT
'Jewel'	JWL
'Meadowlark'	MDL
'Pearl'	PL
'Rebel'	RBL
'Star'	STR
'Sweetcrisp'	SWC

- 'Emerald'-slr, 'Rebel', 'Farthing'-slr, 'Meadowlark'-slr, 'GA Dawn', 'Star'-slr produced first ripe berry from end of the March in 2017.

*Org-Organic fertilizer; Slr-Slow release fertilizer.

Date of Peak Harvest (2016)

Early-Season			Mid-Season					Late-Season		
GAD	MDL	RBL	EMR	FAR	JWL	STR	SWC	GPT	PL	
Apr 22- May 18			May 9 – May 27					May 27 – June 16		
Berries per bush at peak harvest (g)										
323	417	495	374	404	546	312	437	411	486	Organic
258	522	486	418	551	612	398	409	488	624	Slow release

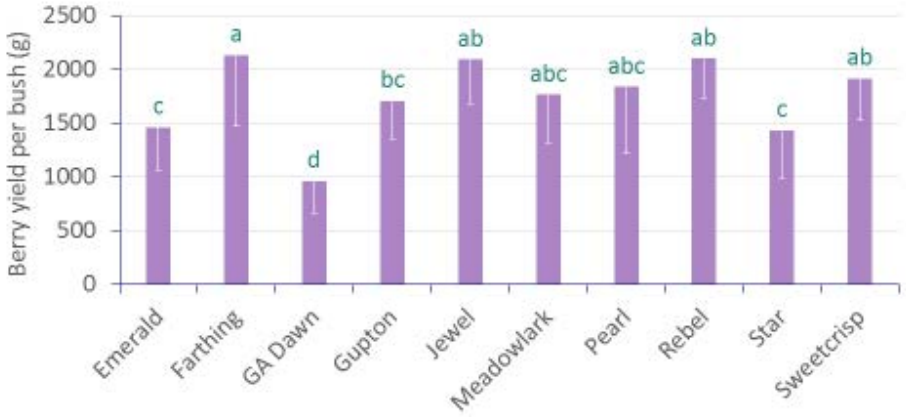
- 'GA Dawn', 'Meadowlark', and 'Rebel' produced peak harvest from Apr 22- May 18.

Date of Peak Harvest (2017)

Early-Season			Mid-Season					Late-Season		
GAD	MDL	EMR	FAR	JWL	RBL	STR	SWC	GPT	PL	
Apr 20- May 11			Apr 28 – June 5					May 11 – June 5		
Berries per bush at peak harvest (g)										
656.0	697.8	623.6	559.5	695.4	575.7	643.8	413.3	515.7	463.8	Organic
581.3	704.4	615.0	571.7	594.7	391.4	669.8	380.5	503.3	543.9	Slow release

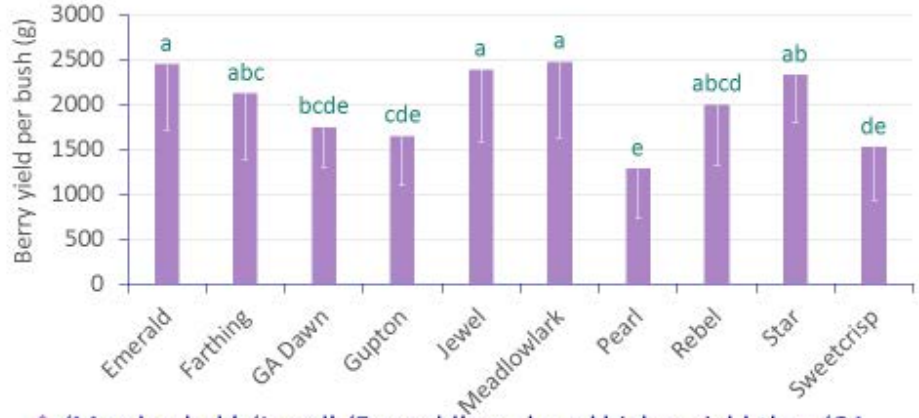
- 'GA Dawn', 'Meadowlark', and 'Emerald' produced peak harvest from Apr 20- May 11.

Berry Yield (2016)



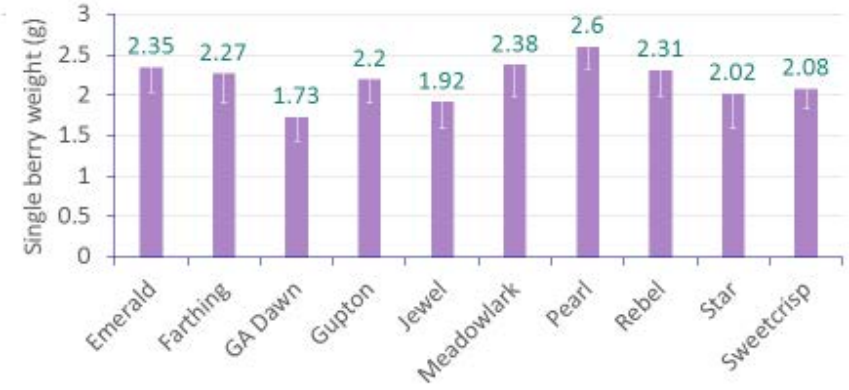
- 'Farthing', 'Jewel', and 'Rebel' produced comparable yield of over 2000 g berries per bush.

Berry Yield (2017)



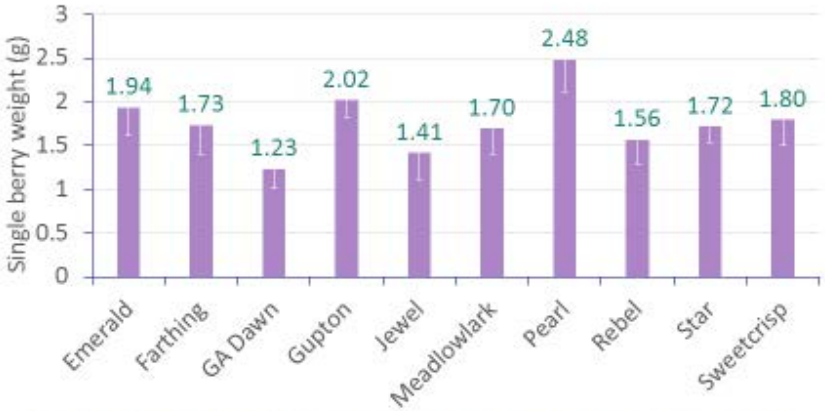
- 'Meadowlark', 'Jewel', 'Emerald' produced higher yield than 'GA Dawn', 'Gupton', 'Pearl', and 'Sweetcrisp'.

Single Berry Weight (2016)



- Eight cultivars produced single berry weight more than 2 g.

Single Berry Weight (2017)

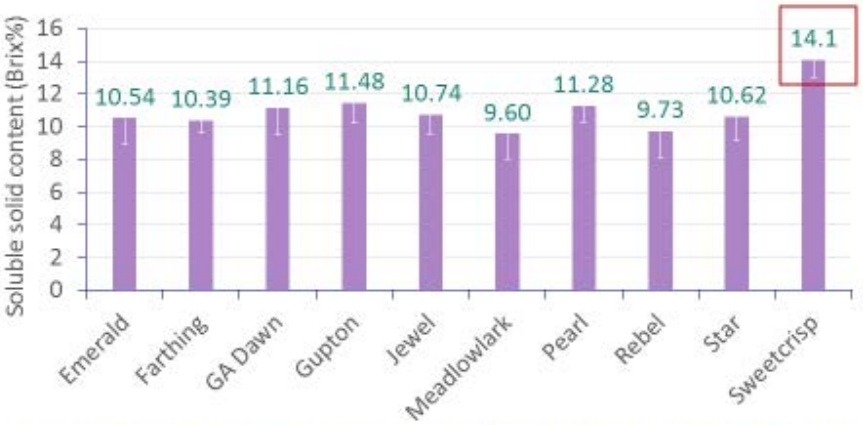


- 'Pearl' produced significantly larger berry than other nine cultivars'; 'GA Dawn' produced the smallest berry.

Soluble Solid Content (2016)

- 'Sweetcrisp' produced berries with significantly higher brix than other nine cultivars in 2016.

Soluble Solid Content (2017)



- 'Sweetcrisp' produced berries with significantly higher brix than other nine cultivars in 2017.

DETECTION OF PRE-STORAGE AND PACKING IDENTIFICATIONS OF FUNGI INFECTED TIP/END ROT SWEETPOTATO ROOTS USING PORTABLE VOLATILE ORGANIC COMPOUNDS DETECTION MACHINERY WITHIN WAREHOUSES

Partner Organization

Mississippi State University

Project Summary

Macrophomina phaseolina (Mp) is an extremely important pathogen of numerous agriculture and horticultural crops causing the loss of millions of dollars annually. This pathogen is the main one associated with tip/end rot and produces the toxin botryodiplodin, which is thought to be a carcinogen. This pathogen can cause external and internal rots of crops important to Mississippi such as sweet potatoes. In the case of internal rot, which cannot be seen at the producer's level, methods to determine Mp presence in presumed healthy sweet potato roots will enable the grower to ensure a quality product being sold in the market place. Portable detection equipment that can be used within warehouse pre-storage and packaging facilities could eliminate losses and prevent infected product from entering the marketplace and maintaining wholesaler and consumer confidence. In addition, the methods developed in this study can be used for Mp in numerous other crops for the future. Therefore the first phase of the study was to obtain a pool of Mp isolates by field sampling, to determine what impacts on VOC data collection, long-term storage had on their cultural stability and pathogenicity potential (biochemical stability) with repeated greenhouse disease screening. Secondly and primary focus of our work during this first phase of research was to explore the development of rapid detection methods and hardware for qualitative and quantitative analysis of microbial volatile organic compounds (MVOCs) in order to identify specific chemicals unique to the Mp. First and second year screening of isolate cultural types (flat and fluffy) showed differences in VOC profiles. *Continued research*: After the initial research, phase 2-3 are being pursued evaluating Mp isolates on actual sweetpotato host tissues to ensure biochemical distinctions between Mp versus host tissue. Phase 3 studies are being used to compare associated other organisms on sweetpotato host tissue with Mp to ensure that the detection device to be developed will be sensitive for Mp alone.

Project Purpose

Mississippi is the third largest sweet potato producer (per CWT) in the United States after California and North Carolina (USDA National Agricultural Statistics Service, 2009). Sweet potatoes are grown on about 29,000 acres by about 90 family farmers in rural Mississippi (Mississippi Agriculture, Forestry and Natural Resources, 2016). The estimated value of Mississippi's sweet potato production rose sharply higher in 2016, to $116,000,000, continuing a two year trend. Since most sweet potato farmers reside in two rural counties which possess the majority of the state's appropriate soils, Calhoun and Chickasaw, any impact on the sweet potato crop will be felt throughout north central Mississippi.

Between 20 to 25% of the sweetpotato crop is lost during curing and storage with another 25% lost during shipping and retailing before customer consumption. Sweet potato storage rots in Mississippi increased annually from 2005-2009. The rot also started occurring earlier in storage, becoming a late November problem instead of a January one. In 2005-2008, the rot increased in incidence, but seldom damaged enough of the crop to cause serious economic loss. Among growers, rot incidence was erratic and with few exceptions, would occur one year but not the next. Until 2008, the most common rots were Rhizopus, different types of Fusarium rots, circular spot, and punky rot but more recently Mp is considered to be one of the primary pathogen associated with tip/end rot (Stokes and Baird, unpubl.data).

Macrophomina phaseolina is known to infect several hundred crop and non-crop plant species worldwide causing a range of diseases including charcoal rot, root rot and seedling blight. MP has been historically present in Mississippi fields and the occurrences of sweet potato tip/end rot have increased annually since 2005. The statewide consequences of MP occurrences have been dramatic with yields decreasing from 172 cwt/acre for the 2008 crop to 115 cwt/acre in 2009, while production showed an even more dramatic decline from 3,354 thousand cwt in 2008 to 1,265 thousand cwt in 2009.

When placed into storage, affected roots appear healthy. When the roots are pulled from storage, washed and sorted on the packing line, end rot diseased roots show areas of black, almost charcoal like color. The black areas may be dry and desiccated or wet and smelly, depending on which other fungi have been present. The black color is due to a fungus called *Macrophomina phaseolina* (Mp). When the disease is discovered, it is at the economically worst time for the grower, since all investments have been made (investments in seed, fertilizer, cultivation, management practices, labor-intensive harvesting, transportation, storage, washing and sorting), only to suffer the additional expense with the disposal of the rotting roots, instead of expected income at the end. Worse, the grower knows how many roots went into storage and can predict what will pack out. This information might well be used to make contracts, which then might have to be filled by purchasing sweet potatoes.

Although the fungus Mp has historically been present in Mississippi fields, recent work shows that it has been especially important in the end rot outbreak, where it accounts for 13%-28% of all fungal

isolates taken from fields with an end-rot history (Stokes et al., 2011). It appears more than likely that the interaction of Mp and other fungi with specific nematode species and increasing in numbers due to lack or limited rotations has caused sweet potato disease losses to dramatically increase (Stokes, Henn, and Baird, unpubl. data). Some also suspect increased stress from defoliants being used recently for managing sweet potatoes.

An additional pathogen added to the study is Rhizopus soft rot caused by *Rhizopus stolonifera* problem pre-and postharvest of sweetpotato in storage facilities. This major root rot pathogen may feed on the same root causing disease symptoms confounding their identities by packers especially with new regulations for use of sanitizers with fungicides. These sanitizers, which inhibit E coli from establishing on roots, may inadvertently reduce efficacy of fungicides which prevent Mp and Rhizopus stonifera from causing root rots in storage. Therefore, developing noninvasive identification methods for both pathogens that could monitor their occurrences in storage facilities would be important for reducing losses. Rhizopus stolonifera can spread within bins and ruin stored roots if not removed. However, this latter pathogen has just started being investigated.

Project Activities

Isolate Availability for Chemical Studies

A major portion of these studies were to obtain isolates of Mp and towards end of fy 14 isolates of R. stolonifera. Thus collection trips by CoPI R. Baird were being done to go to fields where sweetpotato are grown to collect recently harvest roots and later root debris during the study period. Over 50 isolates were obtained, Mp and new ones continue to be collected. What we discovered that after two-three subcultures was that isolates once showing tightly appressed morphology in culture were now becoming cottony and possibly having less pathogenicity. Loss of pathogenicity may be enzymatically controlled thus potentially changing Volatile Organic Compounds (VOC) composition compared to the pathogenic isolates. To confirm loss of pathogenicity, greenhouse tests continue to be important part of our verification process to ensure uniformity of VOC data. It was determined that getting fresh field isolates of Mp were important to use in VOC studies versus ones that were stored. More recently R. stolonifera isolates are being collect for additional VOC data with isolate storage not seeming to be an issue to consider. The Mp research for fy 14 involves 1) isolate collection and storage, 2) pathogenicity screening of isolates, and 3) VOC method development with fungi for VOC studies.

Identifying Volatile Organic Compound Profiles

An emerging method for specific isolate identification involves the analysis of volatile metabolites of the fungus. Complicating this approach is the understanding that many factors influence metabolic production including growth parameters such as growth media, temperature and spore counts. In addition, analytical methods can influence results. We evaluated several growth and analysis methods in order to better understand the requirements of an analytical method that will elucidate metabolomic chemical signatures of these fungi.

In recent years, metabolomics approaches have been widely used for the investigation of metabolites of biological samples for identifying biomarkers that correlate to a disease, drug toxicity, or genetic or environmental variation. Metabolites can belong to a wide variety of compound classes, such as amino acids, lipids, organic acids, nucleotides, alcohols, esters, and hydrocarbons. These compounds are very diverse in their physical and chemical properties and occur in a wide concentration range. Some of these metabolites are volatile enough for headspace sampling. Metabolic profiling and fingerprinting methods are used to elucidate a microorganism's life processes. Metabolic profiling is a determination of the chemicals and their concentrations produced by specific biosynthesis pathway of organisms. Metabolic fingerprinting is the screening approach to classify samples based on metabolite patterns or "fingerprints". The metabolomics study process often includes sample preparation, sample collection, instrumental analysis, data pretreatment, and data analysis.

Relative humidity, temperature, substrate (growth medium), and number of fungal spores inoculated are the main factors influencing fungal growth, metabolism and MVOCs production in a laboratory setting. It has been concluded that the germination time and radial growth rate were significantly affected by the three studied variables. Clearly fungal growth conditions are an important consideration when conducting a metabolomic fingerprinting study involving the production of MVOCs.

Sampling methods such as thermal desorption tube (Tenax TA), purge and trapping of headspace gases, headspace sorptive extraction, and solid phase microextraction (SPME) have been used for the collection of MVOCs. SPME is a popular technique because it has the advantages of low cost per analysis and portability. Volatile chemicals can be selectively enriched on SPME fibers depending on fiber coating selection. Therefore the SPME fiber coating selection is important and should be tailored for specific applications. Optimization of fiber selection for 15 volatile and semivolatile analytes representing 13 organic classes were performed, and extraction efficiencies of the fibers for each of the analytes were compared. Our study illustrated key considerations involved in the selection of a SPME fiber including: (a) the polarity and functionality of the polymer absorbent and (b) the volatility and functional groups of the target analyte.

In metabolomics research, different data pretreatment methods are applied in order to generate 'clean' data in the form of normalized peak areas that reflect metabolite concentrations. These clean data can then be used as the input for data analysis. Data pretreatment aids to enhance relevant (biological) information and to reduce the influence of confounding factors from random error and spurious chemicals from column and absorbent bleeding. Three classes of data pretreatment methods are normally utilized including centering, scaling and transformations. Centering converts all the concentrations to fluctuations around zero. Scaling enable the adjustment of fold differences between the metabolites, increasing the importance of low abundant metabolites. Transformations including log and power transformations are generally applied to correct for heteroscedasticity.

Statistical data analysis methods including multivariate data analysis (MVDA) can be used for extracting important features from large or small data sets containing a number of variables and observations. MVDA includes multivariate ANOVA (MANOVA), linear discriminant analysis (LDA), cluster analysis (CA), principal component analysis (PCA), partial least square analysis (PLS). These methods are widely used in fungal detection and classification.

The effect of sample collection strategy using SPME fibers and sample preparation (fungal growth parameters) on the MVOCs production was investigated. For SPME fiber evaluation, the extraction efficiency of three commercial available SPME fibers coated with Carboxen/Polydimethylsiloxane (CAR/PDMS), Divinylbenzene /Polydimethylsiloxane (DVB/PDMS) and Carboxen/Divinylbenzene /PDMS were compared. For the growth parameters' effect study, fungus was grown under varied conditions using different temperatures and number of spores inoculated and on different substrates to evaluate the influence of these factors on MVOCs production. One aim of this study was to optimize fungal growth conditions for large MVOCs production and to determine MVOC variability within a single isolate. Data pretreatment methods including scaling, centering and transformations were applied to MVOCs data sets.

Growth medium

Malt Extract Agar (MEA), Czapek Solution Agar (CSA), and Corn Meal Agar (CMA) were purchased from Becton, Dickinson and Company (Franklin Lakes, New Jersey). The ingredients of chemical defined agar (CDA) was mixed based on the literature. The ingredients of the growth medium are listed in Table 1.

Table 1. Growth substrates and their ingredients used in the study

Growth substrate name	Abbreviation	pH	Media conc.	Ingredients
Corn meal agar	CMA	6.0±0.2	17 g/L	2 g corn meal, infusion from solid, 15 g agar
Czapek solution agar	CSA	7.3±0.2	49 g/L	30 g saccharose, 2.0 g $NaNO_3$, 1.0 g K_2HPO_4, 0.5 g $MgSO_4$, 0.5 g KCl, 0.01g $FeSO_4$, and 15 g agar
Chemical defined agar	CDA	-	60.28 g/L	30 g sucrose, 10 g Asparagine, 3.5 g $(NH_4)_2SO_4$, 1 g KH_2PO_4, 500 mg $MgSO_4$, 200 mg $CaCl_2$, 10 mg $ZnSO_4 \bullet 7H_2O$, 5 mg $MnCl_2$, 2 mg $FeSO_4$, and 15 g agar
Chemical defined liquid	CDL	-	45.28 g/L	30g sucrose, 10 g Asparagine, 3.5g $(NH_4)_2SO_4$, 1 g KH_2PO_4, 500 mg $MgSO_4$, 200mg $CaCl_2$, 10mg $ZnSO_4 \bullet 7H_2O$, 5 mg $MnCl_2$, 2 mg $FeSO_4$

Malt extract agar	MEA	4.7±0.2	33.6 g/L	12.75 g maltose, 2.75 g Dextrin, 2.35 g Glycerol, 0.78 g Peptone, and 15.0 g agar

SPME fibers

Carboxen/Polydimethylsiloxane (CAR/PDMS), Divinylbenzene/ Polydimethylsiloxane (DVB/PDMS), and DVB/CAR/PDMS SPME fibers were purchased from Sigma-Aldrich (St. Louis, MO).

GC-MS analysis

The analysis of collected MVOCs was performed with a GC-MS. Extracted volatiles were thermally desorbed from the SPME fiber in the injection port (at 270℃), equipped with a 78.5 mm × 6.5 mm × 0.75 mm SPME inlet liner. Thermal desorption was setup for 5 min and the SPME fiber was conditioned for 1 h at 270 ℃ following manufacture instructions before the next usage. The gas chromatography capillary column used for separation was a 60-m DB-1 capillary column with an internal diameter of 320 µm and a film thickness of 1 µm. Helium was used as a carrier gas was with a flow velocity of 1.2 ml min^{-1}. The following GC oven temperature program was applied: 45 ℃ for 9 min, 10 ℃ min^{-1} to 85 ℃, hold for 3 min, 3 ℃ min^{-1} to 110℃, hold for 3 min, 3 ℃ min^{-1} to 120℃, hold for 3 min, and 10 ℃ min^{-1} to 270 ℃, hold for 5 min. The MS analysis was carried out in full scan mode (scan range from 35-350 amu) with ionization energy of 70 eV. Ion source and quadrupole temperatures were 230 ℃ and 150 ℃, respectively.

Data processing

Tentative chromatographic peak identification was made by library matching using the NIST 08 MS Library. Compounds were considered positively identified when both mass spectra and retention index (RI) led to the same identification. Quantitative data for each analyte was determined using peak area. Peak alignment adjustments were required due to instrument drift and experimental error. Peak alignment procedures for samples from GC-MS measurements play an important role in biomarker detection and metabolomic studies in general.

Additional data processing required that peak areas of zero were replaced with values equal to 1 count to allow for log transformation. The lowest peak areas in the rest of the data are on the order of 10^5. Any MVOCs detected less than three times in the 6 replication experiments were removed from further data treatment. Silicon containing peaks with m/z of 73, 207 and 281 are believed to have originated from the column stationary phase and were also removed from the processed data.

Data pretreatment

Systematic data pretreatment can be used to enhance the results of follow-on classification methods including PCA and PLS. The data pretreatment methods listed in Table 2 were compared using PCA to evaluate the classification results of five media types with six replications. In the SPME fiber selection study, log transformation (Table 2) were applied to achieve better group separations. Each MVOC detected represents the dependent variable in PCA and each replication is the observation.

Table 2. Overview of the pretreatment methods in this study

Class	Method	Formula	Goal
I	Centering	$\tilde{x}_{ij} = x_{ij} - \bar{x}_i$	Focus on the differences and not the similarities in the data
II	Autoscaling	$\tilde{x}_{ij} = \frac{x_{ij} - \bar{x}_i}{s_i}$	Compare metabolites based on corrections
	Pareto Scaling	$\tilde{x}_{ij} = \frac{x_{ij} - \bar{x}_i}{\sqrt{s_i}}$	Reduce the relative importance of large values, but keep data structure partially intact
III	Log transformation	$\tilde{x}_{ij} = \log x_{ij}$	Correct for heteroscedasticity, pseudo scaling. Make multiplicative models additive
	Power transformation	$\tilde{x}_{ij} = \sqrt{(x_{ij})}$	Correct for heteroscedasticity, pseudo scaling
	Area normalization	$\tilde{x}_{ij} = \frac{x_{ij}}{\sum x} \times 100$	Relative quantity of analyte

The mean is estimated as: $\overline{x_{ij}} = \frac{1}{N}\sum_{N=1}^{N} x_{ij}$, and standard deviation is estimated as $s_i = \sqrt{\frac{\sum_{N=1}^{N}(x_{ij} - \bar{x}_i)^2}{N}}$. $\tilde{x}_{ij}$ is the data after the pretreatment and x_{ij} is the data before the pretreatment. i is the column and represents the relative concentration of each MVOC. j is the row and represents the samples (observations).

Data analysis

MANOVA was performed to examine whether there is significant difference in the quantities of MVOCs emitted by the fungal culture inoculated with different spore doses. 15 MVOCs, commonly emitted by the fungi, were selected to compare the quantitative variation caused by the change in spore dose. These 15 compounds are ethanol, 1,4-pentadiene, 2-methylfuran, 2-methyl-1-propanol, 3-methylbutanol, 2-methylbutanol, toluene, (-)-aristolene, β-elemene, α-farnesene, cubenene, δ-cadinene, β-germacrene, β-panasinsene, and β-cadinene. The data was treated by log transformation and then MANOVA was performed using SAS 9.3 software (SAS Institute Inc.). PCA was performed using software program SIMCA-P+ 11.0 (Umetrics, Umea, Sweden). PCA classification results were evaluated using score plots.

Evaluation of SPME fiber on metabolic profiling

Extracted MVOC profiles and quantities were determined and the information was used to select the best SPME fiber for metabolic fingerprinting. Experiment precision (repeatability) was evaluated based on relative standard deviation (RSD%) of the six replicates of three SPME fiber types: CAR/PDMS, DVB/PDMS and DVB/CAR/PDMS. These fibers were evaluated in terms of their efficiency in extracting volatile metabolites emitted growth on a MEA substrate. The fungal culture was incubated for 7 d at 30 ℃ with initial inoculation spores concentration of 1×10^6 spores/mL. The SPME extraction was

maintained at 30℃ for 5 hours. The extraction efficiency evaluation included two aspects, MVOC selectivity and quantity (peak area).

Three evaluated fibers showed different abilities to extract volatile metabolites as shown in Figure 1 A and B. The CAR/PDMS fiber not only extracted the largest number of MVOCs (Figure 1A), but also extracted the largest amount of MVOCs based on the total peak area of all the volatile metabolites (Figure 1B). A closer look at the data revealed MVOC functional group selectivity. Identified MVOCs were divided into 9 chemical classes including alcohols, aldehydes, furans, hydrocarbons, ketones, organic acids, organosulfur compounds, sesquiterpenes, and other compounds. Among the chemical classes, hydrocarbons were divided into hydrocarbon1 (fewer than ten carbons) and hydrocarbon2 (ten or more carbons). Other compounds include seven unknown compounds, one ether and one ester.

The CAR/PDMS fiber extracted greater amount of alcohols, furans, hydrocarbons1, hydrocarbon2 and ketones, while DVB/PDMS extracted larger amount of high molecular weight compounds containing the organosulfur compounds, sesquiterpenes and other compounds (Figure 2). These results agree with the literature which describes the CAR/PDMS as likely to extract low molecular weight compounds while DVB/PDMS is better at extracting high molecular weight compounds.

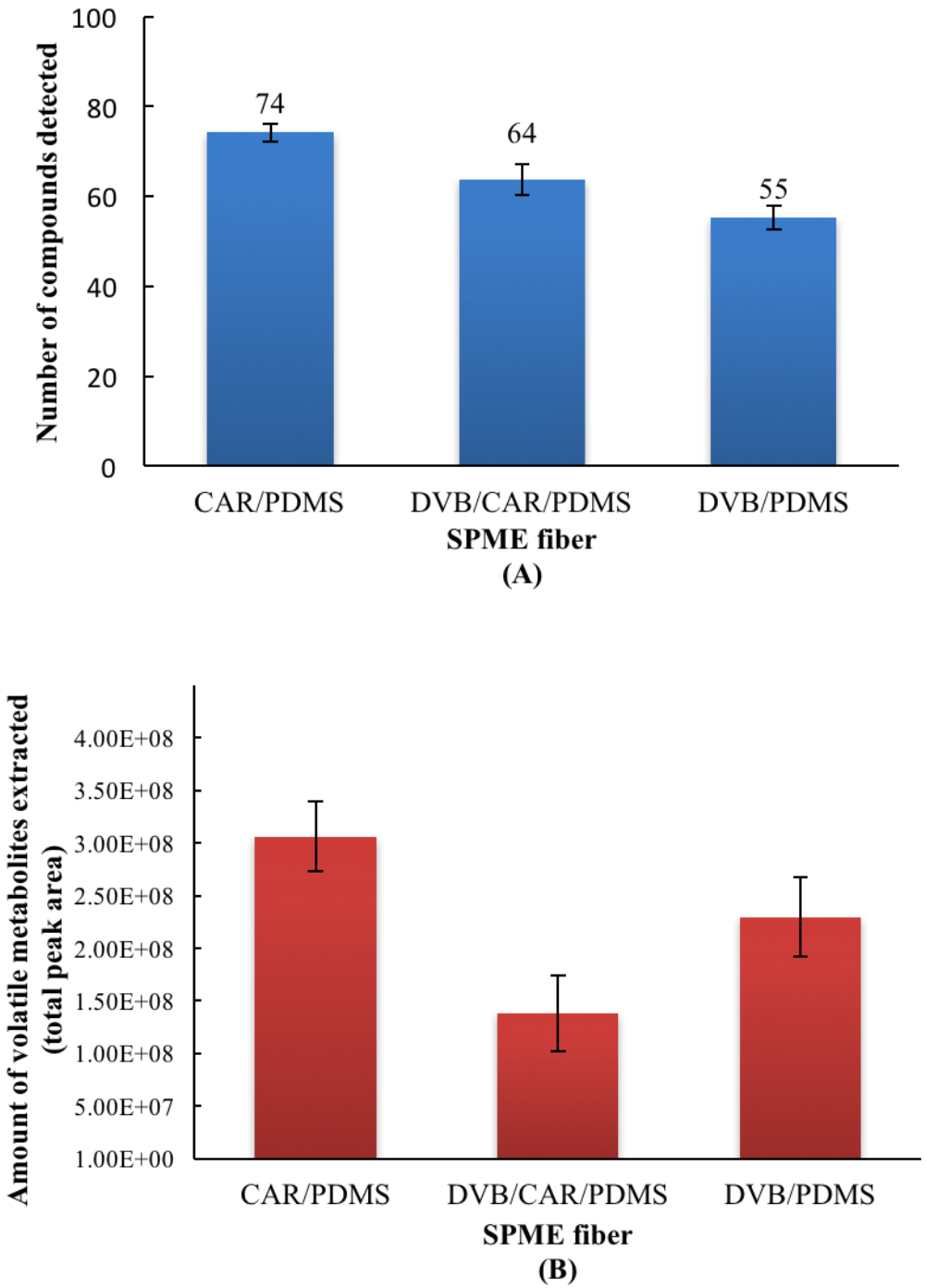


Figure 1. SPME fibers comparison through the number of (A) and amount of (B) volatile metabolites extracted using three types of SPME fibers CAR/PDMS, DVB/CAR/PDMS and DVB/PDMS in six replications. The error bars indicate the standard deviation of six replicates.

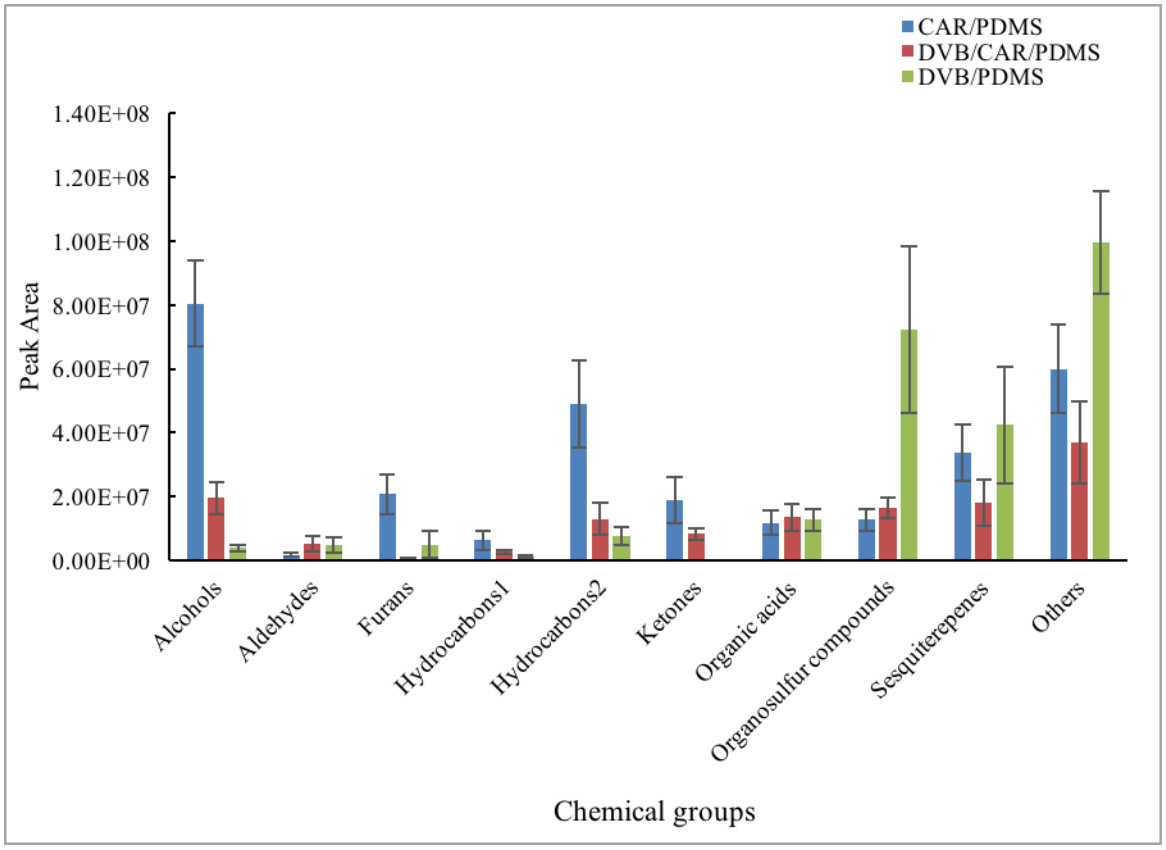


Figure 2. SPME fibers comparison though the amount of volatiles in chemical groups extracted from fungus culture using three types of SPME fibers CAR/PDMS, DVB/CAR/PDMS and DVB/PDMS in six replications. The error bars indicate the standard deviation of peak areas of six replicates. Among the chemical classes, hydrocarbons were divided into hydrocarbon1 (fewer than ten carbons) and hydrocarbon2 (ten or more carbons).

Since the CAR/PDMS fiber has difficulty adsorbing higher molecular weight analytes and DVB/PDMS has difficulty extracting analytes with low molecular weights, a DVB/CAR/PDMS fiber was developed by the manufacturer. The advertised extraction advantage of extended molecular weight range of VOCs was not observed based on our results. CAR/PDMS was determined to be an excellent SPME fiber coating choice for fungal MVOC profiling based on its ability to collect the largest number and greatest quantity of MVOCs.

The precision or repreatibility of this method was examined using the relative standard deviation percentage (RSD%) of each extracted and identified fungal MVOC. RSD% of each metabolite was calculated using both peak area and peak area percentage data. Table 3 lists 15 common MVOCs detected and their RSD% for each SPME fiber.

Table 3. 15 selected MVOCs and their RSD% (using both peak area and peak area percentage) obtained using three types of SPME fibers CAR/PDMS, DVB/PDMS, and DVB/CAR/ PDMS with 6 replications each.

No.	Compound name	R.T. (min)	Peak Area RSD%			Peak Area% RSD%		
			CAR	DVB CAR	DVB	CAR	DVB CAR	DVB
4	1,4-Pentadiene	5.543	48.8	61.9	-	40.4	40.0	-
9	Propanoic acid, 2-methyl-, anhydride	8.313	68.0	31.1	-	64.1	65.4	-
10	Furan, 2-methyl-	8.568	38.4	20.3	-	30.1	22.4	-
11	1-Propanol, 2-methyl-	9.046	30.4	32.6	-	29.7	30.8	-
15	1-Butanol, 3-methyl-	13.825	52.6	51.3	-	57.7	74.6	-
16	1-Butanol, 2-methyl-	13.943	37.8	34.3	-	41.8	32.3	-
18	Toluene	15.501	13.8	15.9	-	25.1	26.2	-
22	Styrene	21.901	23.8	17.3	19.3	35.7	24.5	19.7
36	Undecane, 2,6-dimethyl-	38.682	73.5	37.2	43.5	48.0	37.0	20.0
52	2,4,4,6,6,8,8-Heptamethyl-2-nonene	43.784	26.0	27.0	31.5	15.3	40.0	11.7
56	β-Elemene	44.256	26.8	24.7	30.2	27.1	23.8	7.8
64	α-Selinene	45.591	34.7	46.5	44.5	39.6	0.6	42.7
68	Cedrene	46.060	29.5	37.6	28.4	14.6	20.4	29.0
70	Calamenene	46.338	27.3	52.4	48.8	23.7	45.1	29.0
72	π-Calacorene	46.627	17.0	32.6	36.5	22.8	21.7	23.1
	Average RSD%[a]	**--**	**56.7**	**40.9**	**49.8**	**56.7**	**52.08**	**39.5**

PCA was performed to aid in the evaluation of the extraction efficiency of the SPME fiber types by exploring the correlation between the specific volatile metabolites and SPME fiber types. The raw peak area data was treated using log transformation to reduce the heteroscedasticity (uninduced biological variation), to convert the non-normal MVOC distribution into a normal one, and to make skewed distributions more symmetric. This also helps to add emphasis to MVOCs present in trace quantities that may play a role in fungi identification. PCA was performed using the log transformed MVOCs peak area data.

Effect of the growth substrates on MVOCs production

Five growth media substrates (Table 1) were evaluated. CMA contains the least amount of organic nutrients (around 2 grams), MEA is most commonly used in the MVOC studies while CSA is typically used for fungus cultures. CDA and CDL are chemically defined medium that have previously been used for an aflatoxin production study. The fungal culture was incubated for 7 days at 30℃ with initial inoculation spores concentration of 1×10^6 spores/mL. CAR/PDMS fiber was used for extracting the MVOCs for 5 hours at 30℃. Table 4 lists a subset of the identified MVOCs and their relative quantity

(expressed in peak area) produced on the five different incubation medium (CMA, CSA, CDA, CDL and MEA).

Table 4. Selected common MVOCs and their relative quantities (expressed in peak area on the five different incubation medium (CMA, CSA, CDA, CDL and MEA).

No.	MVOC[a]	Chemical Classes	R.T. (min)	Media (Peak area × 10^5)				
				CDA	CSA	CDL	MEA	CMA
1	Ethanol	alcohol	4.595	15.9±7.29[b]	590±239	2441±2797	50.6±31.8	188±92
2	Acetone	ketone	5.022	-	282±97	142±155	266±151	71.1±24.7
4	Isopropyl Alcohol	alcohol	5.149	4471±601	312±66	-	78.4±46.3	57.03±7.79
7	1,4-Pentadiene	alkene	5.547	-	700±153	466±76	211±103	12.7±2.91
18	Furan, 2-methyl-	furan	8.567	131.7±41.4	360±45	1136±317	172±66.2	11.71±3.08
29	Toluene	aromatic hydrocarbons	15.506	12.9±4.35	24.7±7.95	101±27.2	24.3±3.35	8.63±1.71
36	Styrene	aromatic hydrocarbons	21.984	-	37.7±8.33	91.6±15.7	42.3±10.1	23.7±10.6
50	D-Limonene	aromatic hydrocarbons	30.733	-	34.9±3.24	334±548	3.76±2.38	8.23±2.14
54	Dodecane	alkane	33.053	14.1±2.11	46.4±16	46.5±14.8	96.6±99.6	30.9±5.98
63	2,2-Dimethylheptane-3,5-dione,	ketone	35.810	-	10.1±2.82	40.6±25.8	10.4±13.1	5.38±0.64
67	Decanal	aldehyde	39.186	6.65±0.864	14.9±8.36	238±178	11.1±8.25	8.58±2.82
69	1,3,7-Octatriene, 3,7-dimethyl-	alkene	40.716	12.4±2.45	-	13.5±11.9	13.5±7.87	-
73	Heptacosane	alkane	42.160	19.6±6.76	-	11.2±10.1	53.5±22.2	9.73±4.97
74	δ-Cadinene	sesquiterpene	42.380	-	38.1±17.2	29.7±32.2	11±4.47	20.7±10.8
81	(Z)-2-Hexadecene	alkene	43.313	84.9±22.9	19.7±5.31	-	33.7±8.69	15±7
82	trans-α-Bergamotene	sesquiterpene	43.379	282±77	38.7±25.8	76.7±37.3	13.7±5.65	16.1±8.52

Table 4 (Continued)

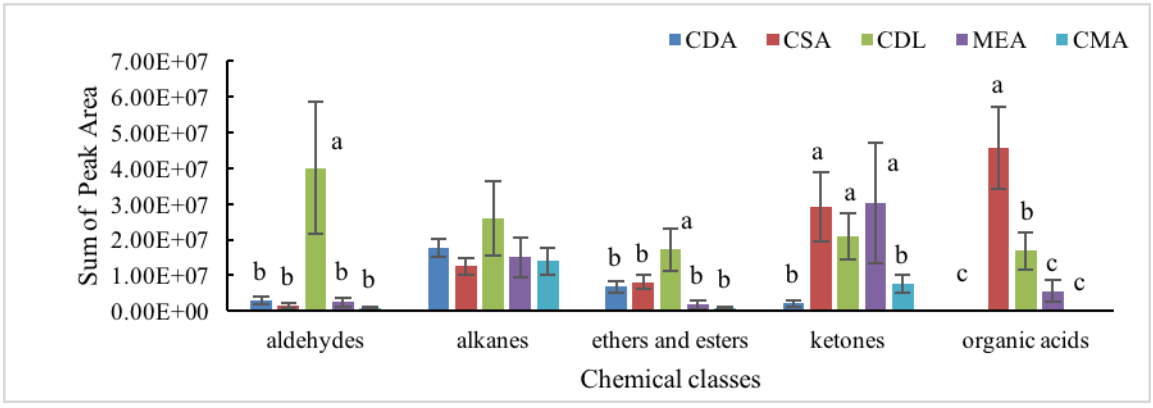
83	α-Cubebene	sesquiterpene	43.489	100±27	81.0±18.3	542±441	188±46.2	-
84	3-Hexadecene, (Z)-	alkene	43.619	61.3±13.8	155±56.7	68.6±35.1	91.6±23.9	75.7±34.3
85	trans-7-Hexadecene	alkene	43.781	-	83.7±30.9	44.2±28.7	14.4±5.98	37.7±16.7
87	Ylangene	sesquiterpene	43.988	10572±1341	96.2±32.1	813±345	39±20.6	-
88	(-)-Aristolene	sesquiterpene	44.106	15240±2280	944±251	13881±6678	154±41.4	27.3±8.56
89	β-Elemene	sesquiterpene	44.253	266±64.2	2770±1203	18305±8626	15.3±5.53	46.5±20.4
90	Isoledene	sesquiterpene	44.383	-	74±10.1	422±318	8.37±6.73	6.03±2.1
92	β-Humulene	sesquiterpene	44.502	-	89.9±34.4	366±194	8.16±2.46	-
95	α-Farnesene	sesquiterpene	44.690	4354±846	63.1±26.8	317±208	-	7.95±3.88
96	α-Gurjunene	sesquiterpene	44.778	647±138	187±79.1	5032±2941	18.3±8.73	-
97	β-Cubebene	sesquiterpene	44.871	2067±470	61.2±18.4	942±514	-	5.61±3.25
101	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	sesquiterpene	45.110	3410±679	-	441±269	16.7±3.74	3.42±1.65
104	Valencene	sesquiterpene	45.511	1694±458	425±215	2675±2334	52.3±18.1	1.74±0.71
105	α-Selinene	sesquiterpene	45.590	10481±2747	536±115	3143±2099	30±20.2	-
106	α-Farnesene	sesquiterpene	45.742	1662±320	1079±553	13975±9284	-	3.58±1.06
109	Cubenene	sesquiterpene	46.030	2869±817	504±235	9414±6261	-	4.51±1.6
111	δ-Guaiene	sesquiterpene	46.181	9186±5597	100±39.7	1255±890	-	1.46±0.44
113	δ-Cadinene	sesquiterpene	46.329	1503±177	3196±1441	11706±8150	-	6.42±1.85
114	β-Germacrene	sesquiterpene	46.421	606±126	335±117	2428±1666	15.2±5.42	-
115	β-Panasinsene	sesquiterpene	46.489	1508±382	161±65.9	1218±853	21.8±3.71	-
116	β-Cadinene	sesquiterpene	46.616	164±39.9	307±178	4222±3500	9.23±3.28	-
122	Cadina-1(10),6,8-triene	alkene	47.141	60.7±16.9	34.9±14	299±145	12.3±8.27	-

Table 4 (Continued)

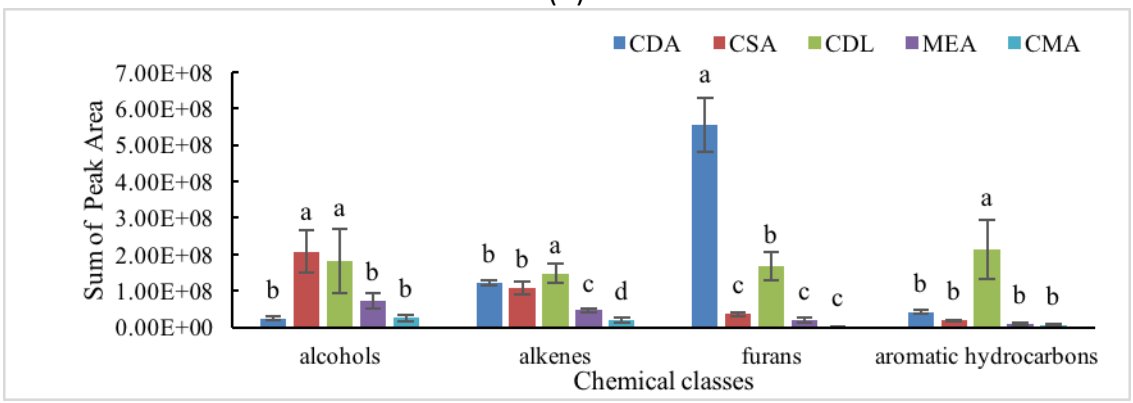
130	Germacrene D	sesquiterpene	47.993	52.8±19.9	37.8±15.4	438±298	10.7±4.56	-
131	α-Cadinol	alcohol	48.145	272±67	23.3±6.58	370±256	-	2.86±2.72
132	Naphthalene, 1,6-dimethyl-4-(1-methylethyl)-	aromatic hydrocarbons	48.345	-	68.7±22.8	603±65	-	13.85±5

Different MVOC profiles are produced when the fungus is grown on different media. This difference can be seen when MVOC are divided into different chemical classes (alcohols, aldehydes, alkanes, alkenes, esters, ethers, furans, hydrocarbons, aromatic hydrocarbons, ketones, organic acids and sesquiterpenes) as shown in Figure 3. The 132 MVOCs were grouped by chemical class and their raw peak areas summed for Figure 3. MANOVA was performed to test whether there are significant differences among the total quantities of MVOCs in each chemicals class across the five growth media.

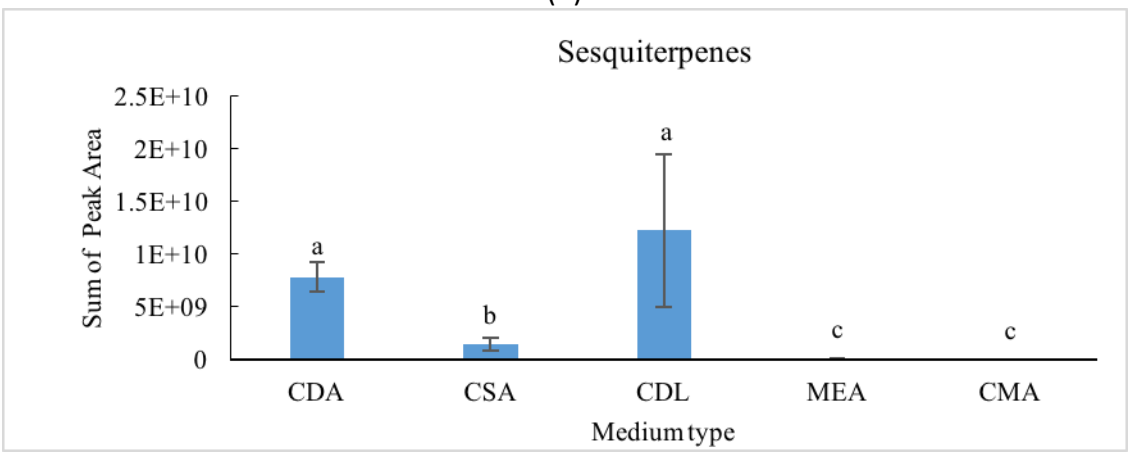
Figure 3B illustrates that the MVOCs production in CDA media has larger amount of furans than the other media. Among these growth medium, the fungi growth on the CDL media produces the largest amount of aldehydes, combination of ether and esters, aromatic hydrocarbons and alkenes. CDL and CDA have an identical list of ingredients except for the addition of 15 g of agar to the CDA media which helps to produce a gel like media. The quantities of MVOCs produced by the fungi growth on the liquid media (CDL) are much greater than those growth on the agar medium (CDA) for all chemical classes expect the furans. Interestingly, both CDL and CDA produced significantly more sesquiterepenes than the other growth media (Figure 3C). One possible explanation is the addition of L-asparagine which has been shown to enhance the production of sesquiterpenes and aflatoxins. Hence, MVOCs production is clearly affected by growth media and growth media, must be considered when developing methods for classification of fungal species.



(A)



(B)



(C)

Figure 3. Comparison of amount of volatile metabolites (sum of peak area with SD (6 replicates)) emitted by fungus on growth medium CDA, CSA, CDL, MEA and CMA.

Different letters above the bars indicate significant differences (MANOVA, $P<0.05$). The data with the highest total TIC for each chemical class starts with label a. The TIC of each medium shows no significant difference in the alkane group.

Effect of data pretreatment methods

Data pretreatment methods can be utilized to convert raw data to a different scale (for instance, logarithmic scale or relative scale) which reduces unwanted biases to more clearly depict important biological signals. The effect of data pretreatment have been illustrated through the application of six data pretreatment methods on MVOCs data from the five different media substrates. Results of these methods are shown in Figure 4 where A) is the raw data. The other graphs represent: B) centering, C) autoscaling, D) pareto scaling, E) log transformation, F) power transformation, and G) area normalization. The pretreatment methods were performed according to the equations listed in Table 2.

The raw peak area data for the 132 identified MVOC are shown in Figure 4A (MVOC profile from CDL media replication 1). Mean centering was applied to obtain a mean value of zero in order to improve the interpretability of the model (Figure 4B). Autoscaling is a combination of mean centering and scaling to unit variance where the scaling weight employed is $1/s$, and s represents the the standard deviation of the variable (peak area of a specific MVOC). After autoscaling, “long” variables are “shrunk” and “short” variables are “stretched” (Figure 4C). In pareto scaling, the scaling weight is $1/\sqrt{s}$, and it is intermediate between the extremes of no scaling and autoscaling (Figure 4D). The data does not become dimensionless as after autoscaling, so this method stays closer to the original measurement than autoscaling.

Another objective of data pre-treatment is converting a non-normal distribution of the specific variable into a normal one. One way to accomplish this is through log transformation (Figure 4E). The benefits of this sort of transformation includes 1) simplifying the response function by linearizing a non-linear response-factor relationship, 2) stabilizing the variance of the residuals, and 3) making the distribution of the residuals more normal, which can serve to eliminate outliers. Power transformation plots the square root of the data (Figure 4F) and is similar to the pareto scaling method. Finally, the area normalization method (Figure 4G) showed similar results when compared to the original data (Figure 4A). The area normalization method is a semi-quantitative approach using the relative percentage of each compound of the total MVOCs extracted.

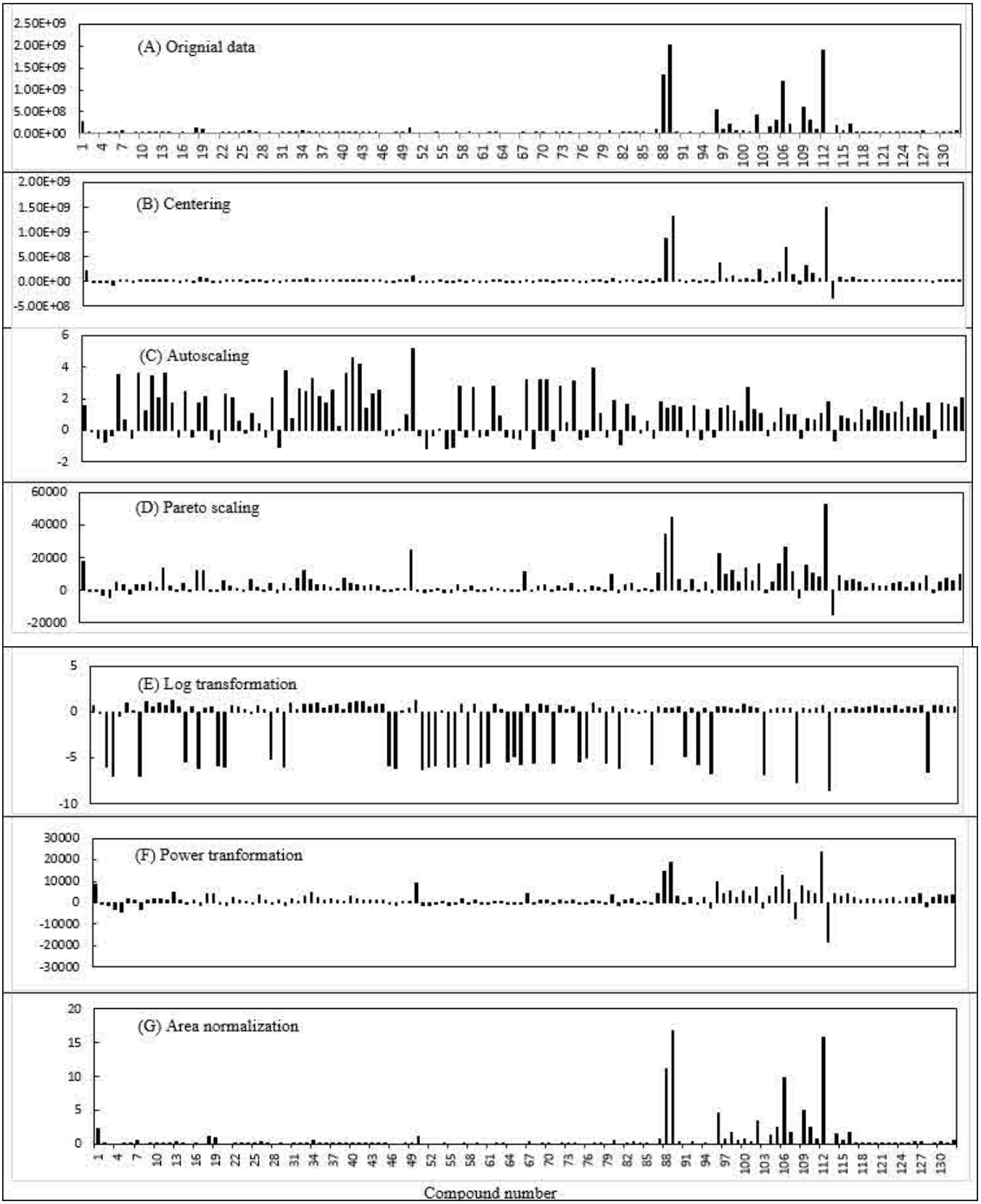
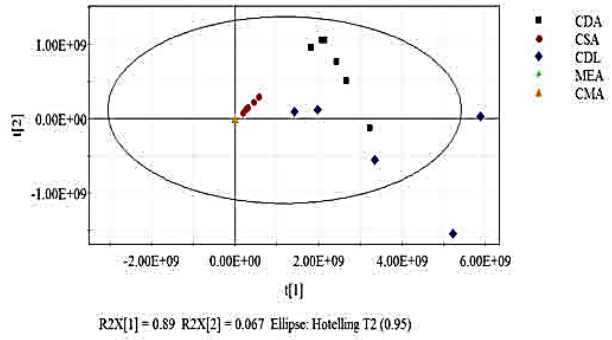


Figure 4. Effect of data pretreatment on the original data.

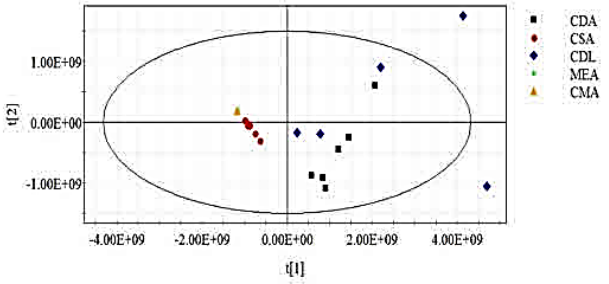
Each of the 6 data pretreatment methods were applied to the entire data set. PCA was used to analyze the effect of each method (Figure 5). PCA can also identify important MVOCs contributing to classification by analysis of the loadings. Suitable data pretreatment methods help provide good cluster separation where the distance within the cluster of a specific category (Media type) and the distance between the clusters of the categories are favorable. The application of log transformation (Figure 5E) provided the best clustering results in the score plots. PCA analysis of the centering (Figure 5B), pareto scaling (Figure 5D) and the original data (Figure 5A) provided poor clustering results compared to the other pretreatment methods. Power transformed data showed intermediate cluster separation. Tight clusters were produced with the area normalization method (Figure 5G), however, the CDA, CSA and CDL clusters were not well separated.

In the original (5A) and centering data (5B), MEA, CMA and CSA clusters “squeeze” together because CDA and CDL have much larger variances in the data caused by higher concentration of MVOCs. Large variances play an important role for classification of different categories (media) in PCA analysis. Poor cluster separation resulted from data pretreatment without a “hard” scaling method such as autoscaling. Pareto scaling is the intermediate between no scaling and autoscaling, which also showed unfavorable classification.



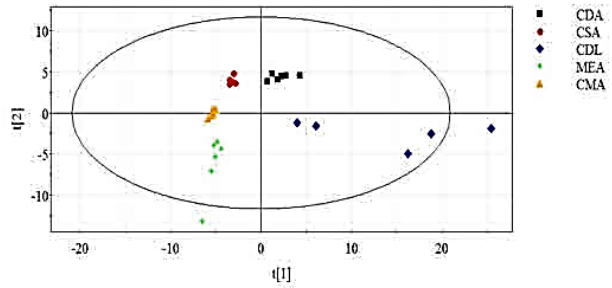
R2X[1] = 0.89 R2X[2] = 0.067 Ellipse: Hotelling T2 (0.95)

(A)



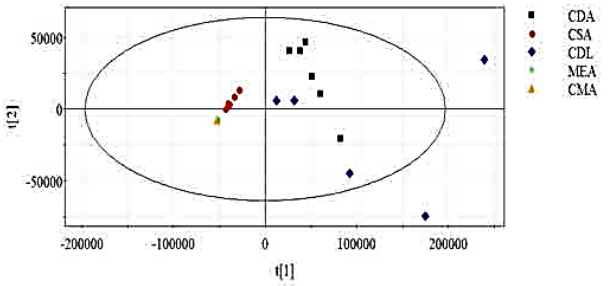
R2X[1] = 0.85 R2X[2] = 0.10 Ellipse: Hotelling T2 (0.95)

(B)



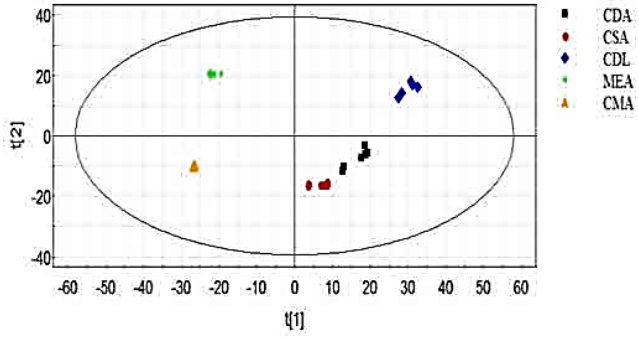
R2X[1] = 0.477257 R2X[2] = 0.148469 Ellipse: Hotelling T2 (0.95)

(C)



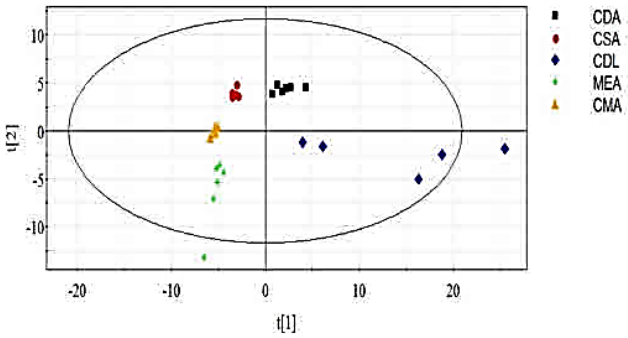
R2X[1] = 0.79 R2X[2] = 0.08 Ellipse: Hotelling T2 (0.95)

(D)



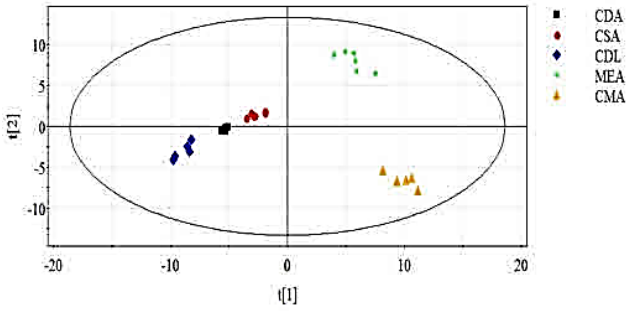
R2X[1] = 0.43 R2X[2] = 0.20 Ellipse: Hotelling T2 (0.95)

(E)



R2X[1] = 0.48 R2X[2] = 0.15 Ellipse: Hotelling T2 (0.95)

(F)



R2X[1] = 0.38 R2X[2] = 0.19 Ellipse: Hotelling T2 (0.95)

(G)

Figure 5. Effect of data pretreatment on the PCA results. PCA results of original data (A), centered data (B), autoscaled data (C), pareto scaled data (D), log transformed data (E), power transformed data (F), and area normalized data (G).

This completed research in fy 14 did define most of the critical experimental parameters used for MVOCs fingerprinting are crucial to the outcomes of MVOCs profiles and the data analysis. Uniformity of isolates (flat and consistent pathogenicity) prior to VOC studies are critical to success of project moving forward to VOC level of study. The identity and quantity of MVOCs extracted can be affected by many factors. MVOC profile trends were observed for: 1) the selection of SPME fiber, 2) fungal growth medium, and 3) growth temperature. Original spore dose also changes MVOC profiles; however, no clear trends were observed. The CAR/PDMS fiber seem to perform better than the other SPME fibers by collecting a larger variety and quantity of MVOC. Fungi grown on the CDL media produced much larger quantities of MVOCs compared to CSA, CDA, CMA and MEA medium. Data pretreatment method is a key component of data analysis. The proper pretreatment methods will lead to better cluster separation which will aid in the discovery of relevant biomarkers.

Preliminary study results:
The following is an example set of data from one of our 4 greenhouse studies.
Pathogenicity Isolate Screening Greenhouse Test 2

A soybean model was used in order to screen pathogenicity of the isolates. MP is a major pathogen of soybeans and pathogenicity in soybean will correlate well with pathogenicity in sweetpotato. Greenhouse studies with soybean have several benefits. For example, soybean has 21-28 turn around in greenhouse to confirm disease potential whereas sweetpotato requires up to 90 days or longer. Furthermore, we could do multiple Mp isolates with soybean MINI pots but we would have to use large 5-liter pots to grow roots for sweetpotato for the require pathogenicity tests. The sweetpotato studies are prohibitively more labor intensive and are not required to determine pathogenic MP isolates. Once pathogenic isolates were identified these active isolates were used in further studies with sweetpotato. Test 2 started with sterilizing of the plastic pots. The soil /sand mixture was also sterilized using an autoclave, twice after waiting for 24 hours. The sterilized soil was stored in autoclave bags until the experiment's initiation. The sterilized soil/sand mixture was mixed with five plugs of *M. phaseolina* culture for each treatment with four replications as follows.

I. Control -Soil/Sand
II. Treatment 1 -Soil/Sand + MP 1
III. Treatment 2 -Soil/Sand + MP 3
IV. Treatment 3 -Soil/Sand + MP 4
V. Treatment 4 -Soil/Sand + MP 5
VI. Treatment 5 -Soil/Sand + MP 6
VII. Treatment 6 -Soil/Sand + MP 215-1
VIII. Treatment 7 -Soil/Sand + MP 212-1
IX. Treatment 8 -Soil/Sand + MP 60-6
X. Treatment 9 -Soil/Sand + MP 151

Four soybean seeds were placed in each pot, all pots were labeled and were arranged randomly using the random generator. The pot trails were carried out for six weeks. Suspected plant tissues were collected every three days to determine infection by Macrophomina *phaseolina* (MP). After six weeks, the roots of the plants were analyzed for the possible MP infection.

Results

Hypocotyl and root discoloration or decay	N: None	0
	SI: Slight	1-10%
	Mod: Moderate	26-50%
	Sev: Severe	51-100%

Table 5. Root disease evaluation

	Crop	Date Planted	7/7/2017	Data collected	7/28/2017
	Soybean	Root Disease evaluation			
	Rep/Treatment	N	SI	Mod	Sev
Control	1	2			
	2	2			
	3	3			
	4	2			
MP 1	1			3	
	2			3	
	3			3	
	4			3	
MP 60-6	1			3	
	2			3	
	3			2	
	4			3	
MP 215-1	1			3	
	2			3	
	3			3	
	4			3	
MP 4	1		2		
	2		2		
	3		3		
	4		3		
MP 5	1				3
	2				3
	3				3
	4				3
MP 3	1			3	
	2			1	
	3			2	
	4			3	
MP 6	1			3	

	2			3	
	3			3	
	4			2	
MP 151	1				3
	2				3
	3				1
	4				3
MP 212-1	1			3	
	2			3	
	3			3	
	4			3	

Table 6. Weight table of Foliage's and roots

	Foliage		Root
	wet weight (g)	dry weight (g)	wet weight (g)
Control	8.03	2.37	6.12
MP 1	8.60	2.62	7.80
MP 60-6	8.29	2.39	5.93
MP 215-1	7.97	2.26	7.52
MP 4	8.60	2.63	6.21
MP 5	7.91	2.42	5.03
MP 3	8.29	2.55	7.34
MP 6	8.64	2.69	7.76
MP 151	8.45	2.62	4.55
MP 212-1	7.90	2.35	7.80

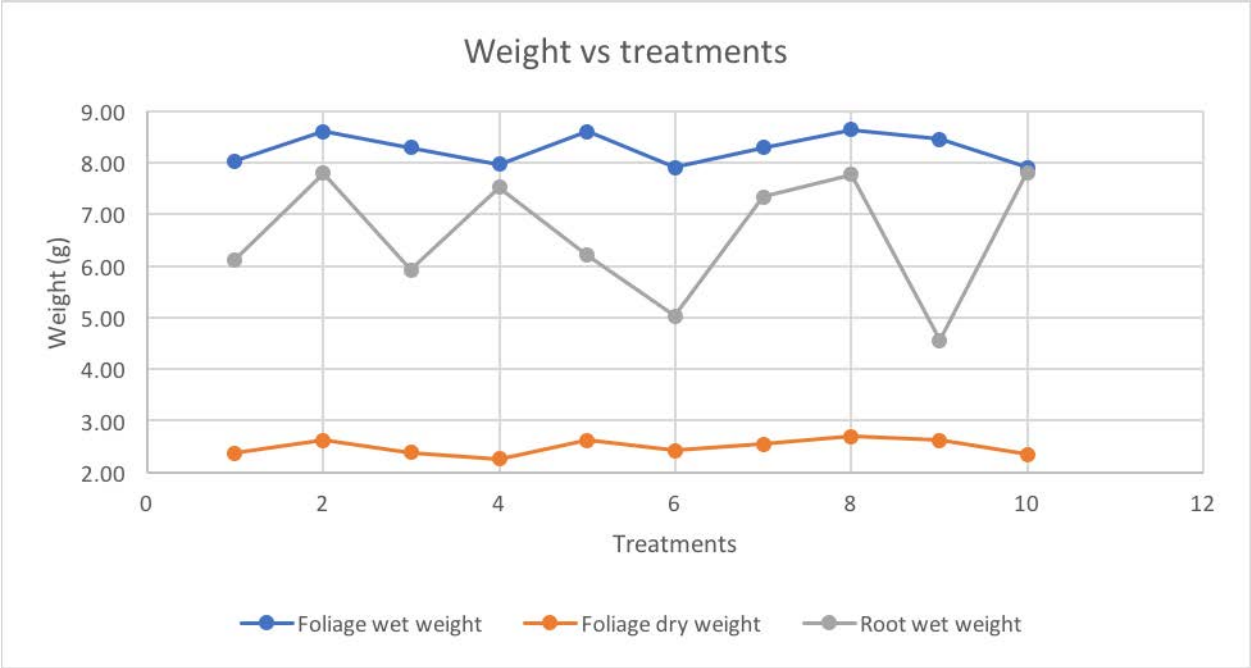


Figure 6. Weight comparison of treatments

The root discoloration was clearly observed with all the MP treatments except for the control (Table 5). However, the plants with the treatment of MP 4 isolate had slight root discoloration, whereas the MP 5 and MP 151 had severe damages to the plants. This observation is accordance with the weights data given in the Table 6. The highest foliage (both wet and dry) weights were observed with the MP 4 treatments and the lower weights (wet root) were observed with MP 5 and MP 151 treatments (Figure 6). It can be concluded that lower plant growth occurred when MP infections were severe.

The MVOCs detected from this study based on the chemical structures can be classified into alcohols, aldehydes, alkanes, alkenes, ketones, esters, aromatic hydrocarbons, and sesquiterpenes. Fungus morphology also plays a role. The initial results suggest that the major MVOCs difference between flat isolates and fluffy isolates (Figure 7) are their sesquiterpenes emissions. As shown in Figure 8, the significant distinction can be observed from raw data total ion current (TIC) spectrum calculations. In the graph, the darker of the color, the larger of the variations. Detailed analyses were conducted by multivariance statistical analysis such as PCA and PLS-DA. PCA model was applied to all samples datasets to observe the general structure of the full dataset. The PCA model with 5 PCs explains 66.4 % of variations. PLS-DA were further applied to maximize the separation among samples. The supervised model was validated with 100 times permutation test. In the PLS-DA model, clear separation can be observed between flat and fluffy isolates (Figure 9). The model parameters R^2X (goodness of fit) = 0.8889, and Q^2Y (predictive ability) = 0.91325. The volatile metabolites passing the combination of multivariate (PLS-DA model with VIP score > 1) and nonparametric Wilcoxon Rank -sum test ($p < 0.05$ and with pFDR < 0.05) were selected (Table 1).

Figure 7. Morphology of *M. phaseolina* isolates. Left: fluffy form of *M. phaseolina,* Right: flat form of *M. phaseolina*

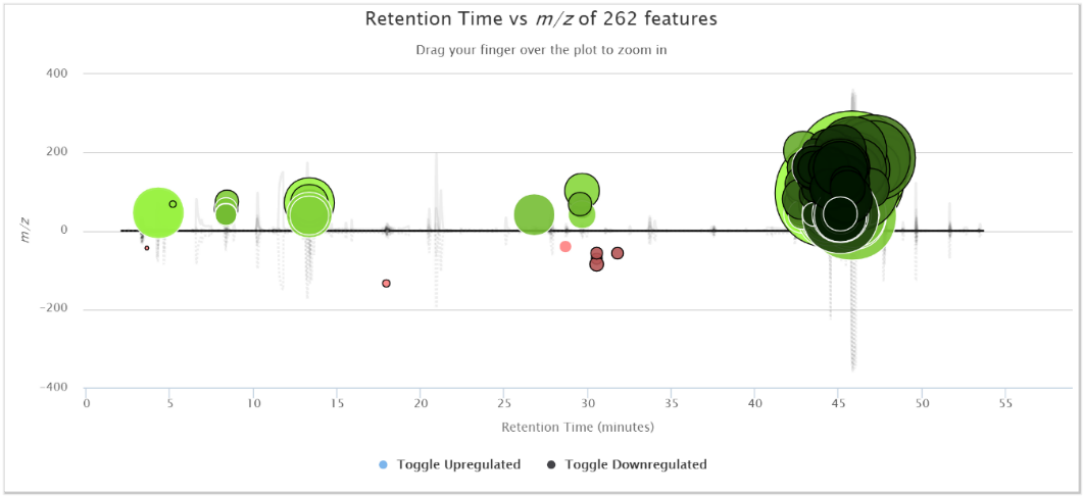


Figure 8. The raw TICs comparison.

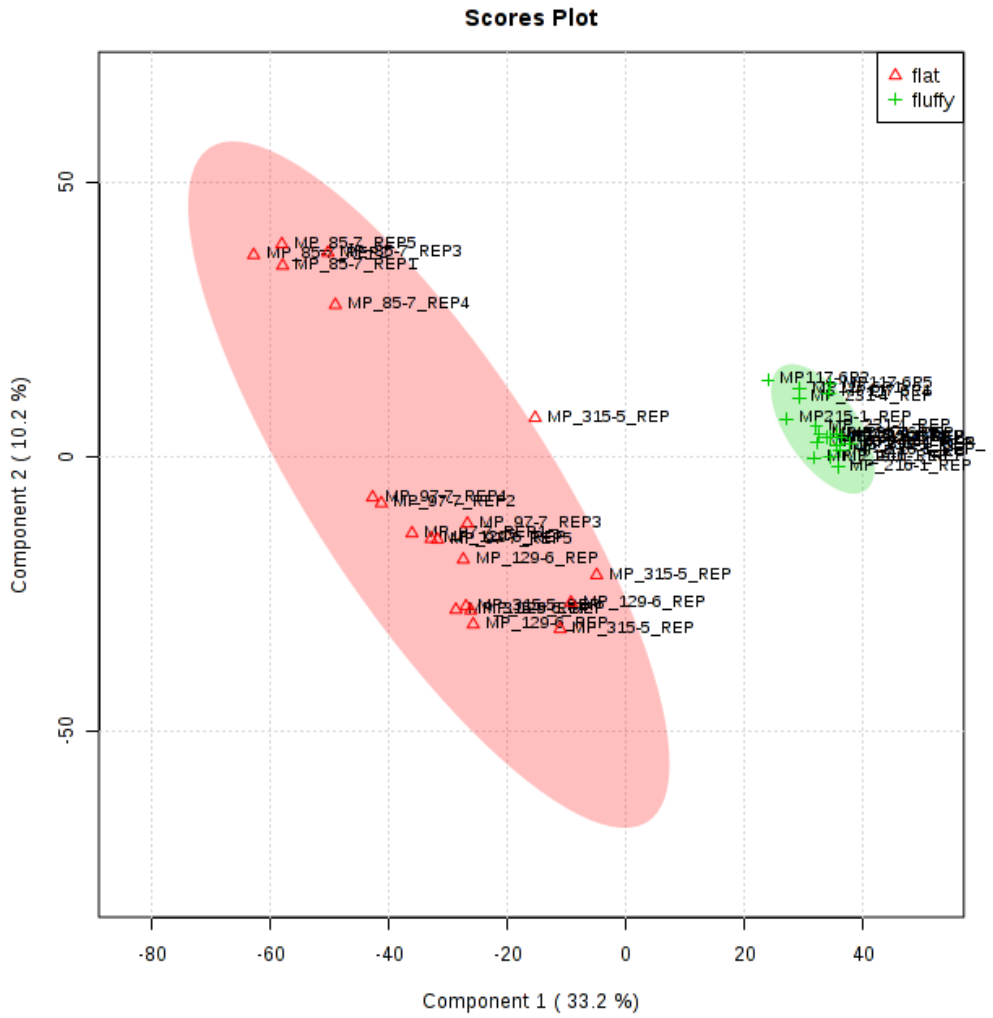


Figure 9. PLS-DA model, where R^2X (goodness of fit) = 0.8889, and Q^2Y (predictive ability) = 0.91325.

Visualization of similarities of volatile metabolites was analyzed with Hierarchical cluster analysis (HCA). HCA measures the closeness of groups, in which all samples was separated as a cluster and proceed to combine until all samples as one cluster. For similarity distance measures, such as Euclidean distance, Pearson's correlation or Spearman's rank correlation can be applied. For the clustering algorithms, including average linkage, complete linkage, and Ward's linkages are commonly used. The clustering is summarized into a dendrogram (Figure 10), in which the lengths of the branch shows the differences among the groups.

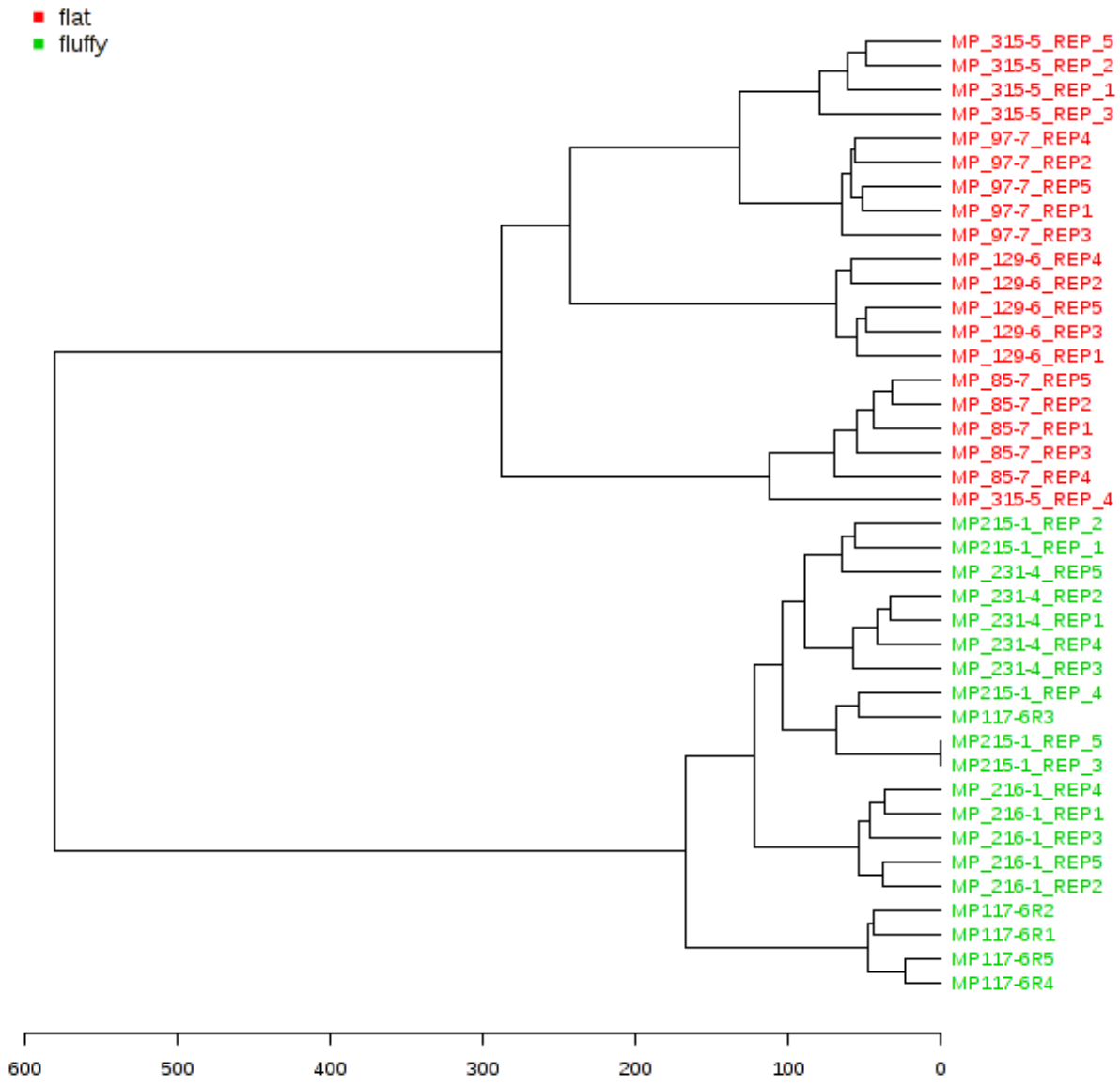


Figure 10. The dendrogram of HCA analysis on flat and fluffy isolates.

1. Growth of 8 *Mp* isolates. Four with a thick mycelium or cotton culture morphology (MP120, MP30, MP218, and MP210) and 4 with very thin appressed mycelial types (MP29, MP32, MP24, and MP23) when cultured on Potato Dextrose Agar medium (PDA) at 35^{o}C for 7 days.
2. Greenhouse study conducted at Mississippi State University north farm testing screen model for MP isolates. Using the eight different thick and thin isolates (above) pathogenicity tests or isolate screening was conducted. All data from the initial trial and two subsequent trials will be used for comparison with future VOC data. This will allow for controlled experiments to be completed to verify how uniform or variable VOC data will be.
3. Six replicate pots with five seeds sown per pot were infested with one of the eight isolates of MP as mentioned above. Uninoculated pots were added to serve as the control.

4. Analysis of greenhouse study focused on pathogenic variability among 8 isolates MP.
5. Pathogenicity was determined using plant seedling survival and growth at 9, 14, 22, and 28 days after planting, and plant height, root-hypocotyls, and root and top wet/dry weights at 28 days.
6. Among the 8 isolates, MP24 (appressed) was highly virulent or pathogenic on plants. Also, MP24 showed the highest isolation frequency from the plant tissues and greatest reduction in the plant stand, and fresh and dry weight of the top. The high disease index of MP23 (appressed), MP29 (appressed), and MP218 (cottony) suggest that these isolates are pathogenic at certain levels. Other isolates, MP30, MP210 (cottony), MP32 (appressed), and MP120 (cottony) showed minor symptoms. However, the thick and thin isolates were significantly similar in pathogenicity. Therefore increased pathogenicity of MP 24 VOC data (which now can serve as a control isolate-highly pathogenic was used for comparisons with the other isolates to verify if VOC data is consistent across isolates.
7. Two greenhouse trials using additional isolates were set up and completed. The isolates used can be found in **Table 7**.

Table 7: Characterization of *Macrophomina phaseolina* isolate morphological types evaluated during a greenhouse study over a 28 d period.

Isolates	Geographical Origin	Date of isolation	Cultural type*
MP120	Tupelo, MS	1999	Thick
MP30	North Greenwood, MS	2013	Thick
MP218	Leflore County, MS	2013	Thick
MP210	Leflore County, MS	1999	Thick
MP29	North Greenwood, MS	1999	Thin
MP32	North Greenwood, MS	1999	Thin
MP24	North Greenwood, MS	1999	Thin
MP23	North Greenwood, MS	1999	Thin

8. * Thick: Feathery or cottony tomentose when cultured on potato dextrose agar (PDA), Thin: Dense or appressed mycelium when cultured on potato dextrose agar (PDA).

9. The pathogenicity of eight isolates of *M. phaseolina* was successfully studied by evaluating the plant stands, hypocotyls discoloration rating, plant height, dry and fresh weight of the roots, stem and leaves of soybean plants under greenhouse conditions. Among the eight isolates, MP24 was highly virulent or pathogenic on soybeans plants. The isolate, MP24 showed the highest isolation frequency and greatest reduction in the plant stand, and fresh and dry weight of the top. The high disease index of MP23, MP29, and MP218 suggest that these isolates are also pathogenic on soybeans. Other isolates, MP30, MP210, MP32, and MP120 showed minor symptoms of the charcoal rot disease. The thick and thin isolates did not vary in pathogenicity overall but individual isolates showed differences in pathogenicity. Low temperatures measured in pots (10.4 to 26.9 ^{o}C) compared to normal (28-35 ^{o}C) could have impacted the disease levels of the isolates.

MVOCs sampling and analysis from morphology studies – morphology studies on *M. phaseolina* was reported previously. The results indicate the morphology of *M. phaeolina* can be divided into two forms, flat and fluffy (Figure 6). In recent months, we have focused on characterizing MVOCs from both morphology types. Flat type isolates MP 97-7, 129-6, and 85-7 and fluffy form isolate MP 216-1, 231-4, 117-6, and 215-1 were used to conduct a preliminary study. Additional *M. phaseolina* isolates, flat isolates 129-6, 304-4, 315-5, 302-4, and fluffy form isolates were used to generate multivariate analysis modeling. Furthermore, to optimize sampling conditions, MP isolates 252-3, 223-4, 212-1, 85-7, 304-4, and 117-6 were employed to conduct a time series experiments.

Contributions/Roles:

Baird group contributions:

1. Gathering of fresh sweetpotato isolates of *Macrophomina* from infected sweetpotato tissues and roots to develop a library or culture collection of isolates. To date approximately ~60 isolates have been obtained from sweetpotato tissues from infected roots and root debris in natural soils from counties where crop is grown.
2. Maintaining the isolates to ensure their availability and biochemical pathogenicity activity for use in the VOC studies.
3. Confirming by molecular identifications/confirmation that the isolates being tested were in fact Mp and not other fungi with morphological features.
4. Maintaining permanent storage of isolates by preparing them in specialized solutions for cryogenic facilities. It is believed that they remain biochemically more stable under these conditions versus repeated subculturing and growth on agar media.
5. To ensure quality control of all VOC testing, isolates from storage will be screened to determine their pathogenicity levels after isolation using repeated greenhouse tests.
6. Continuation of gathering new Mp isolates from fresh field sampling from surrounding sweetpotato counties in MS. As stated previously, isolates lose their disease causing abilities (resulting in biochemical changes) if stored traditional by subculturing and possibly cryogenically.

Mlsna group contributions:

1. Collection and gas chromatic analysis of volatile organic compounds from fungus samples.
2. Development and application of metabolomics procedures for complex VOC profiles.

a. Evaluation and application of varied data pretreatment methods.

b. Development of advance data processing protocols for complex VOC profiles.

3. Characterization of VOC profiles from varied fungus samples.
4. Evaluation of changes in VOC profiles due to due to changes in growth media.
5. Evaluation of Solid Phase Micro Extraction types for optimal VOC profiling.
6. Development of VOC profiles and how they change with changing conditions.
7. HCA analysis of VOC profiles and their ability to discriminate flat vs fluffy isolates.

Goals and Outcomes Achieved

In the original proposal, we indicated that to be considered successful we would need to be able to do the following:

1. We will need to be able to determine the presence of the fungus grown in media from controls using analysis of volatile chemicals that are produced with a success rate greater than 90%.

Comment on outcome:

This turns out to be fairly easy. The growing fungus emits a complex mixture of volatile organic compounds that are significantly different from the growth media. This was established early on in the program.

2. In order to be considered successful we will need to be able to identify the presence of the fungus on sweet potato roots in storage with a success rate greater than 90%. Initial results from cultural VOC evaluations of Mp isolates show unique chemical profiles. However, VOC data for Mp isolates must stand the test of comparison data while in presence of sweetpotato tissues (phase 2) and host tissues + other microbes all growing together with Mp (phase 3). These portions of the study are being conducted beyond the scope of the first funded project.

Comment on outcome:

This is considerably more challenging because the fungal VOC profiles change with age and growth media. Understanding of the changing profiles has become one of the key needs of the program going forward. Herein lie our programs major successful outcomes including the following:

a) We have developed an optimized analytical method to collect and identify hundreds of VOCs produced by the fungus.

b) We have optimized our data processing method including both pretreatment steps and advanced signal processing algorithms.

c) We have quantified the importance of growth media, growth conditions and time on VOC production.

3. The data, conclusions and tools or recommendations for control of the end rot disease problem will be discussed with growers at county sweet potato meetings and on an individual basis.

Comment on outcome:

a. We have used greenhouse studies to determine the relative virulence of the different fungus morphologies.

In the original proposal, we listed the following Targets:

1. Identify a comprehensive list of chemicals produced by the fungus grown under control growth media conditions.
   Completed for a wide range of isolates and growth conditions.
2. Determine relative quantities of the chemicals produced.
   Completed for a wide range of isolates and growth conditions.

3. Determine how fungus chemicals differ from chemicals found in controls or uninoculated agar sames.
   Completed.
4. As above in 2. We are working on the next two phases of the research so equipment can be stabilize and complete VOC chemical library of Mp isolates versus host tissues and associated other microbes. After these have been determined, detection equipment using those libraries can be used to provide for growers information about the number of infected roots by Mp in bins and in packaging.
   Initiated.
5. Secondarily this will alert grower to better define actual healthy roots prior to storage or shipping, and reduce losses by removal of infected root from going into storage contaminating others.
   Initiated.

Beneficiaries

A total of 89 sweet potato farms that bring in 116 million in MS.

Approximately 20-25% curing losses at storage facilities, 5-15% shipping losses, and final losses are when get to consumer for up to 10%. So our research hopes to stop or reduce losses Mp (now Rhizopus in addition) pre storage and storage phase hoping to reduce 25%, find disease roots during packing (shipping) reducing 5-15% and maintaining higher consumer confidence at store level. This indirectly increase consumer confidence at home.

Lessons Learned

We have learned that the VOC profiles produced by the fungus is complex and varies with time, growth conditions and temperature.

We have learned that fungus morphology is related to virulence.

We have learned that with careful sample collection and analysis that there is a significant difference between infected sweetpotato and an uninfected control sweetpotato sample.

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CREATING A MARKETING CAMPAIGN FOR THE 'DEER PROOF' PLANT PROGRAM IN MS

Partner Organization

Mississippi Nursery and Landscape Association

Project Summary

One of the most difficult landscape problems to address is deer damage because they can consume most of the 'desirable' plants in a single night. The white-tailed deer herd in Mississippi is 1.75 million animals, resulting in the highest population density of any state in the country. Repellents are not very effective and exclusion requires the installation of fencing. Plant selection is generally considered the best option for preventing white-tailed deer damage. This is a huge marketing opportunity for the green-industry in Mississippi. Identifying and marketing 'deer resistant' plant material helps the green industry in Mississippi tap into this demand by consumers. A consistent message about deer resistant plants and how to use them in landscapes was conveyed through a media and advertising campaign and with point-of-purchase marketing materials to help consumers select plants that will be successful in areas with large deer populations. The goal of this project was to promote the sale of Mississippi grown ornamental plant material that is resistant to damage by deer. Producer and retailer participation in the program, as well as sales of promoted plants will be followed to determine the success of this program.

Project Purpose

One of the most difficult landscape problems to address is damage from wildlife. The white-tailed deer herd in Mississippi, and the southeastern US, has grown dramatically since the early 1990's and is continuing to expand. There are an estimated 1.75 million white-tailed deer in Mississippi currently. That is the highest population density of any state in the country. As the population density continues to increase, there is more and more damage to gardens and residential and commercial landscapes, costing owners significant amounts of money to repair. Deer damage is especially difficult because they can consume most of the 'desirable' plants in a single night. Repellents are not very effective and require frequent application. Exclusion requires the installation of expensive and unsightly fencing. Plant selection is generally considered the best option for preventing white-tailed deer damage.

Consumer demand for plants that they can *consistently* have success growing is soaring. One only has to look to the success of the Proven Winners®, Plants That Work®, and EarthKind® marketing programs for evidence. However, the focus of these promotion programs has been on adaptability to environmental and cultural conditions or on disease and insect resistance. None have sought to

identify and promote plant materials that resist herbivore damage. This is a huge marketing opportunity for the green-industry in Mississippi and the Southeast, because deer damage has so dramatically limited home owners' and landscape managers' use of much of the 'traditional' plant palette. Identifying and marketing 'deer resistant' plant material will help the green industry in Mississippi tap into this pent-up demand by consumers.

Objectives:

1. Producer Education. This is critical and was the primary focus of this grant. The producer must understand the current market change toward ensuring consumers have consistent success in landscape through plant selection. They need to know the 'deer resistant' plants with the most landscape potential and how to propagate and produce them uniformly for sale. Finally they must comprehend the pull through marketing and promotion concept of the 'Deer Proof' Plant program and what it can do for their business. This educational effort consisted of seminars and color brochures.

2. Retailer Education. Retail garden centers and nurseries in Mississippi are buying approximately 75 percent of their plant material from out of state. This has become a habit or routine that can and must be broken. The goal was to change this with educating the retailer on what the Mississippi Medallion 'Deer Proof' Plant program can do for them, what the 'Deer Proof' plants are and where to get them in Mississippi. We hoped this would lead to increased sales of plant material produced by our growers and our retailers would learn how easy it is to buy in Mississippi without going across state lines.

3. Marketing Assistance. If the consumer doesn't buy, then the program fails. The consumer was educated about the 'Deer Proof' Plant program through a media campaign of press releases to garden writers, newspapers and magazines, and statewide radio and television advertising. Daily seminars were presented at both Mississippi Garden and Patio Shows and multiple Mississippi State University Extension Service (MSU-ES) Field Days. A consistent message about these products and how to use them effectively in the landscape were conveyed through the media campaign and with point-of-purchase (POP) marketing materials. POP marketing included informational signage explaining which plants are 'Deer Proof' and individual pot labels that readily identify plants as 'Deer Proof'.

The Mississippi Medallion program began in 1996 but was made much stronger through the 2008 Specialty Crop Block Grant that allowed for the first paid TV commercials that aired statewide. It also paved the way for statewide newspaper advertising.

This grant complemented that effort, further enhancing consumer confidence in the MNLA/MSU-ES plant promotion programs and the plants selected, thanks to the continuation of a directed marketing campaign. The likelihood of the project becoming self-sustaining and not indefinitely dependent on grant funds was thought to be greatly enhanced because of its use of POP materials. These materials can be sold only to producers, who in turn, pass the cost along to retailers. Retailers recover the cost as part of the increased price that consumers are willing to pay because of an increased perceived value of the products. This funding model has proven very successful for the private plant marketing

campaigns. This grant would represent the equivalent of 'venture capital' in the private sector. It will allow us to develop the educational and marketing materials, as well as provide a low risk 'proof of concept' to producers and retailers.

Timeline	Who's Responsible	Project Activity
Winter 2014	MSU-ES	Create list of 'Deer Resistant' Plants for use in MS
Winter 2014	MNLA	Design and produce brochures and POP Materials
Spring 2014-Spring 2017	MNLA	Distribute brochures
Fall 2015	MNLA	Design and produce POP Materials
Winter 2015-Spring 2017	MNLA	Distribute POP Materials
January 2016, and 2017	MNLA/MSU-ES	Promote program at Gulf States Horticultural Expo with display and presentation.
January – May 2016 and 2017	MSU-ES	Press releases will be written and distributed for use by garden writers, newspapers, magazines and radio personalities
March 2016 and 2017	MNLA/MSU-ES	Educate consumers about the program plants through seminars at Mississippi Garden & Patio Shows
April – May 2016 and 2017	MNLA	Design and release print and digital ads in targeted markets throughout the state.
October 2015 and 2016	MSU-ES	Educate consumers about the program plants through seminars at MSU-ES Field Days and Open Houses
August 2016 and 2017	MNLA	Conduct surveys to determine program outcomes

This proposal was not submitted to another state or federal agency.

Project Activities

Mississippi State University- Extension Service (MSU-ES) partnered with Mississippi Nursery and Landscape Association (MNLA) to create a list of 'Deer Resistant' Plants for use in Mississippi. This list was placed on the MNLA website and promoted at the Gulf States Horticultural Expo in January 2015, 2016 and 2017 and the Garden Extravaganzas in March 2015, 2016, and 2017.

MSU-ES and MNLA designed and produced a colorful brochure explaining the Deer Proof Program. The brochures were distributed at several events 2015-2017, including: the MNLA Garden Extravaganza in Biloxi and in Jackson, the Mid-South Green Industry Conference in Starkville, the SunBelt Ag Expo in Georgia, and at the Fall Flower & Garden Fest in Crystal Springs.

A colorful banner to use at trade shows/events was designed to help promote the program.

MNLA and MSU-ES designed, produced and distributed POP materials.

A press release was written and distributed by MSU-ES.

Consumers were educated about the program at our annual Mississippi Garden Extravaganza in Jackson in March 2016 and 2017.

Advertising campaign – print and digital ads were designed and released throughout the state.

Goals and Outcomes Achieved

The GOAL of this project was to promote the sale of Mississippi grown ornamental plant material that is resistant to damage by deer. Few, if any, producers are growing ornamental plants with the intention of marketing them as alternatives for use in areas with potential heavy deer damage (BENCHMARK). The TARGET for this benchmark was to have 30% of Mississippi producers (63 businesses) participate in the 'Deer Proof' Plant Program. Few, if any, retailers purchase ornamental plants from Mississippi producers with the intention of marketing them as alternatives for use in areas with potential heavy deer damage (BENCHMARK). The TARGET for this benchmark was to have 35% of Mississippi retailers (102 businesses) participate in the 'Deer Proof' Plant Program. Most consumers have little or no idea about potential ornamental plant choices for areas with heavy deer herbivory and do not purchase plants because of their 'deer resistance' (BENCHMARK). The TARGET for this benchmark was to have an increase in sales from Year 1 to Year 2 of plants in the 'Deer Proof' Plant Program.

This project fell short of its targets.

<u>Producers</u>
We were unable to convince any producers to participate in the program. The most commonly cited reason was that they did not want to deal with adding another label to their products. They feel over-pressured with branding materials from the major commercial marketing companies to include labeling and are fatigued.
<u>Retailers</u>
We elected to make the marketing materials and labels available directly to retailers because of the lack of participation by producers. However, only 2% of retailers (7 businesses) chose to participate. The reasons for this lack of participation is unknown. At the educational events that promoted the program, most attendees expressed interest in the program verbally.

Consumers
We are unable to determine the consumer effect because of such low participation and market availability.

Beneficiaries

With the production and distribution of 1000 brochures and a series of educational programs, the Mississippi Nursery and Landscape Association and Mississippi State University Extension Service will be able to reach businesses representing 95 to 97 percent of Mississippi's total nursery production and retail sales (378-386 businesses) with information about the 'Deer Proof' Plant promotion program, how it works, why it's needed and the potential for stimulating sales.

The Deer Proof Plant promotion program was taken to the Gulf States Horticultural Expo January 28-30, 2015 and January 20-22, 2016. A display was developed and exhibited which was be seen by approximately 5000 retailers, landscapers and an additional 600 wholesale exhibitors each year. The marketing assistance part of the 'Deer Proof' Plant program was to be coordinated with wholesalers and retailers so that plant materials will be available for the consumer. To be ready, the retailers will buy from our producers increasing Mississippi grown market share.

Press releases were sent to garden writers, newspapers and magazines and was anticipated to reach approximately 1.2 million people or half of Mississippi's population making sure consumers are aware of the 'Deer Proof' Plant program. To increase consumer awareness and product sales, a print and digital commercial campaign promoting the program was conducted statewide.

Lessons Learned

The MNLA requested and was granted a no cost extension in April 2015. This pushed our timeline one year, with no change in cost, due to a supply issue from the label company we are using. For this program to be successful it needs a big push at the beginning of the spring season and since we were in the middle of the spring season we felt that we couldn't properly introduce it to the public.

Producers
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Consumers
We are unable to determine the consumer effect because of such low participation and market availability.

In addition, MNLA requested to change our advertising approach for this program. Originally we listed television and radio, but we felt that a wider audience can be reached with print and digital advertising.

Contact Person

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Additional Information

Website: http://msnla.org/msnla/deer-proof-plants/

Facebook page: https://www.facebook.com/deerproof/

Mississippi Nursery & Landscape Association

www.msnla.org

Mississippi State University Extension Service

MISSISSIPPI STATE UNIVERSITY EXTENSION SERVICE

www.msucares.com

Funds for this project were provided through the Mississippi Department of Agriculture and Commerce, USDA Specialty Crop Grant Program.

DEER PROOF PLANTS

PLANTS THAT DEER WILL PASS BY!

Deer keep eating all of my plants! What can I do?

One of the most difficult landscape problems to address is damage from wildlife. The white-tailed deer herd in Mississippi, and the southeastern US, has grown dramatically since the early 1990's and is continuing to expand. There are an estimated 1.75 million white-tailed deer in Mississippi currently. That is the highest population density of any state in the country. As the population density continues to increase, there is more and more damage to gardens and residential and commercial landscapes, costing owners significant amounts of money to repair. Deer damage is especially difficult because they can consume most of the 'desirable' plants in a single night. Repellents are not very effective and require frequent application. Exclusion requires the installation of expensive and unsightly fencing.

Plant selection is usually the best option for preventing white-tailed deer damage.

Deer Proof Plant Program

There are no plants that deer will not eat if they get hungry enough! But, there are lots of options that they will avoid most of the time.

This program helps you pick out great plants that deer won't damage. Just look for the Deer Proof logo on plants at your local garden center.

The list of plants that can carry the Deer Proof label was based on University recommendations from across the country and experience from nursery and landscape professionals!

It's as easy as 1-2-3! Just go to the plants with the logo!!!

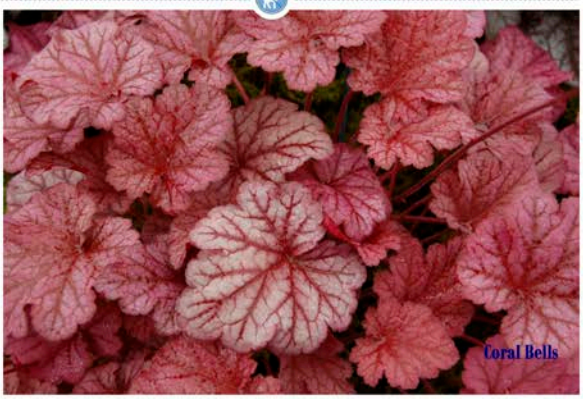
Benefits

- Beautiful landscapes
- Less damage from deer
- Confidence in choosing plants for problem areas
- Easy to pick out the plants that will work for you while you're at the garden center
- Save money on repellants and fencing

Support Local Growers!

One of the best things about the Deer Proof Plant Program is that it helps you support your community by identifying plants that are locally grown! Only growers in Mississippi can receive the Deer Proof Plant tags for labeling their product.

If you see one of these tags, you know the plant was Mississippi grown!!!



TESTING PLASTIC MULCHES FOR SWEET POTATO SEED BED PERFORMANCE

(previously approved in second annual report)

Partner Organization

Mississippi State University

Project Summary

Plastic mulch is used on sweet potato seed beds to increase soil temperature and to prevent weed pressure. One measure of mulch quality was the amount of Photosynthetically Active Radiation (PAR) allowed to pass through the material. PAR is light in the specific wavelength (400-700 nm) which drives photosynthesis in plants. Bench and field methods were develop to measure PAR penetration through common plastic mulch products. Black mulch prevented any PAR pass-through while clear and green semi-opaque mulches reduced PAR pass-through. Plastic mulches were also assessed in seed bed by seed bed plant performance. The number and dry matter of harvested slips were measured across black only, black + clear, and no mulch treatments. Black + clear layered mulch outperformed all other treatments. Therefore, producers should apply layered mulch when possible. The developed methods for light penetration could bring value to other specialty crop production by optimizing materials for production structures through which light must pass.

Project Purpose

Sweet potato is a vegetatively propagated crop, in which slips are grown from seed in a seed bed then the slips are transplanted into production fields. Plastic mulch is used on sweet potato seed beds to improve slip development by increasing soil temperature and preventing weed pressure. Mississippi sweet potato growers reported that some of the black plastic mulch used on their seed beds during the 2014 growing season was not effective at preventing weeds and that their seed beds did not perform as well as expected as a result. Initial literature searches did not reveal a method to measure the performance of plastic mulches, particularly in terms of the amount of light passing through the plastic which would allow weeds to flourish under the mulch. In order for the weeds to grow, the light passing through the mulch would need to be in the photosynthetically active radiation (PAR) range that stimulates plant growth. PAR is light in the specific wavelength (400-700 nm) which drives photosynthesis in plants. Too much PAR passing through the mulch will allow weeds and, potentially, algae to grow under the mulch and compete with seed stock. Therefore, plastic mulches need to be assessed so that growers are not paying for material that is not meeting their needs.

The objectives of this project were to 1.) develop benchtop methods to assess the performance of plastic mulch, 2.) develop field methods to assess the performance of plastic mulch, 3.) and evaluate the impact of different plastic mulch types on sweet potato bed performance.

There was a shift in approach as the project was underway. A group of Mississippi sweet potato producers reported failure of their black plastic mulch which allowed weeds to flourish on the seed beds. The weeds competed with the growth of slips which directly influences the outcome of the final production crop. The black mulch was purchased through the same channels as in previous years and was applied in a similar manner. Over the course of the bedding season, the plastic began to decompose. The development of this project was in direct response to those complaints so that the issue could be prevented in future seasons. The goal was to develop a method to identify the plastic performance issues by first evaluating any existing samples of the failed mulch as compared to new mulch. However, the failed mulch decomposed quickly or was quickly disposed of by producers to prevent any chance for future re-use. There were no samples remaining to analyze. Further conversations with growers on their bedding practices identified that growers were commonly using two layers of plastic mulch: one clear and one black. The approach shifted to continue developing methods to test plastic mulch agricultural performance, of which no published methods were identified, but also now included evaluating the efficacy of multiple layers of plastic mulch on seed bed performance.

Project Activities

There were two distinct phases to meeting the project objectives. The first was the development of bench and field plastic mulch performance assessment tools. The second was the field study in which mulches, which had been tested for performance, were applied to sweet potato bed plots and their effects on slip development was evaluated.

Method Development

Two types of plastic mulch test fixtures for measuring PAR through plastic mulch were designed and fabricated: one type for benchtop controlled environment tests and one type for exterior in-situ tests. The benchtop fixture (Fig. 1) featured an artificial light source, an interior chamber completely covered with light-absorbing materials, and a sensor designed for use with artificial light. This single fixture allowed rapid multiple replicated readings of a large number of samples. The exterior fixtures (Fig. 2) featured a modular design, an interior coated with light absorbing paint, and a sensor designed for use with natural sunlight. Twelve of the in-situ fixtures were created allowing for multiple treatments and replications. Both fixtures were designed to use samples of plastic mulch sized at 0.5 m by 0.5 m.

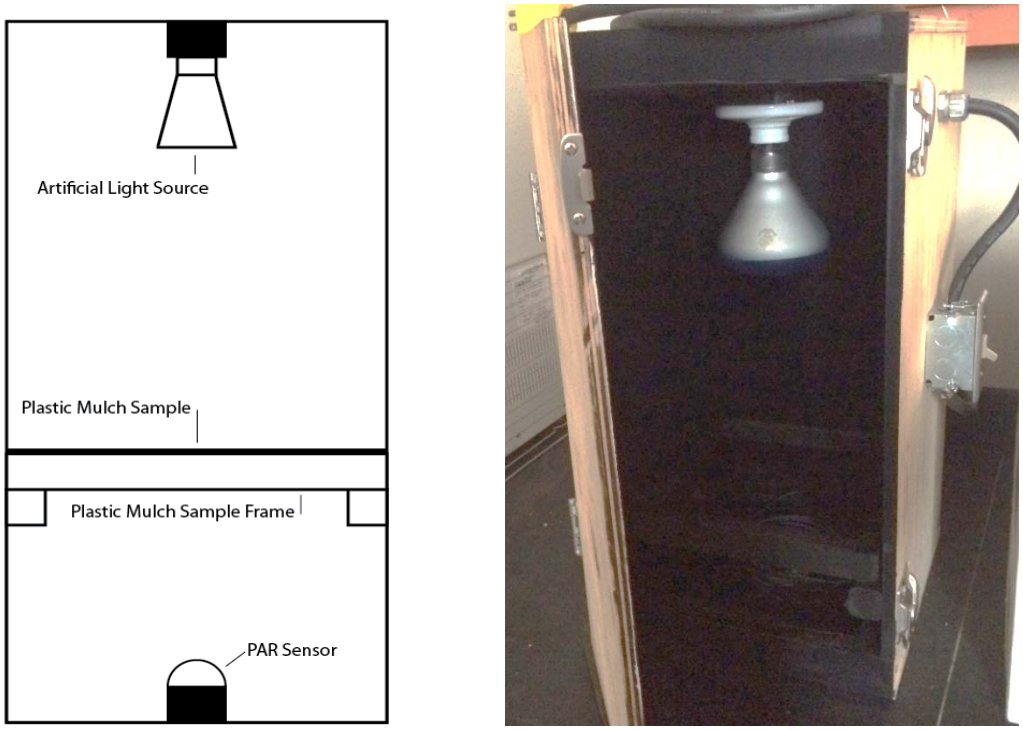


Figure 1. (L) Drawing representing the benchtop plastic mulch testing fixture. (R) Photo of fixture.

Figure 2. (L) Deployed in-field plastic mulch fixtures, (R) Detail of data logger and ambient PAR sensor.

The primary provider of plastic mulch to Mississippi sweet potato growers provided samples of black and clear plastic mulch. A green "solar" mulch was purchased for testing. The treatments were ambient, black only, clear only, clear over black and green plastic mulch. All treatments were replicated in triplicate. In both fixtures, the PAR sensor was placed under the plastic mulch sample.

The interior of the fixtures were coated with light absorbing paint or paper. The coating prevents light from bouncing within the fixture and ensures that the sensor is only receiving radiation that was directly emitted from the light source. Data were analyzed using SAS 9.3 and significance was divided at a 0.05 confidence level. Throughout the study, PAR was measured and reported in µmol/m²s.

Data from the lab study indicated that black plastic mulch alone and combined with clear mulch does not allow any PAR penetration (Fig. 3). Clear plastic mulch alone attenuated artificial PAR by approximately 7.5%. Green semi-opaque "solar mulch" attenuated peak ambient PAR by approximately 72%. Data from the field the study indicated that black plastic mulch does not allow any PAR penetration. The same trend is observed in black plastic mulch combined with clear plastic mulch. Clear plastic mulch alone attenuates peak ambient PAR by approximately 32%. Green semi-opaque "solar mulch" attenuates peak ambient PAR by up to 88%.

The values differ between the benchtop and field quantitatively but the same trends in the ranking of PAR transmittance holds. The amount of total light emitted from the source is much lower with the bench fixture than under field conditions and could influence the response of the mulches to PAR transmittance. Additionally, wavelengths may differ between artificial light and natural light which could influence light penetration through the mulch.

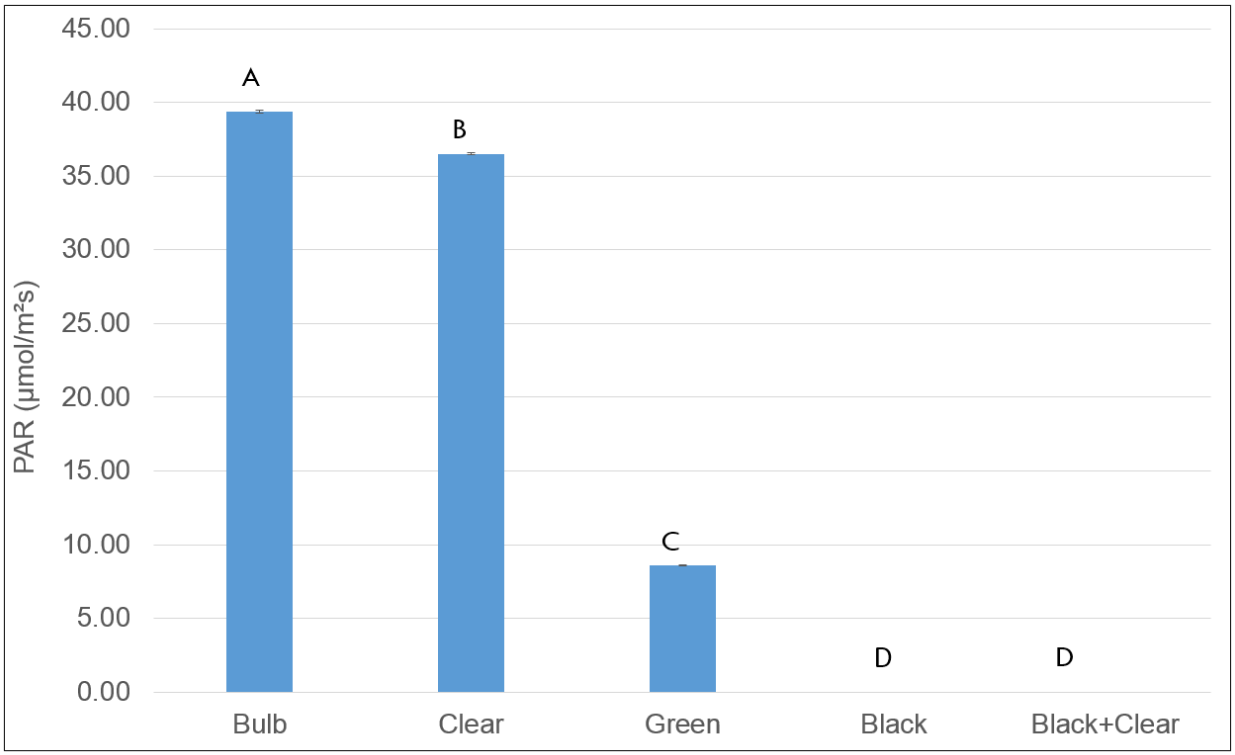


Figure 3. Benchtop artificial PAR penetration through different plastic mulch products.

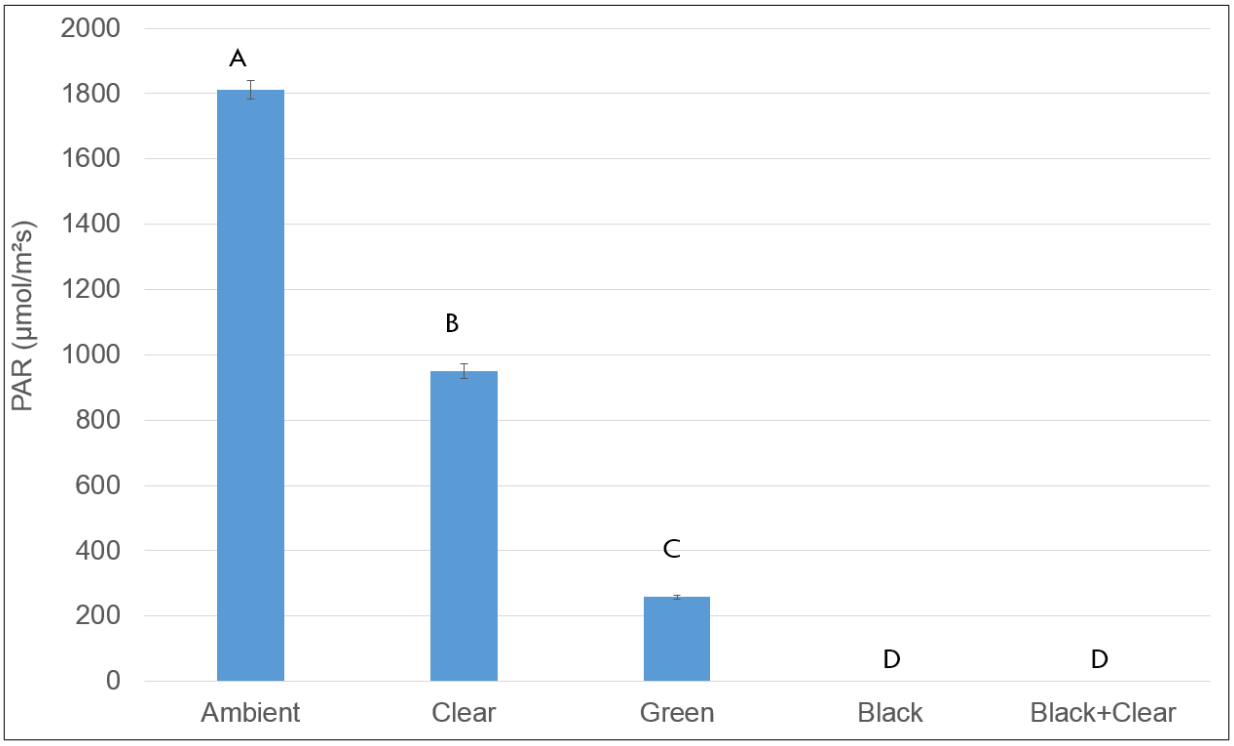


Figure 4. External In-situ PAR penetration through different plastic mulch products.

During the course of the study the plastic mulch did degrade (Fig. 5). Most notably the clear mulch and not the black mulch. Growers indicated that the degradation of the clear plastic visually appeared similar to the degradation of the black plastic which led to the initiation of the project.

Figure 5. Plastic mulch decomposition during the measurement period.

In summary, a method was developed that allowed evaluation of the amount of PAR allowed to pass through plastic mulch products. As expected, a treatment with completely opaque black mulch prevented any penetration. The other plastic mulch products allowed in varying degrees of PAR but clear mulch allowed more penetration than a green partially opaque mulch in both lab and field studies. Mulch could be tested prior to installation on sweet potato seed beds, especially using the field study approach to determine if specific lots of mulch degrade faster than expected.

Seed Bed Performance

Assessment of the plastic mulch itself is important, but the mulch serves an important purpose in seed bed productivity. The mulch prevents weed competition from undesirable plants, will increase soil temperature, and preserve soil moisture. Recall that sweet potato is a tropical plant so the warm, moist conditions are important to allow sprouting and slip development early in the season. Temperature and soil moisture data are still under analysis but the effect of the plastic mulch treatments on the number and dry-matter weight of slips allows insight into seed bed performance.

The number of plants is an indicator of seed bed performance, because each individual slip represents a future set of storage roots in the production field. High plant counts allow growers to be more selective in the slips chosen for planting and can represent additional income by selling slips to other producers. Slip dry matter was chosen to indicate the vigor of the slip. A slip with more vegetative material, such as a thicker stem, has greater potential to survive the transplanting process and start growing sooner.

Plant beds were established with three treatments: black mulch only (B), black and clear mulch layered (BC), and a control with no plastic mulch (CON). Slip samples were randomly collected from a 0.25 m2 area using a frame dropped on the beds. During sample collection the slips were sorted by length but that data is still under analysis, only total weight or count will be discussed currently. However, to be counted as a slip the plant material much be greater than 4 in. long. This distinction explains why there is plant dry matter when no slips were counted. Samples were collected weekly for six weeks starting in the first week of May 2016.

No slips met the minimum length to be considered a viable slip until week four of the sapling period. The control treatment with no plastic mulch resulted in seed bed failure. There were nearly no viable slips harvested from plots with no plastic mulch. This result indicates the absolute importance of plastic mulch to the sweet potato industry. During week four and five there were no significant differences between the black and black + clear treatments. In week six there were significant differences between the treatments with the black + clear treatment producing more slips than the black only treatment. The black mulch only treatment produced approximately 65% of the number of slips counted from the black + clear treatment.

A similar pattern holds with the slip dry matter. Negligible plant dry matter grew on plots with no plastic mulch. The dry matter from the black and black + clear treatment tend together with no significant differences until week six when the harvested dry matter is significantly different. The black + clear treatment outperformed the black only treatment in plant dry matter. Black only produced approximately 70% of the black + clear treatment plant material.

In summary, use of two layers of plastic mulch increased sweet potato slip number and slip dry matter.

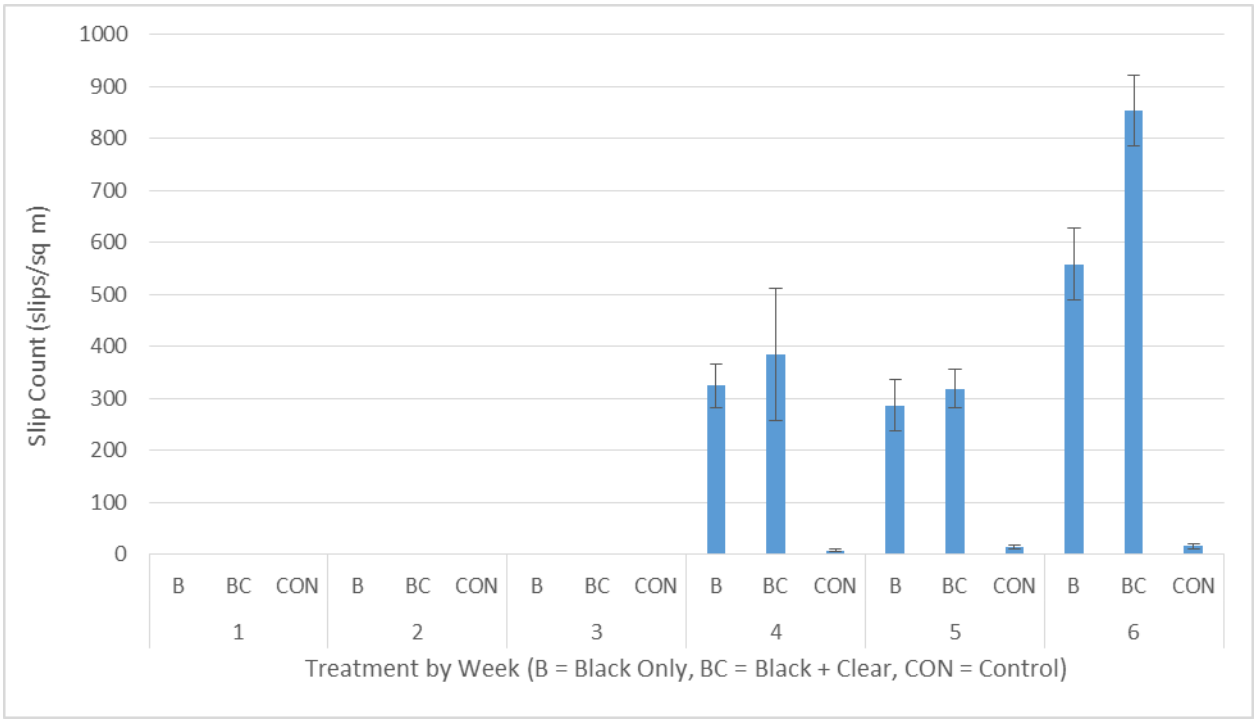


Figure 6. Slip Count

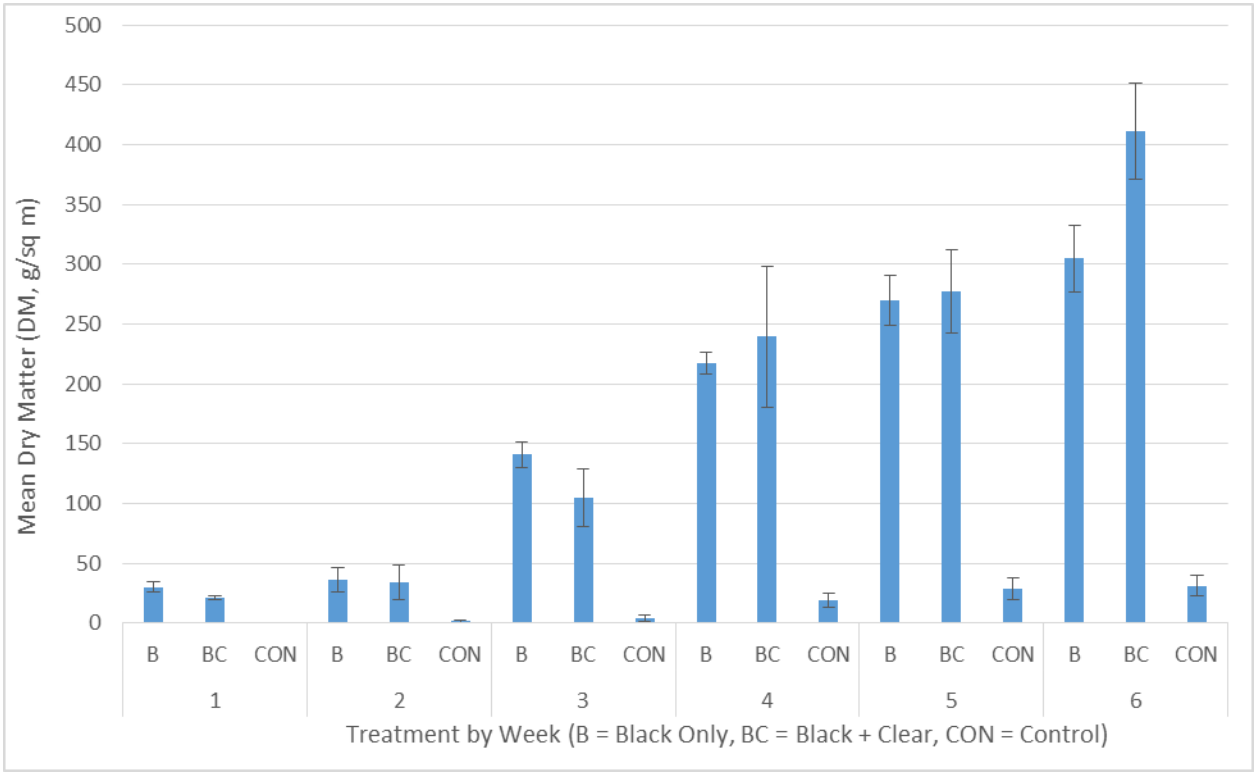


Figure 7. Slip Dry Matter

Goals and Outcomes Achieved

The original measureable outcome of this project was to prevent Mississippi sweet potato growers from using poorly performing plastic mulch with the tared of reduce failed mulch by 50%. This outcome was met by the industry through market forces when growers realized there was a problem and eliminated the failed mulch from their operations. The original goals of creating methods to assess plastic mulch were still valid and needed. After assessing the state of the industry and the grower practice of layering plastic mulch, the measurable outcome developed to improve implementation of plastic mulch in sweet potato bedding systems with the target to reduce double layer plastic mulch by 10%. None of the research described in the report had been conducted and there were no published studies found by the author to indicate the layering mulch would provide a substantial performance increase. Therefore, the outcome was chosen based on the hypothesis that double mulch layers were wasteful and costly. However, the research conducted by this project has proven that hypothesis wrong. The outcome is still viable, but the target was not appropriate.

This project met the goals of creating novel methods to assess plastic mulch light penetration for benchtop and field. This project met the goal of assessing the effects of plastic mulch on sweet potato bedding systems. The goal of improving implementation of plastic mulch has been met by being able to confidently recommend double layering of mulch when possible. Deliverables made available to producers will reflect that information. The practice is common to many producers but what has been a colloquial practice is now supported by research. Further work could continue to optimize the system by developing recommendation on the most cost effective pairing of mulch layers, by finding layering options that are more environmentally friendly, or by understanding the mechanism that leads to this performance improvement.

Beneficiaries

Sweet potato producers are the primary beneficiaries of this project by identifying a practice that improves their operation. The methods developed to assess plastic mulch, however, could find application in a wide range of agricultural materials common to specialty crop production. Specific examples are assessing glass coatings green houses, or plastic films used on high-tunnel vegetable structure. Examining materials to identify the optimal amount of light penetration for their use could improve production or profitability.

Lessons Learned

Build outcomes based on the industry in its current state. Build measurable targets based on facts, not hypothesis. Double layers of plastic mulch will increase sweet potato bed performance.

Contact

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INTERPLANTING SPECIALTY CROPS USING A GREENHOUSE AND HIGH TUNNEL

Partner Organization

Piney Woods School

Project Summary

This project was initiated to allow The Piney Woods School's students to learn how to interplant specialty crops using high tunnels and greenhouses. The overall goal of this project was to encourage the use of high tunnels and greenhouses in planting various crops throughout the year. In addition, the project provided students with knowledge regarding the benefits of interplanting using greenhouses and high tunnels. Students in the Community Garden Club took the lead on the project with assistance from the Jr. MANRRS (Minorities in Agriculture Natural Resources and Related Sciences) club. In addition, the students partnered with the Master's Gardening Program via the Rankin County Extension Service (Mississippi State University) to develop a final class project centered around specialty crop use.

Due to various environmental challenges, the project was severely curtailed in the final year. Culminating events such as the Farm Festival Day were cancelled. Although we are still dealing with the aftermath of severe storms on the farm, various new partnerships and the remaining funds from this grant are allowing us to proceed with activities we envisioned last year with all 130 students involved.

Project Purpose

The purpose of this project was to introduce students enrolled at The Piney Woods School (PWS) to a new concept in the field of agriculture. Students learned how to interplant specialty plants (in summer and winter) using the high tunnel and greenhouse on the campus. The crops chosen for the project are usually planted in the summer; however, in the first year of the project, the high tunnels and greenhouse were utilized to show that the same crops can be interplanted successfully in the winter months. The objective of this project was to allow students to evaluate whether using a greenhouse and high tunnel are beneficial for planting certain crops out of season. This project allowed planting herbs and vegetables using the greenhouse and high tunnel. Under the leadership of the science teachers and existing Piney Woods staff (Agriculture Coordinator, Mr. Terry Cannon), students learned how to interplant the following using a greenhouse: parsley, basil, and thyme. In addition, the following crops were interplanted using the high tunnel: hot and sweet peppers, rainbow colored bell peppers (carnival mix), and cherry tomatoes. Each of these is a warm-weather crop; however, the

competiveness of these crops can be enhanced by planting them out of season. Through this grant, students at The Piney Woods School learned about the nutrients in the crops and were given an opportunity to taste them during their lunch and/or dinner hours. They also learned how to explore soil, how weather affects agriculture, and researched various diseases that may affect plants. Upon successful completion of this project, it was the intent of the Piney Woods School to extend the crops for community-level distribution.

We believe that our target population makes this project important. A resurgence in specialty gardening along with renewed interest in healthy living makes it timely as well. Because many of our students come from economically deprived rural areas with few resources, from inner-city regions, or from third world nations with little in the way of agricultural development, this project has provided a meaningful impact that they will take back to their home communities to share. Several students have indicated that they will continue their education with agriculture business, environmental research, or botany. This is especially significant in a school population that is primarily African American because farming is a nontraditional course of study for black students. Research shows that young people from lower socio-economic groups have issues with food (including obesity) that can lead to disease. Introducing gardening, conservation, outdoor activities, cooking with local produce, and a love and appreciation of nature is essential to overcoming these problems. Additionally, as more people in cities begin small gardens, the techniques our students have learned through this project will provide them with the expertise to serve as leaders in the field when they return to their home communities.

130 students participated in the interplanting project with 35 adults and community members taking part. The students research and beginning log books was limited to those in the Community Garden Club. Also, flooding that limited access to the farm led us to decrease the number of community participants. When these issues are addressed, we will move forward with the community outreach component detailed in this grant. We anticipate that the potential impact of the project will be on-going for students in other districts and community farmers who tour the model farm which will continue utilizing these techniques.

This project has not been submitted to or funded by another Federal or State grant program. This project is not a continuation of a previously funded SCBGP.

Project Activities

Thirty students from the MANRRS Group and the Garden Club actively participated in interplanting experimentation and began log books to document their findings. Students also participated in workshops with the Rankin County Extension Service, FoodCorps, and local farmers. Students learned and researched the usefulness and benefits of interplanting using high tunnels and greenhouses in summer months.

Teachers, administrators, and physical plant staff all reported a high level of enthusiasm among students actually engaged in planting, fertilizing, and harvesting the specialty crops. Approximately 130 students learned this new concept while watching the process from start to finish. A total of 6 crops

were interplanted with output monitored and measured using a gardening journal. The process was curtailed after the damaging of the high tunnel and greenhouse, but then re-emerged in a limited way utilizing the partial high tower that remained (see photos).

The project was shared using social media and via local media outlets. The resulting garden projects were highlighted in the school's newsletter, *The Tornado Watch. S*everal students developed science fair projects based on interplanting.

One of the most popular activities among the students was eating the specialty crops that were grown. On Tuesday, September 19th, during lunch, FoodCorps service members conducted their first "Tuesday Taste Test" for the Piney Woods School students and faculty. The featured item was fried green tomatoes, utilizing green tomatoes fresh from the Piney Woods Farm. They served the tomatoes with a dipping sauce of sriracha ranch, and encouraged the students/faculty to grab a sample on their way through the dining hall line. After the students/faculty tried the fried green tomatoes, they were then encouraged to evaluate the dish.
After counting the votes, the results show:

- 84%..."Loved it!"
- 10%..."It's okay."
- 6%....."Not today..."

On Tuesday, October 3rd, during lunch, FoodCorps service members conducted their second "Taste Test Tuesday" for the Piney Woods School students and faculty. The featured item was a pickled radish salad, using radishes from the PWS Farm. The radishes were pickled in a honey and garlic brine and served over fresh spinach tossed in an italian vinaigrette.
The results:

- 66% "Loved it!"
- 17% "It's okay..."
- 17% "Not today."

On Tuesday, October 24th a third specialty item was featured in pak Choi fried rice, utilizing pak Choi fresh from the Piney Woods farm. Results of that taste test:
After counting the votes, the results show:

- 72%..."Loved it!"
- 19%..."It's okay."
- 9%..."Not today..."

We plan to conduct taste tests using Piney Woods farm grown produce on Tuesdays, and, if the votes are in favor, to feature the recipe on the dining hall line on Thursdays. This is a way to increase exposure to local produce, and hopefully, give the students/faculty a say in what they are eating!

Funds from this grant were used solely to enhance the competiveness of specialty crops, although the tools purchased have been used in the raised beds for garden work with specialty crops not necessarily interplanted in the greenhouse.

Goals and Outcomes Achieved

Although the goals for community involvement were not met due to unforeseen circumstances (see Lessons Learned), we plan to go forward with development of a model farm suitable for tours by surrounding school districts and community farmers and to include demonstrations on campus by experts from the Rankin County Extension Service and others. Additionally, we are incorporating the specialty crops used into our dining hall's menus and are implementing plans to bring several top chefs (including "Chopped" winner Nick Wallace) to campus for demonstrations. (The raised bed gardens are located adjacent to the dining hall to facilitate this initiative.) The taste tests are introducing students to unfamiliar foods. Our future goal is to invite surrounding school districts and community farmers to become a participating part of the Piney Woods Farm movement. We hope to introduce a new generation of Mississippi farmers to sustainable farming practices and promote a love of nature and passion for conservation. Specialty crops will be sold on a limited basis in a new store on campus set to open in November. In addition to partnerships with Mississippi Food Corps and NCAT, we plan to develop a relationship with Alcorn and Mississippi State University to provide workshops, tours of their facilities, and scholarships for Piney Woods seniors who major in farming related study. The farm and the sustainable practices put in place by this grant are being integrated into the curriculum, along with robotics, in order to facilitate an empowered STEM program. We are in the initial phase of creating a composting facility on campus. These goals are high, but we are already putting in place the activities that will lead to their accomplishment. This grant has set in motion a movement more far-reaching than its initial outcomes would suggest. We hope USDA will again partner with us when we have corrected the problems that limited the final year of this project.

Cited Goals and Expected Outcomes: Students will learn and research the usefulness and benefits of interplanting using high tunnels and greenhouses in summer and winter months. Our cited performance measure projected 30 students would be involved in the actual interplanting project. Those 30 students were directly responsible for the data collection, journaling, and analysis of the success of interplanting, but the project impacted all students and staff in a positive way, providing access (and piquing interest about) healthy, locally grown vegetables. In a post-test, the Garden Club students demonstrated increased knowledge of interplanting, factors of success in interplanting, and 98 percent of participating students reported a more positive perspective toward interplanting, and farming in general.

Expected Outcome
Students will demonstrate Increased knowledge of interplanting in high tunnels and greenhouses.
Achievement
98% of students in Garden Club demonstrated increased knowledge of interplanting in high tunnels and greenhouses; 130 students and 25 staff and community members participated in fall interplanting.

Expected Outcome
Minority students will be exposed to nontraditional careers in farming.
Achievement
30 students in the Garden Club expressed a desire to continue activities in interplanting and farming. 10 students expressed interest in majoring in an agricultural-related field of study in college.

Expected Outcome
Growing seasons for specialty plants will be lengthened.
Achievement
The project was so successful that we were able to utilize the produce in the school cafeteria, introducing the students and community to healthy locally grown food; 75% of students responded favorably to the enhanced menu, with 45% claiming that this was a first introduction to particular specialty crop foods. (Raised bed gardens near the cafeteria also contributed to introducing healthy food choices to students.)

Expected Outcome
Community involvement with the PWS Demonstration Farm will be enhanced.
Achievement
30 community members participated in interplanting and in Harvest Fest. Partnerships with Mississippi Food Corps, National Center for Appropriate Technology (NCAT), Alcorn University, and the Rankin County Extension Service are facilitating greater community involvement. MOUs with 5 Rankin County Schools will provide area schools with increased opportunities to participate in agricultural initiatives.

Unexpected Outcomes
A revitalized campus demonstration farm; a renewed push to enhance community relations and become a catalyst for developing small farms in a rural "food desert;" integration of the farm into an empowered STEM program, along with robotics; and plans to develop a composting facility on campus. Perhaps the most significant unexpected outcome was the development of an enthusiastic farm to cafeteria movement on our campus that we hope spreads to surrounding schools.

Beneficiaries

Our original goal was to include community members from surrounding counties by showcasing the model farm, demonstrating special crop interplanting techniques, and offering an affordable source of nutritious produce. Virtually all rural counties in Mississippi have high percentages of families who live below the poverty line with rural populations earning 7% less than urban populations. In our service area, the percent of the total population living in poverty is near 25%. [USDA Economic Research Service.] Forty percent of children in Simpson County who are under 18 live in poverty with extremely limited resources. [Mississippi Data Works Profile] Piney Woods students from throughout the United States typically come from underserved areas where resources are scarce, be it inner-city Baltimore, New Orleans, or the Mississippi Delta. Ten percent of our student body comes from Ethiopia, the Virgin Islands, and Haiti. We predict that as students return to their homes with these new techniques, they will be able to provide leadership in a field that is important to their communities' survival and economic sustainability.

Our original target was for students to benefit from the project through learning how to effectively plant seasonal and unseasonal crops and research the feasibility of planting/gardening throughout the year. Although this did happen to a limited extent, a more profound benefit came through exposing

students to the natural world. Many of our students come from urban areas and have no access to farm or forest. Their exposure to planting and harvesting specialty crops has allowed them access to a world (and a livelihood) they had never before considered.

During the final grant year, 130 Piney Woods students benefitted through direct involvement in the program, including planting, harvesting, and participating in experiential learning activities, with several inner-city students selecting agriculture as their field of choice for post-secondary education. Faculty, staff, students, and some community members (approximately 200 participants) met for a Farm Volunteer Day to transplant the seedlings that were interplanted to the main garden since repairs to the greenhouse and high tunnel have not yet been completed.

Lessons Learned

Tornadic winds severely damaged both the greenhouse and the high tunnel during the final grant year. Although the first portion of the Work Plan (ordering supplies and ensuring that the greenhouse and high tunnel were in operation) took place, there was no contingency plan for weather-related disaster. We decided to go forward by continuing the interplanting in the field at the farm, but spring weather hampered this plan. And, certainly, a part of the grant was designated specifically to study the use of greenhouses in interplanting specialty crops so this alternative was not particularly helpful. We continued interplanting in the partial high tunnel. One action that could have mitigated damages might have been placing the greenhouse and the high tunnel in separate areas of the campus so that if one was irrevocably damaged, the other might remain operational.

In spring 2016, the bridge connecting the main campus to the farm washed out in torrential rains along with a portion of the dam that surrounds a 20-acre lake. Coupled with vehicle issues, this event effectively ended the students' involvement with the project. It also prevented the planned Farm Festival. Eventually, we found a stop-gap solution to this problem through utilizing an old school bus to transport students through a back trail to the farm.

Although this grant has ended, we are pleased to report that the work continues. In fact, several recent partnerships and a renewed commitment to the farm have brought about a change in our approach and a nascent farm to cafeteria movement on campus that could provide real benefits to our students. More to the point, we are now carrying out what we feel is, at least, the spirit of the grant. NCAT (National Center for Appropriate Technology) is working with Mississippi Food Corps to create a model farm (including interplanting of specialty crops) and utilizing the knowledge gained from this grant to do so. (FoodCorps has a vision that connects all children to healthy food while dismantling health disparities that occur in children of color and of low-income families. The Piney Woods School seeks to provide a space to share their vision as well as establish and carry out priority goals and objectives.) In addition, we have created several raised bed gardens from recycled wood near the cafeteria and have plans for a composting facility. The model farm is providing food for our cafeteria and produce for the Piney Woods faculty and staff. Student taste tests are conducted with specialty crops from the raised bed to introduce students to new healthy food options.

In addition, we are engaged in soliciting MOUs from five Rankin County schools to bring students of all ages to our demonstration farm and help them begin their own farm to table movement. We also plan to host field days for the broader community several times a year.

We have determined that the most valuable lesson learned is that commitment to a project is key to its accomplishment and *that* means buy-in from all community members as well as a willingness to "work with what you have" to reach stated goals.

Contact Person

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TRAINING MS FARMERS AND AG PROFESSIONALS THROUGH ANNUAL FOOD SAFETY CONFERENCES

(previously approved in second annual report)

Project Partner

Mississippi Association of Cooperatives & Alcorn State University

Project Summary

The SCALE Food Safety Conference was held on Tuesday, May 19, 2015, to assist specialty crop producers, agricultural professionals, students, and others to increase food safety knowledge for specialty crop production, and other agricultural commodities. The specific objectives of the project were to: (1) increase conference participants' food safety knowledge capacity; (2) equip participants with the necessary tools to develop and implement effective farm food safety programs; and (3) assist agricultural professionals in accessing continued food safety education. The outputs were: (1) development of farm food safety plans for participating farm operations and (2) increase the number of Mississippi food safety specialists in the state. Approximately 65 specialty crop producers, agricultural professionals, and students attended the event. A Hazard Analysis and Critical Control Points (HACCP) training and certification was also held May 18-19, 2015, to increase the number of food safety professionals in Mississippi. The training was only open to persons employed or seeking employment with fruit and vegetable entities. Nine persons were certified in introductory HACCP. Primus instructors taught the course and disseminated certificates to participants. Participants work with specialty crop producers in Mississippi.

Project Purpose

Mississippi specialty crops are found in local commercial markets, schools, institutions, and farmers' markets; however, select markets require food safety certifications while others have no specific food safety requirements. Local Wal-Mart distribution centers purchase locally-grown specialty crops to reduce the costs of distribution, shipping, and transportation associated with high food miles; fulfilling the company's food safety requirements are necessary to sell these products. Moreover, the final ruling of the FDA Food Safety Modernization Act will require specialty crop producers to incur expenses in implementing farm food safety programs. The final ruling date has not been identified; however, the proposed ruling for growing, harvesting, packing and holding of produce for human consumption will impede specialty crop production as operations implement food safety requirements.

The Mississippi Association of Cooperatives and Alcorn State University conducted a food safety conference on May 19, 2015, to assist specialty crop producers, agricultural professionals, students,

and others to increase food safety knowledge specialty crop production, and other agricultural commodities. The specific objectives of the project were to: (1) increase conference participants' food safety knowledge capacity for specialty crops; (2) equip participants with the necessary tools to develop and implement effective farm food safety programs; and (3) assist agricultural professionals in accessing continued food safety education. The outputs were: (1) development of farm food safety plans for participating farm operations and (2) increase the number of Mississippi food safety specialists in the state.

Furthermore, the number of persons trained in food safety and certified in Hazard Analysis and Critical Control Points (HACCP) for specialty crops were inadequate to provide outreach and training to all Mississippi specialty crop farm operations. The project allowed participants to learn food safety in a greater quantity than such specialists could conduct in outreach activities and for agricultural professionals to become HACCP certified. A total of nine participants were HACCP-certified. Participants are employed with Alcorn State University Extension Program (6), Mississippi Association of Cooperatives (2), and Mississippi Department of Agriculture and Commerce (1). All participants work with specialty crop production in the state of Mississippi.

Alcorn received SCBG FY2012 funding for multi-state collaboration, "Enhance the Competitiveness of Vegetable Farmers by Enhancing Food Safety." This project was not a continuation of the previously funded project. It differs from the proposed project because it includes scientific and industry food safety education and technical assistance. A local food safety specialist conducted the training specific to food safety certifications in previous project. This project gave participants the necessary tools to develop and implement their own farm food safety program for their specialty crop operation. Also, the project provided food safety certificates to conference participants and students and HACCP certifications for agricultural professionals.

Project Activities

The Mississippi Association of Cooperatives (MAC) and Alcorn State University (ASU) developed and implemented programming for a food safety conference for specialty crop production to assist specialty crop producers, agricultural professionals, students, and others to increase food safety knowledge. The participants had an opportunity to interact with food safety experts and partake in concurrent sessions, demonstrations and technical assistance activities for Mississippi specialty crop production during the conference. As mentioned in our original proposal, more food safety is needed to enhance Mississippi specialty crop production. Furthermore, the number of persons trained in food safety is inadequate to provide outreach and training to all Mississippi specialty crop farm operations. The project was designed to allow participants to learn food safety in a greater quantity than such specialists could conduct in outreach activities.

According to the work plan, MAC and ASU completed the following tasks during the one year project:

1. Identified staff persons
2. Developed program and learning objectives
3. Identified speakers and presenters

4. Requested speakers/presenters participation
5. Identified conference locations with distance learning capabilities and rooms for 3-4 concurrent sessions
6. Perused existing databases for specialty crop producers
7. Developed and implemented a marketing campaign
8. Disseminated save-the-date cards
9. Secured conference location and caterer for the conference
10. Disseminated conference information
11. Identified and printed conference program agenda, instruction material, etc.
12. Confirmed speakers and presenters
13. Host a food safety conference for specialty crop producers

Ben F. Burkett and Nicole A. Bell directed all project activities; however, Darnella Burkett-Winston (MAC), Daniel Teague (MAC), Joe Barnes, (MAC), Maya Crooks (MAC) and Velma C. Oliver (ASU) assisted in planning the conference. The conference program objective was to educate specialty crop producers on the importance of food safety and assist in the development and implementation of farm food safety programs. The learning objectives were to: (1) identify food safety needs for individual specialty crop production; (2) construct farm food safety plans; and (3) apply new food safety knowledge and skills to enhance specialty crop production.

The conference planning committee requested several top food safety experts to participate. Some experts had a scheduling conflict and some did not respond to communications sent by the committee. The committee confirmed participation from food safety experts from USDA Agricultural Marketing Service, Louisiana State University, Mississippi State University, etc. The guest speaker was Jennifer Dougherty, Audit Coordinator for the USDA-AMS Specialty Crop Division. Distance learning was not applicable to the project needs since all speakers and presenters could travel to the conference.

In regards to the conference location, the committee met with sales managers and associates and toured various conference venues. After review of the budget and discussion with the planning committee, the conference was held at the Eagle Ridge Conference Center on Tuesday, May 19, 2015. A Hazard Analysis and Critical Control Points (HACCP) training and certification was also held May 18-19, 2015, to increase the number of food safety professionals in Mississippi. The training was only open to persons employed or seeking employment with fruit and vegetable entities. Nine persons were certified in introductory HACCP. Primus instructors taught the course and disseminated certificates to participants. Participants work with specialty crop producers in Mississippi.

The development of the marketing campaign began in November 2014. A company developed a conference logo, save-the-date cards, and publications for dissemination to existing databases for specialty crop producers. The company developed the logo and provided drafts of the save-the-date cards. Yet, several errors were found when approving drafts. There was a time delay in correcting errors which subsequently caused a delay in disseminating the cards to the databases and giving cards to participants at the 2015 MFPC Farm to Cafeteria Conference and Small Farmer Conference. The committee distributed cards at the Small Farmer Conference and emailed persons listed in internal specialty crop producer databases. Conference information was also sent through MDAC and USDA

email listservs. Farmers and agricultural professionals registered for the conference. Student participation was low since the conference was held when universities and colleges were closed for the spring semester. Yet, a speaker transported students to the conference.

The conference agenda was developed to include specialty crop inspection, implementing on-farm food safety practices, and the Food Safety Modernization Act. Also, as aforesaid, a HACCP training and certification was held for 2-days. The speakers and presenters for these workshops and presentation were also confirmed.

In conclusion, the conference was held on May 19, 2015. Approximately 65 persons were in attendance for the event. The SCALE Food Safety conference included more than information on specialty crop production. Project staff used external funds from Alcorn State University Extension Program, Mississippi Small Farm and Agribusiness Center, Mississippi Association of Cooperatives and Project Healthier Mississippi. Funds from the Specialty Crop grant were solely used to enhance the competitiveness of specialty crops. Funds from the aforesaid sources were used to purchase lunch for conference participants and cover expenses associated with aquaculture and livestock enterprises.

Goals and Outcomes Achieved

The project's goals and outcomes included an increase in conference participants' food safety knowledge capacity, number of specialty crop producers and agricultural professionals participating in the conference, and the number of farm food safety plans developed over the duration of the project. These outcomes and outputs supported Mississippi specialty crop production and enhancing the producer's competitiveness. The number of future food safety specialist was another expected outcome; however, it is a long-term measure that will occur after the project's completion.

GOAL: Increase in conference participants' food safety knowledge capacity.

PERFORMANCE MEASURE: The actual project results will be measured through evaluation and test assessment for food safety/HACCP certifications and development of farm food safety plans and programs.

BENCHMARK: Current behavior. The participants' current behavior will be assessed through pre- and post-evaluation.

TARGET: The target is to increase food safety knowledge capacity of at least 65% of the conference participants.

The goal was achieved. This project increased food safety knowledge of those who attended; however, the number of participants was lower than expected. Evaluation was completed by specialty crop producers. The results of the project were shared with Alcorn State University and Mississippi

Association of Cooperatives administration. Also, other specialty crop growers and interested specialty crop stakeholders can request the information disseminated at the conference.

	Excellent	Above ave	Average	Below ave	Poor
Overall conference experience	**15.38%**	**36.92%**	**44.62%**	**1.54%**	**1.54%**
Conference location	**3.08%**	**7.69%**	**36.92%**	**44.62%**	**1.54%**
Meals and refreshments	**10.77%**	**36.92%**	**44.62%**	**7.69%**	**0.00%**
Helpfulness of conference staff	**12.31%**	**29.23%**	**49.23%**	**4.62%**	**0.00%**
Registration process	**32.31%**	**24.62%**	**30.77%**	**6.15%**	**1.54%**
Opening session	**16.92%**	**47.69%**	**26.15%**	**1.54%**	**0.00%**
Increase in knowledge gained from Jennifer Dougherty, Guest Speaker	**10.77%**	**35.38%**	**40.00%**	**10.77%**	**1.54%**
Increase in knowledge gained from Breakout session I workshop	**36.92%**	**44.62%**	**7.69%**	**6.15%**	**4.62%**
Increase in knowledge gained from Breakout session II workshop	**41.54%**	**32.31%**	**21.54%**	**3.08%**	**0.00%**
Increase in knowledge gained from Food Safety Modernization Worksho	**12.31%**	**36.92%**	**38.46%**	**7.69%**	**4.62%**
The Way, Inc.	**24.62%**	**30.77%**	**18.46%**	**20.00%**	**3.08%**
MS Farm Food Safety Checklist	**47.69%**	**26.15%**	**12.31%**	**10.77%**	**3.08%**
Increase in knowledge gained from Farm Food Safety Plans	**41.54%**	**26.15%**	**15.38%**	**12.31%**	**0.00%**
Conference wrap-up	**23.08%**	**32.31%**	**30.77%**	**6.15%**	**1.54%**

The food safety conference included diverse agricultural commodities; however, SCBG funds were solely used for the specialty crop portion of the conference and the HACCP training and certification that is for fruit and vegetable production. Recommendations for improving the conference should include having the conference take place in cold, winter months, sometime in November – February.

Beneficiaries

Approximately 65 persons attended the food safety conference. The beneficiaries included specialty crop producers, agricultural professionals and college students. Most of the participants were agricultural professionals from Alcorn State University, Mississippi Association of Cooperatives and Mississippi State University.

This conference trained farmers, students, and agricultural professionals and allowed participants to network with each other. Food safety requirements are being mandated and specialty crop producers must remain competitive to enhance the viability of the farm operation. The specialty crop beneficiaries of the project were projected at 200 specialty crop producers, agricultural students, and federal, state, and local agency agricultural professionals; however, approximately 65 persons benefited from the conference. The project was advantageous to the specialty crop beneficiaries because they increased food safety knowledge, developed individual farm food safety programs and increased the number of food safety specialists, as nine professionals were HACCP-certified. The economic impact of the project could not be estimated in dollars; however, the tables below display an assessment of a potential cost for implementing the final FSMA ruling in the United States. The second table is an approximate cost for very small, small and large farm operations that grow, harvest, and pack produce. With successful food safety certification, specialty crop producers are positioned to meet food safety regulations and sell produce to commercial markets.

Summary of Costs and Benefits of the Proposed Rule	Prevented foodborne illnesses *(in millions)*	Total benefits *(in millions)*	Total Domestic Costs *(in millions)*	Total Foreign Costs *(in millions)*	Total Costs (Domestic + Foreign)	Net Benefits *(in millions)*
Total	1.75	$1,036.40	$459.56	$170.62	$630.18	$406.22

	Very Small	*Small*	*Large*
Average Annual Cost per Farm	$4,697	$12,972	$30,566

Lessons Learned

The number of conference participants was lower than expected. One lesson learned was not to have this event in a summer month. Inclement weather caused specialty crop producers to plant late, with many planting on May 18-19, 2015. Also, the number of students was also lower than expected. Seemingly, having the conference on Alcorn State University's campus while school is in session would greatly improve student participation. A positive lesson learned was the way the conference agenda was set up. Instead of having so many speakers in one setting, the participants heard a couple of speakers during the opening session, then they could participate in concurrent sessions. We had three tracks and two time slots. The conference agenda allowed participants the opportunity to move around to other sessions.

Contact Person

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Improving the Safety and Market Competitiveness of Mississippi Produce

(project implemented with relinquished funds)

Project Partner

Mississippi State University

Project Summary

The purpose of the proposed project was to enhance the competitiveness of Mississippi fruit and vegetable growers by ensuring they have access to training required by FDA and produce buyers. The project funded trainer and grower courses to meet federal Food Safety Modernization Act Produce Safety Rule (FSMA PSR) requirements and buyer requirements such as Good Agricultural and Handling Practices (GAPs/GHPs). The project funded the training of a cadre of Produce Safety Alliance trainers in Mississippi that will be ready for future outreach efforts initiated by the MDAC and MSU. Specifically, one Train the Trainer (TTT), one GAP/GHP training, and 5 FSMA PSR educational seminars were delivered.

Project Purpose

The Centers for Disease Control and Prevention estimates that 48 million people (one in six Americans) are sickened each year from foodborne diseases, and an estimated 3,000 people die (Centers for Disease Control and Prevention, 2011). The US Food and Drug Administration reports approximately 131 produce-related outbreaks from 1996 to 2010 (Food and Drug Administration, 2015). There is a need for growers across the country to respond to the growing food safety concerns of consumers. This project addressed this concern by offering a series of food safety workshops to improve the safety of produce and meet the need to comply with the new FSMA PSR requirements. Improving the safety of Mississippi produce and meeting federal regulations will enable growers to realize higher economic returns, improve produce quality, expand sales by working with larger markets, and increase grower income.

Project Activities

The trainer course developed 19 potential lead trainers for the state to deliver trainings; answer questions and assist farmers meet food safety and related requirements. There are up to 1,400 produce growers in Mississippi that may benefit from produce safety training (Census of Agriculture, 2012). The project funded the training of a cadre of Produce Safety Alliance trainers in Mississippi that will be ready for future outreach efforts initiated by the MDAC and MSU. Specifically, one Train the

Trainer (TTT), one GAP/GHP training, and 5 FSMA PSR educational seminars were delivered. A total of 86 growers were trained (it is estimated that ~300 farms will be affected by the rule in MS).

Description of activities (see Table 1 at end of this section for a summary**)**

Train-the-Trainer (TTT) course

A Produce Safety Train-the-Trainer (TTT) course was held in Hernando, MS on April 5-6, 2017. A total of 24 persons attended this training course. Nineteen of the attendants were associated with MSU (15), MDAC (3) or MSDH (1).

Attendees spent approximately 16 hours of instruction time covering the content contained in the seven standard modules:

- Introduction to Produce Safety
- Worker Health, Hygiene, and Training
- Soil Amendments
- Wildlife, Domesticated Animals, and Land Use
- Agricultural Water (Part I: Production Water; Part II: Postharvest Water)
- Postharvest Handling and Sanitation
- How to Develop a Farm Food Safety Plan

In addition to learning about Good Agricultural & Handling Practices, key provisions of the FSMA Produce Safety Rule requirements are outlined in each module. Day 2 included additional presentations to ensure trainers are ready to deliver the modules to growers and an in-depth discussion of the seven modules. Other trainer specific topics included principles of adult education, how to incorporate the PSA curriculum into other Extension trainings, how to develop working partnerships, expectations for trainers, how to become a PSA Lead Trainer, and how to register a PSA Grower Training Course with the Association of Food and Drug Officials (AFDO).

Participants received a manual, jump drive, and a certificate of course attendance from AFDO that verifies they have attended the PSA TTT Course.

The Produce Safety Alliance Southeastern Regional Extension Associate, Kristin Woods, led instruction, along with another PSA trainer, Ms. Gretchen Wall. The Mississippi PI for the Southern Center for FSMA Training, Dr. Juan L. Silva and another PSA trainer, Dr Joy Anderson collected data, arranged the location, arranged meals, and promoted the PSA TTT Course.

This course provided a foundation of Good Agricultural Practices, information about wildlife co-management, FSMA PSR requirements, and details on developing a farm's food safety plan. Through this process, a database of produce safety trainers in Mississippi was developed. In addition, about 6-8 of the trainees showed interest in pursuing the lead trainer certificate. However, the application is $325 and has been a hindrance for them.

GAP/GHP workshop

A GAP/GHP workshop in Hattiesburg, MS on May 5, 2017. A total of 12 growers participated in the workshop. The workshop had a presentation by MDAC on how to become GAPs certified.

Producer/Farmer/Grower/Handler Produce Safety Rule (PSR) Courses
The PI participated in one course as co-Instructor. This course was held n Okolona, MS. A total of 5 instructors and 12 participants attended the course on May. The participants were for the most part, a group of minority farmers that are part of a cooperative. Five other courses were programmed between August and September 2017. The Grower courses were held in Stoneville, Hattiesburg, Hernando, Verona, and Raymond, MS. The PI, the only Lead Trainer in the state, led all the courses with co-instructors from the Lead Trainer course held in Hernando in April. This would give the co-instructors a chance to practice on delivering the course while they prepare for becoming Lead Instructors. A total of 7 co-instructors (another one was not able to participate due to illness) taught and helped organize the courses. All sites except for the Okolona training were Mississippi State University Research and/or Extension Centers (REC) or offices.

Goals and Outcomes Achieved

From a total of 74 questionnaires/tests collected, the growers averaged gain in knowledge ranged from 31-61%. This is impressive and it shows that growers will need more training and assistance in order to comply with regulations. At least 33% of growers that attended the PSA courses already were familiar with GAPs but they also showed a gain in knowledge through the PSA courses (See the Table 1). Additional assessments were sent to the PSA which will gather data and send back later on.

Outcomes and indicators from: 2016 Specialty Crop Block Grant Evaluation Plan.
Outcome 6: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety.
Indicator: Number of individuals (86) who learn about prevention, detection, control, and intervention food safety practices and the number of those individuals who increase their food safety skills and knowledge.
Assessed through end of training retroactive survey for growers.

Additional indicator specific to this project: Number of trainers trained to deliver food safety education to farmers.
Assessed through counting the number of attendees that complete the TTT course (24).

Outcome 7: Enhance the competitiveness of specialty crops through increased understanding of threats to food safety from microbial and chemical sources.

Table 1. Courses held, # instructors and participants, and gain in knowledge and evaluation of instructors

Course host city	Site	Course	# Instructors	# participants	% gain (or loss) in knowledge	Overall evaluation (5=excel)	
Hernando	Hotel	PSR Lead Trainer	2	24 (19 from MS)			
Hattiesburg	Forest County Ext. Office	GAPs & GHPs	2	12			
Okolona	MS Minority Farmers Alliance	PSR	4	12			
Stoneville	Delta REC	PSR	4	3	55.0	5.0	
Hattiesburg	Forest County Ext. Office	PSR	4	29	38.9	5.0	
Hernando	DeSoto County Ext. Office	PSR	3	13	60.8	4.8	
Verona	North MS REC	PSR	3	8	37.0	5.0	
Raymond	Central MS REC	PSR	4	21 (only 16 received certificate)	44.5	4.9	
TOTAL or OVERALL				**24 trainers, 12 grower GAPs and 86 growers Produce Safety Rule**	**47.0**	**4.95**	

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Beneficiaries

A total of 86 growers/packers/handlers of produce participated in the PSR trainings (it is estimated that ~300 farms will be affected by the rule in MS).

All but 4 of them received PSA grower training certificates. The other 4 did not complete the course and thus could not be presented with PSA certificates. About 20% of the participants had GAPs training and/or knowledge. Growers showed an average gain in knowledge of nearly 50%, a tremendous

achievement for us as trainers and for them. Even those that had prior knowledge in GAPs showed a gain in knowledge. This shows that we need to educate the growers more, and assist them to be ready for the enforcement of the PSR.

Growers asked for more training, assistance with water training and testing, developing the food safety plan and resources for further training, amongst other things.

Lessons Learned

Growers showed an average gain in knowledge of nearly 50%, a tremendous achievement for us as trainers and for them. Even those that had prior knowledge in GAPs showed a gain in knowledge. This shows that we need to educate the growers more, and assist them to be ready for the enforcement of the PSR.

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Through this process, a database of produce safety trainers in Mississippi was developed. In addition, about 6-8 of the trainees showed interest in pursuing the lead trainer certificate. However, the application is $325 and has been a hindrance for them.

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Collecting southeastern indigenous wildflowers for conservation and re-vegetation and survey of *Macrophomina phaseolina* in impatiens

(project implemented with relinquished funds)

Project Partner

Mississippi State University

Project Summary

Mississippi wildflowers are a largely untapped genetic resource of native plant material. For Mississippi greenhouse producers, growing ecotypes from the local region would likely result in more disease-resistant plant material with superior performance. One particular disease of interest is M*acrophomina phaseolina*, which was first reported on impatiens here in Mississippi, and we have not been able to find disease resistance in cultivated varieties. Additionally, the scope of this disease on impatiens has not been studied. To overcome these challenges, we collected wildflower seeds and impatiens samples from the southeastern US. More than 60 seed accessions were collected. These seeds were cleaned and sown in plug trays for future transplant into the field for evaluation. Of the collected seed accessions, 24 had at least 15 plants developing. Twenty impatiens symptomatic of *M. phaseolina* infection were collected from 12 states. Preliminary data suggest that *M. phaseolina* may have been found in Texas, Louisiana, Alabama, Kentucky, Ohio and Georgia; however, genetic testing is needed to fully verify these cases. This work will assist in determining the geographic spread of *M. phaseolina* infection in the southeastern US and the germplasm collection will provide a source of locally-sourced plant material for the Mississippi horticultural industry.

Project Approach

Many of the valuable perennial crops in the commercial ornamental trade are native to Mississippi, but the ecotypes that have adapted to thrive in this region have not been well utilized in perennial production or breeding programs at the state or national level. Therefore, many of the perennial crops sold are not as well adapted to Mississippi's irregular rainfall patterns or have the necessary genetic components for good disease resistance, particularly for fungal pathogens. Additionally, Mississippi soils are typically heavy and often don't provide optimal drainage. Locally sourced seed can therefore be used as a base for important disease-resistant traits of commercially available horticultural crops for Mississippi and throughout the rest of the nation. For example, in 2016 a new fungal disease for impatiens was reported in Mississippi called *Macrophomina phaseolina*. It is unclear how far spread

this problem is outside of Mississippi, however, the disease thrives in hot conditions and can be found on other crops throughout the US. Impatiens are the second most valuable bedding crop worth over $215 M annually in the US alone. Cultivated impatiens do not have resistance to this pathogen, but it likely exists in wild populations where disease pressures are present. Other crops, such as coreopsis and echinacea have disease problems with powdery mildew and susceptibility to soil-borne diseases in wet climates. This project initiated the process of developing locally-sourced, adapted germplasm that can be made available to greenhouse producers and established throughout Mississippi as part of the Wildflower Trail. Additionally, this project involved scoping the southeast for potential *M. phaseolina* infection on impatiens and to collect native populations of impatiens for potential disease resistance and future breeding efforts.

Mississippi ornamental horticultural growers are facing increased competition from neighboring states such as Georgia, Florida, and Louisiana. This is at a time when plant material costs are increasing due to royalties. These patented cultivars do not always provide satisfactory garden performance to the Mississippi landscaper or homeowner, since nearly all commercial cultivars were developed outside of this state particularly in regions such as the Midwest and California, and even other countries. This means that disease resistance for specific problematic diseases in this region may not be present in plant material. Currently, there are few, if any, sources of native perennial germplasm available for sale or distribution that originate from Mississippi. Revegetation efforts and native landscaping in this state require seed stock that is locally adapted and match both abiotic and biotic factors as much as possible (i.e. elevation, soil type, climatic regime, pathogens, and predators) to maximize planting success. This lack of viable germplasm has generated the need for the collection, development, and distribution of locally adapted seed and plant material. This is especially true for impatiens and the need to find resistant impatiens germplasm to *M. phaseolina*. We will also utilize this time to survey impatiens from this region to determine the scope of *M. phaseolina* infection.

Objective 1) collect, clean and sow native perennial ecotypes from the southeastern US for evaluation, propagation and future distribution to Mississippi greenhouse growers.
Objective 2) collect and survey impatiens in the southeastern US for *M. phaseolina* infection and potential sources of resistance of impatiens crop improvement.

Project Activities

We proposed two project activities for our Work Plan that consisted of 1) collecting wildflower material throughout the state and neighboring states, and prep seed for sowing at an appropriate time and 2) collect native impatiens and diseased impatiens for determining the distribution of *M. pahseolina* infection in the southeastern US.

A total of 64 wildflower collections were made across the states of Louisiana, Mississippi, and the east side of Texas. Some of the seed was not identifiable at the time of collection. Identified seed consisted of *Rudbeckia hirta*, *Helianthus divaricatus*, *Hibiscus moscheutos*, *Verbesina helianthoides*, *Vernonia spp*. *Erythrina herbacea*, *Penstemon digitalis*, *Ruellia spp*., *Ratibida columnifera*, *Coreopsis lanceolata*, *Chasmanthium spp*. and *Iris brevicaulis*.

Chaff from the accessions was removed and seeds were sown in 72-cell flats. Accessions that did not germinate were sown again after they were imbibed in 1000 ppm gibberellic acid for 24 hours before being planted. Plant plugs that developed a robust root system were placed outdoors on landscape fabric for vernalization during the winter. They will be planted in the fields this spring as temperatures warm and soils get to a workable moisture level. This work demonstrates that fall seed collections can provide a broad range of genera and what seed will readily germinate from these collections. Collections of other plant material may need to be scheduled for different times of the year due to maturity, seed shattering, lodging and dispersal mechanisms.

We collected impatiens from 20 locations across 12 states, including Texas, Louisiana, South Carolina, North Carolina, Georgia, Alabama, Tennessee, Kentucky, Indiana, Illinois, Missouri and Arkansas, that were symptomatic of *M. phaseolina.* Potential pathogens were isolated and cryo-preserved. Fungal tissue was also collected and DNA extracted for genetic confirmation of *M. phaseolina*. Preliminary results suggest that *M. phaseolina* may have been present in collections from Texas, Louisiana, Alabama, Kentucky, Ohio and Georgia; however, genetic sequencing is needed for full confirmation and will be performed in the coming few weeks. If these samples are confirmed to be *M. phaseolina*, it will demonstrate that this pathogen has a much wider impact on the horticultural industry than previous thought. Properly identifying this pathogen will aid in developing solutions to control it throughout the Southeast and to develop resistant plant material.

Goals and Outcomes Achieved

This project consisted of two goals:

- GOAL 1: Build up the diversity of native perennial seed from Mississippi and surrounding states to improve access to locally adapted plant material. To reach GOAL 1, we will collect at least 30 populations of wildflowers, such as Black-eyed Susan (*Rudbeckia hirta*), lance-leaf coreopsis (*Coreopsis lanceolata*), purple coneflower (*Echinacea pallida* Nutt.), impatiens (*Impatiens capensis* and *I. pallida*) and plains coreopsis (*Coreopsis tinctoria*)

- GOAL 2: Determine the scope of *M. phaseolina* on impatiens in the southeastern US and collect native impatiens for future disease-breeding efforts. To reach GOAL 2, we will collect at least 20 samples from at least five southeastern US states of wild and diseased impatiens

GOAL 1 was very successful with the collection of so many wildflowers from neighboring states. We more than doubled the number of accessions from what was originally proposed and collected (from what we could properly identify from seed collections) more than 12 species from many genera. This number will increase as unknown accessions are identified. Many accession are already growing, and they will be evaluated this spring in the field.

GOAL 2 was also very successful in that we collected 20 samples of impatiens from 12 states. The diseased collections were plated out and fungal cultures were isolated. If confirmed, *M. phaseolina* will have been found in at least 6 states in this region, suggesting that *M. phaseolina* is more problematic than originally hypothesized, and that more research efforts should be made to find viable solutions for homeowners and landscapers facing this problem. It will be extremely important that these potential pathogens be confirmed genetically to verify that they are indeed *M. phaseolina* and work is underway for that to occur.

Beneficiaries

This project will ultimately help the horticultural industry of Mississippi, including producers, landscapers, and homeowners. This completed project is a large step in the process. Now that so many accessions are collected. Plants can be transplanted in the field, evaluated and selected based on performance, and bulked to be made available. Also, understanding the scope of *M. phaseolina* will aid in obtaining necessary research funds and industry support of find viable solutions for impatiens.

Lessons Learned

For our goals, collections of *Impatiens capensis* and *I. pallada* could not be obtained as we had planned. It was not possible for us to locate native populations of these plants. It is likely that they are present only during the earlier part of the growing season. Collection trips made earlier in the growing season will need to be made to find these plants. It may also be necessary to cover pollinated flowers in bags to collect seed, since these plants have seed heads that expel mature seed. All successful collections of impatiens were commercially-available varieties growing in cultivated gardens. Additionally, we will work to get the remainder of the seed accessions germinated. Some accessions may require scarification or vernalization to germinate. Other accessions may have seed that is not viable. More time will be needed to grow the seedlings before they are mature enough to be transplanted out into the field for further evaluation.

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