Indiana State Department of Agriculture
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Specialty Crop Block Grant Program 2016 Final Report

Final Report

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Project Title: Indiana Grown

PROJECT SUMMARY

- *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*

With the 2015 launch of the Indiana Grown initiative and consumer demand at an all-time high, ISDA felt it was time to position local producers for the spotlight and raise awareness of locally grown specialty crops. The goal was to increase consumer awareness of Indiana Grown produce by continuing the "buy local" initiative. Producers were not able to effectively connect with consumers about the specialty crops they produced and consumers were unaware of the plethora of products produced in Indiana. This project was designed to start to bridge that gap.

- *Describe the importance and timeliness of the project.*

The Indiana Grown initiative was relaunched in 2015, so the timeliness of the project connected heavily to the overall program efforts. These grant goals and the program goals align and built upon each other to provide even more effectiveness than either could alone.

- *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.*

N/A

PROJECT APPROACH

- *Briefly summarize activities and tasks performed during the entire grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Specifically, discuss the tasks provided in the **Work Plan** of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

The tasks for this project were generally completed by two contract employees hired by the State of Indiana. Their job description included:

1. Visiting specialty crop producers and farms. The two employees visited hundreds of producers and farms and collected data at each location. As a part of these discussions, they also collected information about difficulties and concerns of specialty crop producers and relayed that information back to Indiana Grown staff.
2. Representing Indiana Grown at conferences and events involving specialty crops. They attended the Indiana Horticultural Congress, Indiana Small Farms Conference, Illiana Melon Growers meetings, Illiana Vegetable Growers Association Conferences, Indiana State Fair, and numerous Purdue Extension meetings and local events.

3. Conducting informational meetings. At various conferences and events, Indiana Grown was able to host informational presentations about the organization and the specialty crops produced in Indiana.
4. Visiting farmers markets. Each market season, the employees attended approximately 40 farmers markets throughout the state. This was done to connect with the producers and ensure research coverage throughout the state.
5. Small group public speaking to introduce Indiana Grown to specialty crop audiences. Periodically, various groups asked for a speaker to inform about Indiana Grown and the specialty crop landscape of Indiana.
6. Research specialty crop producers in Indiana. Data collection for each specialty crop producer included the full farm/business name, contact information, the specialty crops they produce, specialty crops used in their products, any other crops they produce, and additional questions or details as available. If they became a member of Indiana Grown, we also obtained information about the number of acres on their farm and product details for potential buyers.
7. Providing photos and content for Indiana Grown social media channels during their visits/interactions. When appropriate, the employees provided content that could be used on social media for the general consumer.

- *If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops*.

Indiana Grown, as an overall program, does benefit all of Indiana agriculture (not just specialty crops). We clarified with the contract employees that they could only meet with producers who used specialty crops in their production and required a written report for each individual/farm with whom they met with detail about the specialty crops involved.

- *Present the significant contributions and role of project partners in the project.*

Our partners included Purdue Extension and the various commodity group organizations representing specialty growers. Their contribution extended to the invitations for speaking to their audiences and a sharing of information about their members/connections (individuals/farms with whom the employees could meet.)

GOALS AND OUTCOMES ACHIEVED

- *Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments.*

1. Increase the number of specialty crop producers involved with the Indiana Grown program: our program currently has 1250 members of whom over half are specialty crop producers of some sort. At the start of this grant period, we had fewer than 200. Our target was to gain 200 specialty crop farmers, and we have far exceeded that mark. We have approximately 1000 specialty crop farmers and producers in the organization.

2. Increase consumer awareness by number of followers on social media: Facebook likes currently number 5,337, Instagram followers include 2,190, and 1,738 followers on Twitter. We did not hit our goals on Facebook or Twitter (10,000 Facebook and 5,000 Twitter) but did reach our goal on Instagram (1,000) and had significant growth on all social media channels.
3. Increase purchases of locally grown specialty crop produce: We have not been able to get retailers to provide sales data, as had been expected. Instead, we are able to report increased sales based on the higher number of retailers who carry specialty crop products in the state. Partnerships include Target, Baeslers, Smoking Goose, Martins, Kroger, and Fresh Thyme.

   The author of the original grant application thought she could obtain sales information from retailers, but she did not confirm that information before submitting her application. Unfortunately, we have not been able to obtain this information because she did not have any previously determined partners in the retail setting. For the future, we plan to coordinate in advance with partners to confirm their willingness to share this information before submitting a grant application.

4. Increase production of specialty crops: Unfortunately, the NASS data that would provide a year-over-year comparison of acres planted is not available. The individual who wrote the original grant application was under the impression that NASS data for Indiana acres planted was available each year. That figure is only available every 5 years as a part of the NASS survey. Therefore, we can do a 5 year comparison of numbers when the new data is released in 2019, but not until then.

5. Increase sale numbers for specialty crop producers: We had anticipated doing surveys of our members to obtain sales numbers, but our attempts did not result in many responses. Members were either unwilling to share their propriety sales numbers, or simply did not have the time to respond to the survey. As a result, we do not have specific numbers to show increases in sales. We do, however, have anecdotal information from members to indicate they have had increases in sales.

   The original author for this grant did not coordinate with partners in advance and assumed data would be available. By new awareness and new program managers, the lessons being discovered is confirming data availability will be a priority before submitting grant applications in the future.

6. Increase confidence in Indiana Grown program: Again, producers are not willing to respond to surveys, so we do not have official data to show an increase in the confidence of the program. We have numerous anecdotal references showing an increase in confidence and reliability on the program to promote their crops and products.

- *If outcome measures were long term, summarize the progress that has been made towards achievement.*

N/A

- *Provide a comparison of actual accomplishments with the goals established for the reporting period.*

The goals established for this grant reporting period proved difficult to quantify. The project has provided substantial awareness of Indiana producers and continued consumer awareness of specialty crops grown in Indiana. Therefore, the goals of the project have been fulfilled, but this knowledge is generally only known through anecdotal and non-quantifiable sources.

- *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

The Indiana Grown member count continues to grow at an average rate of 1 per day. This growth, and knowing that many of these members grow or produce a product using specialty crops, indicate continued progress toward achieving the goals of the grant project. Additionally, our continued growth on social media directs toward a trend of increasing awareness by the general consumer public. We will continue to monitor these targets and push toward the originally set goals.

- *Highlight the major successful outcomes of the project in quantifiable terms.*

ISDA was able to make connections with hundreds of producers of specialty crop products and learn more about the volumes they produce. We now have contact information and product information for a majority of the state and the resources and connections to finish the survey of growers statewide.

BENEFICIARIES

- *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments*.

Beneficiaries include first and foremost – the producers themselves. Many of these producers were connected on in their own community and sometimes in their industry group. By increasing the connections for these producers, they are able to network to share new research, production techniques, and overall education. They can also take advantage of the promotion from the Indiana Grown program.

Other beneficiaries include commodity groups and Purdue Extension. The connections and producer contact information can be used by these groups as they do food safety training, new education on product research, and overall promotion of specialty crops.

- *Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

Beneficiaries would include hundreds of producers (the current membership in Indiana Grown is over 1200) and dozens of organizations throughout the state.

For economic impact, a study done in 2012 detailed that Indiana spends $16 Billion on food and over 90% of those dollars are on our-of-state products. Current figures would result in a higher dollar figure spent on food, but using this research, a 1% increase in local spending would mean a $160 Million economic impact for Indiana.

LESSONS LEARNED

- *Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.*

Overall, the number of producers of specialty crops and specialty crop products in the state of Indiana is much higher than had originally been projected. We had hoped that a fairly comprehensive survey of all producers could be done through this project, but we have learned that the network of growers is much larger than originally anticipated.

While a great result, it means more work remains to be done. We hope to continue the efforts of cataloging producers and connecting with specialty crop growers throughout the state.

We also learned that due to the sheer volume of producers, it became difficult to coalesce the information into an easily used format. Future work will also center on creating a system or database with easy access to data and contact information.

- *Describe unexpected outcomes or results that were an effect of implementing this project.*

Due to staffing changes at the beginning of the project, these efforts were very difficult to get started. Once our internal staffing was managed, hiring details and the state's contract process for the contract positions meant that the contract employees were not able to start work until almost a year into the grant period. This meant there was little leeway for additional time in the schedule of work. Due to the occasional vacation or personal life event, the contract employees were not able to expend all of the funds appropriated for their work.

- *If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.*

The initially outlined social media goals were not met. However, there was no explanation provided by the initial author of the grant for how those goal numbers were derived, so we are unable to know the methodology or reasoning for the goals. They may have been wildly inaccurate expectations for a state program of this sort. Goals for this grant were over estimated. By new awareness and new program managers, the lessons being discovered is confirming data availability will be a priority before submitting grant applications in the future.

Additionally, we have learned that relying upon outside retail partners or farmers to provide the measurable outcomes for goals may not be a realistic expectation. These groups/individuals guard this information closely, so are not interested in sharing information they may deem to be proprietary to their business.

- *Lessons learned should draw on positive experiences (i.e., good ideas that improve project efficiency or save money) and negative experiences (i.e., lessons learned about what did not go well and what needs to be changed).*

One lesson learned is to better identify an organizational method for collecting the data before the project begins. As we currently have the reports from our contract employees, all the information is available, but it may be difficult to sort and use. Data that is time-consuming to review is not typically useful data. For any future projects involving data collection, the design of a collection system should be one of the initial goals.

Another lesson learned is referring to the budget. Due to a lack of staffing in the Grants Administrator position for a period of time, some of the Grant Admin line item was not used as expected. This funding was therefore transferred for the use of ISDA/Indiana Grown as one of the awarded applicants. A copy of the amendment document is attached. I do not have a scan of the final copy as signed and sent to USDA.

BUDGET:

	Paid:	Allotted:
Contract Employee Time	$101,237.50	$104,000
Contract Employee Travel	$8,156.65	$14,000
Supplies	$15703.71	$16,060.81
TOTAL SPENT	$125,097.86	$134,060.81

CONTACTPERSON

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ADDITIONAL INFORMATION

- *Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections*

Growing Places Indy, Perennial Specialty Crops: Establishing a Long-Term Production Model

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PROJECT SUMMARY

- *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*

Even at the peak of the growing season, Indianapolis residents struggle to gain access to fresh, sustainably grown specialty crops. A March 2014 report from Walk Score ranked cities based on how easily their residents could access healthy food options. Indianapolis ranked last, with only five percent of residents able to walk to a grocery store in five minutes. Over the past several years, GPI, in partnership with the Chase Legacy Center, has expanded its growing operations and methods of making sustainably grown specialty crops directly available to consumers on the Near Eastside. In 2014, GPI created a 10,000-square-foot U-Pick Farm, Farm Stand, wash

station, walk-in cooler and outdoor educational space to support the expansion of specialty crop production and educational opportunities. In 2015, GPI continued to build at this successful farm site by incorporating year-round production methods, including installation of a hoop house. However, diversity of locally grown specialty crops available to consumers across Indianapolis continues to be an issue.

Additionally, GPI continually sees a need for greater educational opportunities. Our Family Cooking and Nutrition Classes have expanded to meet this overwhelming demand. By adding perennial specialty crops, GPI has not only increased production of, and access to, specialty crops in an urban environment, but also has been able to expand classes, workshops, tours and volunteer opportunities to educate community members about the possibilities for perennial specialty crop production.

Finally, this site has served as a model for other urban farmers and specialty crop growers who are interested in adding perennial crops to their production models. This year we have established new perennial specialty crops and are starting to see the initial returns on those crops with a new production reality in place. Our perennial production focus is on perennial herbs, greens and edible flowers and a small amount of fruit. This project has increased the variety of sustainably grown specialty products produce offered by GPI by nearly 50%.

- *Describe the importance and timeliness of the project.*

Located just outside the heart of downtown Indianapolis, the Near Eastside (where this project is located) includes 20 different neighborhoods with 40,000 residents. This project has supported the vision of community leaders to improve the quality of life for neighbors through developing grassroots leaders and fostering involvement among community members, embracing the community's diversity, encouraging residents to value and engage in educational opportunities and providing a safe, attractive environment. This project has helped to provide year-round, free educational opportunities for all residents; welcome the full diversity of residents to a beautiful, productive micro-farm, both as visitors and volunteers; and strengthen our partnership with the John H. Boner Community Center and Chase Legacy Center to collaborate and provide the best services to the community. Children and adults are welcomed as volunteers, class participants and customers to the U-Pick and Farm Stand. Families can shop for healthy foods at GPI's expanded Farm Stand and U-Pick.

Through our relationship with the Chase Legacy Center, GPI has had unique resources and opportunities to engage community members in learning about and consuming specialty crops from seed to plate. This project has expanded on already existing programs and year-round production at the CLC, allowing us to build off successes that have already been realized through the farm stand, U-Pick Farm, summer apprenticeship, greenhouse production and classes/workshops. This project has highlighted the role that urban agriculture plays in establishing perennial specialty crop access, demand and consumption. Our continued growth at

CLC has served as a model for other communities and organizations. In tours and consultations, we emphasize the importance of increased access to locally grown perennial specialty crops.

- *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.*

In 2014, GPI received a SCBG to create a new 10,000-square-foot diversified U-Pick Farm at the Chase Legacy Center, and in 2015, GPI expanded production at this site by launching a four-season extension project, including installation of a hoop house and other season extension methods. We have seen incredible successes in increasing production of specialty crops and involvement of Indianapolis residents in educational opportunities centered on cultivating, harvesting and consuming specialty crops. The 2016 Perennial Specialty Crop project has enhanced the impact of this site by expanding the variety of specialty crops available to consumers, serving as a model for other urban growers interested in putting perennial specialty crops into production and providing increased opportunities for education about perennial specialty crop production through classes, workshops, volunteer activities and tours.

PROJECT APPROACH

- *Briefly summarize activities and tasks performed during the entire grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Specifically, discuss the tasks provided in the **Work Plan** of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

Our work plan included the following activities and staffing:

The Perennial Crop Apprentice (PCA) under the supervision of the Director of Farming Operations has overseen the project from January 2017 until now. The PCA has been responsible for data collection as well as being largely responsible for the planting, care and harvest of the perennial specialty crops. Throughout the project, the PCA has had an average of more than 10 hours per week of volunteer assistance, plus 8 weeks of summer help from 10 GPI apprentices averaging 20 hours per apprentice per week. The PCA researched the best perennial specialty crops to grow and how to properly grow them in January and February. In March, the PCA executed site preparation for perennial expansion, which converted nearly ½-acre growing area dedicated to perennial specialty crop production.

From May until now, the PCA and GPI farm team have conducted tours, workshops, classes and volunteer activities focused on perennial production. GPI has hosted workshops to engage area urban farms and gardeners in the entire process of planning, designing, planting and harvesting perennial specialty crops. From March until now, the entire GPI team has conducted perennial crop production and distribution. We have conducted more than 75 harvests that have involved

perennial crops this year and distributed through our farm stand, CSA and to nearly 50 area restaurants and groceries.

- *If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops*.

At Growing Places Indy we exclusively grow specialty crops with no exceptions.

- *Present the significant contributions and role of project partners in the project.*

This has been one of the most exciting parts of this project and I will try to be succinct in this response while capturing the role of partners. We worked closely with our site partners, Chase Legacy Center and Boner Community Center to increase production space for growing perennial crops as well as promote sale of perennial crops in our community. Furthermore, local business and community organizations have volunteered in large numbers to assist in executing the project including Sun King Brewery, Cummins, Eli Lilly, FFA and Purdue Extension Marion County.

GOALS AND OUTCOMES ACHIEVED

- *Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments.*

Our goals and performance measures for this project were as follows:

GOAL ONE: ***Increase involvement in educational experiences that engage participants in growing perennial specialty crops and increase consumer knowledge about how to grow and consume perennial specialty crops.***
MEASURE ONE: GPI will offer at least four perennial specialty crop workshops/learning opportunities in 2016 and participation in specialty crop educational experiences will increase by 25 percent as compared to 2015.

OUTCOME ONE: GPI conducted a total of six workshops between January 2016 and October 2016 that covered a range of topics on perennial crops including planning, bed preparation, planting, cultivation, harvest, soil health and overwintering with a total of 255 participants. This represents a 50% increase in participants from 2015.

GOAL TWO: ***Create, trial and showcase perennial specialty crop production as a viable model for small specialty crop farmers in Central Indiana.***

MEASURE TWO: GPI will train at least five urban farms or gardens in perennial specialty crop production methods with the goal of two urban farms or gardens putting these production methods into place at the end of the two-year project.

OUTCOME TWO: GPI worked with over 15 established or emerging urban farms during 2016 to demonstrate perennial crop production methods. By the end of the year, four urban farms have implemented new measures to drastically increase perennial crop production. These include Indy Urban Acres, CUE Farm at Butler University and as yet two unnamed urban farms – one on the west side of Indianapolis and one on the east side of Indianapolis – that have started production during the 2016 and will drastically increase production during 2017. Furthermore, GPI has now employed one full time farmer (and one part time farmer) each of whom has at least a 50% farming focus on perennial specialty crop production.

GOAL THREE: ***Record a 25% increase in the diversity of specialty crops we are able to harvest and distribute.***

MEASURE THREE: GPI will increase consumer access to perennial specialty crops through the farm stand, U-Pick, winter farmers market, restaurants and local groceries.

OUTCOME THREE: Due to slower than expected growth and lack of season staff, GPI was not able expand the days and hours for our farm stand and U-Pick, however we increased the number of restaurants/groceries that receive our produce from 35 in 2015 to 49 in 2016 as well as increasing our presence at farmers markets from 4 markets in 2015 to 24 in 2016.

- *If outcome measures were long term, summarize the progress that has been made towards achievement.*

All our outcomes were planned around a single year (2016) so the long-term progress towards achievement is not relevant in our case.

- *Provide a comparison of actual accomplishments with the goals established for the reporting period.*

GOAL1	TARGETS
Planned # of general workshops: 4	Actual # of general of workshops: 6
Planned number of participants: 40	Actual number of participants: 255
Planned number of volunteers: 400	Actual number of volunteers: 300 in groups & 300 individuals totaling 600

GOAL 2	TARGETS
Planned number of workshops for urban farmers: 2	Actual number of workshops for urban farmers: 2

Planned # of other farms focusing on perennials: 2	Actual # of other urban farms focusing on perennials: 4
Planned # of GPI staff focused on perennials: 1	Actual # of GPI staff focused on perennials: 1 ½
GOAL 3	TARGETS Perennial varietals sold in 2015:10 Perennial varietals sold in 2016: 19 (47% increase) Total produce quantity in 2015: 1,289 Total produce quantity in 2016: 2,550 (49% increase)
# of Farm Stand/U-Pick Occasions Planned: 40	# of Farm Stand/U-Pick Occasions Executed: 20
# of Farmers Markets Planned: 6	# of Farmers Markets Attended: 24

- *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

GOAL 1 OUTCOMES – see above answers that demonstrate that we executed more educational experiences than planned (4 planned – 6 executed) that had 6 times the number of participants as planned as well as 50% more volunteers than planned.

GOAL 2 OUTCOMES – see above answers that demonstrate that we exceeded our goals on stimulating other urban farmers to commit to perennial crop production (2 planned – 4 committed) as well as exceeding our own staff goal of farming staff committed to perennial crop production (1 planned – 1 ½ hired).

GOAL 2 OUTCOMES – once again, see above answers that demonstrate that we were able to increase the diversity of perennial specialty crops available to consumers as well as the outlets where perennial specialty crops were distributed. The only outcome that did not reach our planned target was number of U Pick and farm stand occasions which was due to lack of staff issue during the primary period for these activities.

- *Highlight the major successful outcomes of the project in quantifiable terms.*

I believe we have demonstrated these quantifiable outcomes in the answers above. At a most basic level, outcomes were all successful as we at least met, and in most cases, exceeded our quantifiable goals and outcomes on this grant in terms of educational experiences focused on specialty perennial crops, stimulating other urban farms to focus on perennial specialty crops and increasing consumer access to specialty perennial crops.

BENEFICIARIES

- *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments*.

Our focus on specialty perennial crops has resulted in many beneficiaries.
These include:

- GPI farming staff who now have a focus on perennial production
- Workshop participants who have learned the basics (and next level) of perennial crop production
- Other urban farms that were able to learn how to integrate perennial production
- Consumers having increased access to perennial specialty crops through farmers markets, farm stand, CSA and U Pick
- Customers of GPI (restaurants and groceries) having increased access to perennial specialty crops

- *Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

Of course it is difficult to pinpoint the actual number of beneficiaries impacted by this project. However, given the records we have kept throughout this project we can get quite close. We estimate between staff, participants in educational experiences, farmer's market/CSA/farm stand customers, other urban farms, and restaurant/grocery customers that the total number of beneficiaries is about 2,000 people.

LESSONS LEARNED

- *Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.*

Our insights into lessons learned during this project our overwhelmingly positive. In particular with a focus on perennial production, this created a greater farming commitment to the longer-term growing/planning, longer-term profit and longer-term soil health of growing perennial crops relative to the short-term planning of annual crops. This project forced us to think about soil amending/health in new and better ways, crop planning in creative ways and how to create the correct conditions for perennial crops to thrive. Furthermore, consumer interest (both in consuming but also in growing) in perennial crops was surprisingly robust. Our biggest challenge moving forward is wishing we had more space to have an even greater focus on perennial crops and we are already thinking about how to carve out more space to do this. I can truly imagine a drastic increase in perennial crop production from urban farms and can even imagine urban farms being created that are exclusively focused on perennial specialty crops.

- *Describe unexpected outcomes or results that were an effect of implementing this project.*

No unexpected outcomes, we did not have any challenges in implementing this project and I believe a lot of this had to do with the realistic goals we set for the project.

- *If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.*

With the exception of not being able to offer the number of farm stand and U Pick occasions that we had planned, all other outcomes were achieved.

- *Lessons learned should draw on positive experiences (i.e., good ideas that improve project efficiency or save money) and negative experiences (i.e., lessons learned about what did not go well and what needs to be changed).*

To be very specific, one lesson we learned was forcing ourselves to commit the resources (time, space, money) to focus on perennial crops. The payback for annual crops is so much quicker and tangible that we had to keep forcing ourselves to look out into the future to see the positive results of perennials.

CONTACT PERSON

- *Name the Contact Person for the Project:* Tyler Henderson
- *Telephone Number:* 317-652-5745
- *Email Address:* tyler@growingplacesindy.org

ADDITIONAL INFORMATION

- *Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections*

In order to be paid: All expenditures to be reimbursed must have copies of invoices paid, with canceled checks (front and back), or credit statements. Any pictures, graphics or other marketing materials must be included if grant dollars were used to pay for purchases/services.

Budget: (Please list items paid for verses items ordered/invoiced and not yet paid for in the allotted column. Total amount Spent must be greater than or equal to 100% of your grant award.)

Please see our attached spreadsheet. We have already been reimbursed **$1,155.82** and are requesting the final reimbursement amount of $**23,844.18** to close out the grant.

Project Title: Specialty Crops and High Tunnels: Evaluating Success and Building Future Capacity

PROJECT SUMMARY

- *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*

Indiana's specialty crop growers are increasingly adopting high tunnels to extend the growing season and increase profitability. The popularity of these unheated greenhouses is partially due to federal cost-share programs driven by expectations of social, environmental, and economic benefits. The adoption of high tunnels has outpaced knowledge about how to successfully utilize them, leading to potential loss of benefits. This project's goal is to understand what determines success of a high tunnel enterprise so producers can best utilize the infrastructure. Our objectives were to: 1) understand characteristics of high tunnel enterprises that determine their success in meeting growers' and society's goals; 2) contribute research-based recommendations for best management production practices (BMPs); 3) disseminate information to farmers and stakeholders in order to inform practice, high tunnel programs, and specialty crop policy.

- *Describe the importance and timeliness of the project.*

This project was important because of the massive investment by the USDA and specialty crop farmers in the new and innovative technology of high tunnels. When we applied for the funding, not much research had either critically or systematically studied on-farm success or challenges with the infrastructure. To date, a few studies have been published, but none provide the breadth or depth of this project.

- *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.*

N/A

PROJECT APPROACH

- *Briefly summarize activities and tasks performed during the entire grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Specifically, discuss the tasks provided in the **Work Plan** of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

This project included eight primary activities in the work plan. The text below details the various activities and the outcomes from each.

1) Conduct a survey of Indiana farms that have added a high tunnel to enhance specialty crops capacity.

   This exploratory survey examined the outcomes of participation in NRCS's HTI, as well as compares those farms with only HTI funded high tunnels to those whose high tunnels are all self-funded or in part self-funded. Predominantly we build from the earlier case study works on high tunnel users, through a quantitative focused mailed survey that was distributed to farmers across Indiana, USA (Waldman et al. 2012).

   Indiana, while known for its commodity agricultural products like corn, soybeans, wheat, pork, and poultry, has a growing trend of specialty crop producers distributing through local food system venues (Meter, 2012). In 2012, 2,935 specialty crop farms were operating in Indiana (USDA-NASS, 2015)., up from 2,925 in 2007 (USDA-NASS, 2007). The Indiana division of the USDA Natural Resources and Conservation Service (NRCS) began administering the Environmental Quality Incentives Program (EQIP) HTI cost-share program to Hoosier farmers in 2012. Of note is that three years passed between USDA approving the HTI and other states adopting it, and Indiana beginning to offer the cost-share. Program interest and demand among the state's farmers has grown since 2012, with over 170 tunnels constructed on farms since its inception. This represents an investment of nearly $1.5 million in Indiana (A. Heichelbech, personal communication, February 20, 2015). In comparison, over 10,000 farms had installed new high tunnels nationally due to the cost-share program by 2014 (Starmer, 2014). In addition to these investments from the USDA, growers have personally invested significant amounts in high tunnels.

   Since the study needed to construct a list of high tunnel owners in Indiana from an unknown denominator, we followed a convenience sampling approach, which suffices in exploratory research (Schutt, 2006). Procedures included garnering as much contact information as the Indiana NRCS office could disclose for HTI participants (143 names, with city and county of residence); using online databases (whitepages.com and county GIS platforms) to garner mailing addresses; incorporating respondents who had reported owning a high tunnel in a previous survey our research group administered (author's name removed); and names of our research group's personal/professional contacts who have a high tunnel. Additionally, one county extension educator hand-delivered the questionnaire (and return envelopes) to 14 growers who use high tunnels. The unsystematic selection process is a limitation to this study's results. In total, the questionnaire was distributed to 178 farms with high tunnels.

While paper instrument was the primary tool for data collection, an electronic option was also made available for responding. Every survey included a $5 cash incentive to encourage participation (Dillman et al., 2008; Singer, 2002). We followed a modified Dillman tailored-design survey method (Dillman et al., 2008) for distributing the questionnaire and collecting responses. The survey was mailed to 164 contacts. The four-phase approach included (1) a postcard announcing the survey soon to follow, (2) the survey one week later, (3) a reminder postcard to non-respondents two weeks after that, (4) a follow-up survey mailed two weeks thereafter to non-respondents. We then followed up with a phone call to non-respondents in order to evaluate the underlying issues for the non-response.

The survey consisted of 6 unique sections that solicited data through 38 questions. Section 1 included questions about farm location, number of high tunnels, EQIP funded high tunnels, and descriptive statistics on use of high tunnel. Section 2 was comprised of questions concerning growers' perception of the value of the high tunnel for the farm. Section 3 queried farmers about distribution approaches they utilized. Section 4 asked farmers about the crops they produce in the high tunnels, production issues and challenges, research needs, and common practices they employed. Section 5 asked about farm characteristics and economic issues. Section 6 queried participants for demographic information.

We input data into an online version of the questionnaire that was built through Qualtrics software. Data were analyzed using SPSS 23.0. Descriptive and cross-tab statistics were used to calculate general results for demographic variables, farm characteristics, distribution type (direct-to-consumer or otherwise), and general mean scores related to Likert-style questions under analysis. Based on farmer responses, we created a dichotomous variable to compare farmers that (1) had only EQIP funded high tunnels (n=47) vs. (2) those that had no EQIP or combination of EQIP/self-funded high tunnels (n=56). Analysis of Variance (ANOVA) was used to compare results related to the continuous variable questions (as well as the Likert-style responses) and Chi-square analysis was used to explore the differences in categorical variables (i.e. distribution method, gender, and education) between the two groups of farmers.

We also performed a binary logistic regression to compare the two groups (EQIP only [1] vs. Combo/Self-funded [0]) in order to define key points of differentiation between the two. The 6 covariate variables included the following: likelihood of purchasing a future high tunnel without EQIP funding cost share support, percentage of household income earned through off-farm employment, high tunnel effect on improving farm economic stability, educational attainment (bachelor's degree vs. no bachelor's degree), and their

perception of the utility of high tunnels in reducing pest problems and improving harvest quality.

2) Case studies with farms to explore and develop the findings of the survey.

The case studies included in-depth interviews with 20 farmers using high tunnels in Indiana. The interviews were designed to identify both the opportunities and challenges farmers experience with using high tunnels to grow specialty crops. A project researcher visited each of the 20 farms one time between 2016 and 2017 and spent half a day at each farm. Case study data collection included an interview lasting an average of 40-90 minutes, and a tour of their high tunnel(s) and completion of a questionnaire garnering information about how they managed their high tunnels. The interviews included a series of questions about the history of the farm, farming experience, marketing, and their experience with high tunnels, perceived challenges, opportunities, and their thoughts on what ways they were successful and why. Farms participating in the case study were generally located in central Indiana.

The interviews were transcribed verbatim and coded and analyzed with NVivo qualitative analysis software. The coding process included an initial read to identify general themes, a second reading and initial coding for important themes and topics, and a third reading and coding phase that refined the initial coding categories into general categories and subcategories, based on emerging themes (Creswell & Poth, 2017). The general categories and subcategories related to opportunities and challenges identified by farmers are presented in the findings section as general headings and subheadings.

3) Conduct a production trial in high tunnels to address an important issue that limits production that is identified in the surveys.

We conducted production trials in two 30X48-ft. movable high tunnels at the Pinney Purdue Ag Center in Wanatah, IN; one conventionally managed and one organically-managed (but not certified). Planting schedules were identified as one area where more research is needed. We conducted trials to quantify the effect of planting date on yield and growth of kale, lettuce, and spinach grown in soil in the unheated high tunnels. was transplanted and spinach was seeded in tunnels on six dates at two-week intervals beginning 30 Aug. and ending 11 Nov. 2016. Lettuce was transplanted in tunnels on 30 Aug., 15 Sept., and 14 Oct. 2016, and 7 Feb., 21 Feb., and 3 Mar., 2017. Each tunnel had three replications of each planting date for each crop. Crops were harvested and marketable and total yield recorded approximately biweekly, with 17 harvests for kale and 22 for spinach between Sept. and Apr, and 24 harvests for lettuce between Sept. and May. Plant size, and kale and spinach leaf number were measured biweekly, 13 times from Sept. to March. Yield data were analyzed using ANOVA and linear regression. We found the marketable yield drops rapidly with delayed planting for kale and spinach: a two-week delay in planting could result in 20%-30% less yield. For lettuce a two-week

delay to mid-Sept. may not reduce yield if heads reach marketable size before cold reduces quality. October plantings of lettuce may survive cold temperature better than earlier plantings, and be harvestable in the spring, but yield may be reduced compared to Sept. plantings.

Crop varieties suitable for high tunnel production were another topic suggested by growers for research. In summer 2017 we established a replicated tomato variety trial with 6 varieties in each tunnel, and 7 varieties altogether. Plants were started from seed and transplanted in the high tunnels on 28 Apr. Tomatoes were harvested weekly; 7 times between 18 July and 28 Aug. For each harvest tomatoes were graded for quality and size, and number and weight in different grades recorded. Data were analyzed using ANOVA and mean separation using Fisher's protected LSD. From this work we characterized the varieties for marketable and total yield, fruit size, fruit quality according to USDA grade standards, and relative earliness of harvest. 'BHN 589' produced yield of No. 1 fruit comparable to most other varieties, with fruit in the middle of the size range. It was among the earlier varieties. 'Big Beef' tended to produce lower yield of No. 1 fruit, but among the highest for total red and green yield. It was also one of the earlier varieties. Most 'Cherokee Purple' fruit did not meet No. 1 grade standards, but total yield was in the middle of the range for the trial. The market for heirloom varieties like 'Cherokee Purple' may not require that fruit meet those grade standards. 'Red Deuce' tended to have the largest No. 1 fruit in the trial; No. 1 yield was higher than or comparable to others, and total yield was in the middle of the range. It was one of the earlier varieties. 'Grand Marshall' was in the middle of the range for No. 1 fruit yield, average fruit size, and total yield. 'Summerpick' produced smaller fruit and was one of the later hybrids in the trial. 'XTM 1134' produced the second largest No. 1 tomatoes in the trial, yield of No. 1 fruit was similar to others, and total yield was among the lowest. It was one of the later hybrids in the trial.

Irrigation was another topic suggested by growers for research. In summer 2017 we established a preliminary trial to evaluate how the frequency of irrigation influences yield and grades of tomatoes in a high tunnel. Two tomato varieties, 'Big Beef' and 'Red Deuce' were started from seed and transplanted into high tunnels on April 27. In each tunnel, a trial was established as a randomized complete block design with two replications and three irrigation treatments: 1) watering as needed, when tensiometers 6 inches deep exceeded 20 kPa soil water tension: 2) once daily, from 10-40 minute intervals; 3) four times per day, from 5-11 minute intervals. Soil moisture readings from dielecctric soil moisture sensors connected to an Onset HOBO® RX3000 remote monitoring station were also utilized to supplement tensiometer readings. Treatments began when plants were well-established, about 5 weeks after transplanting. Irrigation volumes were managed to provide similar weekly amounts of water to all treatments. Tomatoes were harvested

weekly, 6 times between 25 July and 29 Aug. For each harvest tomatoes were graded into marketable and cull, and number and weight in the categories recorded. At the final harvest on August 29 all fruit that was at least 2 -1/4 inches in diameter were harvested. Fruit at or beyond the turning stage were graded as above. Green fruit were counted and weighed. Data were analyzed using ANOVA and mean separation using Fisher's protected LSD. Irrigation treatments had no significant effect on number or weight of marketable fruit, or all (marketable plus cull plus green) or on average fruit size, for either variety. Soil moisture measurements suggested that the daily and 4-times daily irrigation treatments permitted soil below 6 inches to dry out more than the as-needed treatment. This was a small trial with limited replication, but it suggests that when the total volume of water applied weekly is adequate, different irrigation frequencies can lead to similar tomato yields and grades. Additional work is warranted to verify this, and to develop best practices recommendations for tomatoes in a variety of soil types and nutrient management programs, as well as other crops in high tunnels.

4) Develop a high tunnel handbook to be distributed in hardcopy and online.

We developed a handbook entitled: Indiana High Tunnel Handbook. The handbook is a 36-page guide that covers the following topics: opportunities and challenges; considerations for new users; site selection and preparation; high tunnel construction; planting dates; planting arraignments and spacing; environmental management; soil management; pest and weed management; irrigation; and is concludes with a thorough list of available resources on high tunnel production. The handbook has 36 color figures, photos, and tables to illustrate what is being covered in the narrative. Results and lessons learned from the survey, case study, and production trials were used to develop the information in the handbook. The handbook is published by Purdue Extension: Horticulture & Landscape Architecture. The handbook is free and downloadable from Purdue Extension (https://edustore.purdue.edu/item.asp?Item_Number=HO-296-W), while a limited number of color, printed copies are free and being handed out at high tunnel events. The handbook has been distributed to extension educators, NRCS, and a postcard is being mailed to other interested parties. Hard copies are being distributed for free at appropriate extension events (while supplies last).

5) Develop and deliver a webinar with project results.

We developed and delivered a 75-minute webinar that covers the results of the project. The webinar was presented on April 17, 2018 and can be viewed at https://www.youtube.com/watch?v=dpm4t4Ws5nQ&feature=youtu.be. We had 69 people in attendance, with most being affiliated with extension and NRCS offices (which was the primary intended audience). Our goal was to educate the educators and those working with farmers to acquire EQIP funded high tunnels.

6) Presentations at grower conferences.

We presented findings from the project at 10 different conferences and meetings. The following citations provide details for our presentations.

Presentations at Professional/Grower Meetings/Conferences:

- Maynard, L. and Bluhm, E.A. (2018). Pinney Purdue Ag Center high tunnel research update . Michiana Vegetable, Fruit and Flower Growers Meeting. March 28, 2018, Goshen, IN (14 attendees)

- Maynard, L. and Bluhm, E.A. (2018). Irrigation for high tunnel tomatoes. Wakarusa Produce Auction Vegetable Meeting .February 22, 2018, Wakarusa, IN. (68 attendees)

- Maynard, L., O'Donnell, M., and Robb, D. (2018). Cool season vegetable production for winter harvest in high tunnels. Ohio Ecological Food and Farming Association. February 16, 2018, Dayton, OH. (78 attendees)

- Maynard, L., Bluhm, E.A. and Grant, Z. (2018). Planting schedules for high tunnel winter greens production. Illiana Vegeable Growers Symposium. January 4 2018, Schererville, IN. (30 attendees)

- Bruce, A., Farmer, J., and Maynard, E. (2017). High tunnels and their implications for farms. Midwest Organic and Sustainable Education Service (MOSES)- annual meeting. February 23-25, 2017, La Crosse, WI. (20 attendees)

- Bruce, A., Farmer, J., and Maynard, E. (2017). Lessons learned from Indiana high tunnel growers. Indiana Small Farm Conference. March 3, 2017. (23 attendees)

- Farmer, J., Bruce, A., & Maynard, L. (2017). Problems and opportunities for Indiana high tunnel growers. Indiana Horticulture Congress. January 10, 2017. (18 attendees)

Presentations at Academic Conferences:

- Maynard, E., Bluhm, E., Bruce, A., and Farmer, J. (2018). Yield Decrease With Delayed Fall Planting of Kale, Lettuce, and Spinach in High Tunnels. American Society for Horticulture Science. Washington, D.C. (25 attendees)

- Maynard, E.T., Bluhm, E.A., Calsoyas, I.S., O'Donnell, M., Fingerle, M., Hartman, B., Robb, D., Farmer, J.R., & Bruce, A. (2017). Crop growth and environment in Indiana winter high tunnel production. American Society for Horticultural Science. Waikoloa, Hawaii. (20 attendees)

- Bruce, A., and Farmer, J. (2017). Using high tunnels to promote season extension, produce quality, and yield: Comparing outcomes for organic and conventional growers. Rural Sociological Society. Columbus, OH. (13 attendees)

7) Field day training workshops.

We co-organized three field workshops in conjunction with other programs occurring through Purdue Extension. Workshops were held on August 10, 2017 at the Southwest Purdue Agriculture Center (SWPAC) in Knox County, Indiana, on August 21, 2017 at the Pinney Purdue Field Station in Winamac, IN, and on September 25, 2017 at the Hamilton County Fairgrounds and Full Hand Farm near Noblesville, IN. The workshops were attended by 194 participants collectively (SWPAC-30; Pinney-65; Full Hand Farm- 27).

8) Publication of results in peer-reviewed journals

Published:

- Bruce, A., Farmer, J., Maynard, L., & Valliant, J. (2017). Assessing the impact of the EQIP high tunnel initiative. *Journal of Agriculture, Food Systems, and Community Development.*

In Review:

- Bruce, A., Farmer, J., Maynard, L., & Valliant, J. (In Review- 2nd). Success and challenges in high tunnel production. *International Journal of Agricultural Management.*

- Bruce, A., Farmer, J., & Maynard, E. (In Review). Opportunities and challenges with using high tunnels to enhance specialty crop production in the U.S. Midwest state of Indiana. Preparing for *Journal of Alternative Agriculture.*

In Development:

- Bruce, A., Farmer, J., & Maynard, E. (In Development). Factors affecting successful high tunnel management for farmers in the U.S. Midwest state of Indiana. Preparing for *HortTechnology*.

9) Publication of research reports

Maynard, E.T., and E.A. Bluhm. 2018. Tomato Cultivar Evaluation in High Tunnels, Northern Indiana, 2017. pp. 127-136 in Maynard, E. B. Bergefurd, W. Guan and P. Langenhoven (eds.) Midwest Vegetable Trial Report for 2017. Purdue University, W. Lafayette, IN. *44 downloads through Aug. 2018.*

- *If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops*.

The overall project entirely benefitted specialty crops.

- *Present the significant contributions and role of project partners in the project.*

The primary project partners included James Farmer and Analena Bruce from Indiana University and Elizabeth Maynard from Purdue University. The IU team led the surveying of high tunnel specialty crop growers, on-farm case studies, the development of the webinar and high tunnel handbook, and general oversight of the project. The Purdue team led the production trials, field day organization and facilitation, and publication of the high tunnel handbook. The two partners were highly collaborative, which is evidenced by the co-authored publications, presentations, and outreach materials.

GOALS AND OUTCOMES ACHIEVED

- *Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments.*

The activities performed to achieve the performance goals and measurable outcomes identified in the approved project proposal include activities 1-9 listed on pages 3-6 of this report.

- *If outcome measures were long term, summarize the progress that has been made towards achievement.*

N/A

- *Provide a comparison of actual accomplishments with the goals established for the reporting period.*

We present the original goals, performance measures, benchmarks, target, and performance monitoring plan, below, in bold. We follow the original articulation with the details on our success in meeting what was originally proposed.

GOAL:

Specialty crop producers will better understand how to utilize and manage high tunnels in order to achieve (or contribute to) expected benefits of high tunnels, including increased production, sales, income, and sustainability. *(Objectives outlined in abstract, purpose, and work plan)*

We were able to succeed in meeting the goal of creating a better understanding by accomplishing the research and disseminating the results to professionals through seven grower-conference presentations, three presentations at academic meetings, the 75-minute webinar, the development of the 35-page high tunnel handbook, by holding 3 field workshops, and through the publication of journal articles.

PERFORMANCE MEASURE:

> **Number and percentage of participants at educational programs who plan to use knowledge gained in their farm operations, or outreach to farmers*

Assessing presentation attendees' knowledge gain proved rather challenging as they were able to come and go at will. We assessed the information shared during the webinar and are pleased to report that 85.37% (n=58) of participants found the information presented to be useful, with 90.24% (n=62) expressing a likelihood of sharing the information they learned with others. Regarding the participants at the field day facilitated at Purdue Pinney Field Station, 43% grow fruits or vegetables in a home or community garden, 24% grow fruits or vegetables for sale direct to consumers, and 28% already own a high tunnel. 66% said that they would try something that they learned at the field day. Some of these included trying new tomato varieties, pest management, and irrigation management in high tunnels. Respondents at the high tunnel field day delivered at Full Hand Farm all showed in increase in knowledge on items related to general knowledge regarding high tunnel structure and use (on a 1-4 scale [1=low knowledge and 4=high knowledge] participants' scores (amongst those completing both the pre and post-test) went from 2.3 on the pre-test to 2.6 on the post-test), leafy green production and winter harvest (on a 1-4 scale participants' scores went from 1.9 on the pre-test to 2.5 on the post-test), and pest management in high tunnels (on a 1-4 scale participants' scores went from 1.7 on the pre-test to 2.3 on the post-test). Of eighteen respondents to an evaluation for the January 4, 2018 presentation on planting schedules for winter greens, 66% reported the information was valuable to them and 33% planned to make changes based on what they learned.

BENCHMARK:

Zero (Because the performance measure is intention to use knowledge gained at the program, the benchmark is 0, meaning no plans to use knowledge prior to the program)

N/A

TARGET:

Among the projected 40 webinar participants, collective 75 participants at the 3 field days, and total of 100 attendees at the 3-conference presentation, 108 individuals, or 50.2% of participants will plan to use knowledge gained from this project in their farm operations/business, or in outreach to farmers. Additionally, our target for downloads of the manual is 250+ for the grant period alone.

The proceeding table outlines the projected number of participants for each media being used to distribute project information, as well as for the total to date of what is actual/realized.

	Projected	**Realized**
Webinar participant	40	69 live and 82 via Youtube
Field day participants	75	122
Conference presentation attendees	100	309
Handbook copies distributed	250	182 hard copies + 30 downloads since going live on 9/24/18 (as of 10/11/18)
Bruce et al. (2017)	0	176 downloads of article
Total	465 projected	970 as of 10/15/18

Collectively, we have distributed the information from the project to 970 people to date, nearly double what we proposed. That said, the High Tunnel Handbook was only recently published, thus, we do not have an accurate count on the number of downloads it will receive given time to disseminate amongst growers and interested parties. Based on our post webinar evaluations, 85% of participants plan to use the knowledge gained form this project, which is all collectively presented in the high tunnel handbook.

PERFORMANCE MONITORING PLAN:

Participants will complete an evaluation survey immediately following each educational program (farm field days, conference presentations), or immediate-response devices (e.g. iclickers or polls during webinar) will be used to obtain responses during events.

We used paper, online, and electronic mechanisms to collect attendee feedback on the outreach materials (see notes below of quantifiable outcomes).

- *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

We assessed the information shared during the webinar and are pleased to report that 85.37% (n=58) of participants found the information presented to be useful, with 90.24% (n=62) expressing a likelihood of sharing the information they learned with others. Regarding the participants at the field day facilitated at Purdue Pinney Field Station, 43% grow fruits or vegetables in a home or community garden, 24% grow fruits or vegetables for sale direct to consumers, and 28% already own a high tunnel. 66% said that they would try something that they learned at the field day. Some of these included trying new tomato varieties, pest management, and irrigation management in high tunnels. Respondents at the high tunnel field day delivered at Full Hand Farm all showed in increase in knowledge on items related to general knowledge regarding high tunnel structure and use (on a 1-4 scale [1=low knowledge and 4=high knowledge] participants' scores (amongst those completing both the pre and post-test) went from 2.3 on the pre-test to 2.6 on the post-test), leafy green production and winter harvest (on a 1-4 scale participants' scores went from 1.9 on the pre-test to 2.5 on the post-test), and pest management in high tunnels (on a 1-4 scale participants' scores went from 1.7 on the pre-test to 2.3 on the post-test).

- *Highlight the major successful outcomes of the project in quantifiable terms.*

The major successful outcomes of this project include: (1) a baseline study of high tunnel use and utility, (2) translation of this research into media to be used by farmers (high tunnel handbook, extension educators, NRCS staff, etc., and (3) the scientific evidence to support farmers using this valuable infrastructure piece. We recently started distributing the high tunnel handbook and have garnered the following responses:

> - *Thank you so much for getting this publication together. I will make sure we spread the news far and wide.*
> - *Congrats on a good, helpful tool for high tunnel users and those of us who may have to give advice or consult with them. Do you know if a copy of this publication is being sent to NRCS folks, who may have or will be providing funding to producers to construct and operate high tunnels for ag production?* (a link to the online

copy has been provided to NRCS and hard copies have been sent to the Indianapolis office).

- *Wow! That is a nice publication!*
- *Nice job on this! Got my office copy today.*

BENEFICIARIES

- *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments*.

Groups that benefited from this project include Indiana specialty crop growers, Indiana buyers of specialty crops, consumers of Indiana specialty crops, NRCS and extension specialists working with growers who currently use or intend to use high tunnels, and other educators and students interested in high tunnels. These groups benefited by having sound research to base decisions on, to learn from, and to develop their operations with. This project assists farmers by providing much needed educational material and empirical evidence for those factors (from a farm planning, operations, and growing perspective) that contribute to or impede the successful use of high tunnels. This was communicated at presentations/workshops, field days, in the webinar, and in the high tunnel handbook that is available for free via Purdue Extension. Finally, this project will benefit policy makers seeking to better understand the value in their investment and programmatic changes that may be necessary to maximize the benefits of the current cost-share program facilitated by NRCS. Our publications (in print and in review) provides concrete evidence on what works well and what doesn't, with high tunnels.

- *Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

The number of direct beneficiaries affected by this project, as of 10/17/18, has been 970. Thus, the project will inevitably reach a broader crowd as time progresses with the distribution of the high tunnel handbook that was officially published online on 9/24/18. Additionally, this project's chief aim to better equip farmers to capitalize on high tunnels to produce food during the cooler months will benefit Indiana's 2.5 million households whose demand for local specialty crops currently outpace supply. Many Hoosiers will benefit from the newfound knowledge that will better equip farmers to produce specialty crops throughout the year. Finally, this project is set to continue benefiting extension educators and the NRCS staff working in Indiana's 92 counties, who seek information to share with specialty crop farmers considering the innovative strategy for increasing production capacity.

LESSONS LEARNED

- *Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.*

Ultimately, we learned that high tunnel users are finding the innovative infrastructure quite useful for their farming operation. Specifically, those that make it a central part of their operation, intentionally planning for its role in the farm business, find the greatest success with a high tunnel. We also learned that growers who focus on mono-culture plantings (say only tomatoes in the summer) are having long-term challenges with disease, pest, and soil problems. This is likely due to the lack of diversity in their operation and the ability of disease/pests to overwinter in the structure for the same host to return in the next growing season. Finally, we learned that over the long-term, growers are experiencing soil fertility issues that may be caused by the lack of natural occurring rainfall necessary to flush out mineral deposits in the soils. These deposits build up over time due to the use of hard-water for irrigation, the higher rate of evaporation that occurs in high tunnels versus open fields, and limited amounts of water filtration in the soils. Removing the plastic on a more frequent basis and taking the tunnel out of production periodically may help remedy this issue. Additionally, newer, moveable tunnels may hold the solution to this challenge.

- *Describe unexpected outcomes or results that were an effect of implementing this project.*

Now thinking back, unexpected outcomes / events within the project are twofold. First, it was much more challenging to get participant (of the webinar, conference presentations, field days, etc.) feedback than originally conceptualized. While we are comfortable with the feedback we did receive, having better incentives in place to get feedback is an important consideration for future projects. Secondly, the production of the high tunnel handbook took longer to complete in order to ensure it was completed in a professional manner. The handbook publication was quite similar to writing a book and having to go through the pagination and editing sequence. Any activity similar to this should build in extra time to complete.

- *If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.*

Based on our analysis, we feel like we achieved the outcome measures originally proposed. That said- we point to the aforementioned challenges to consider for future projects of this variety.

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Project Title: Management of Bacterial Spot of Tomato Caused by Diverse Xanthomonas spp. Isolates

PROJECT SUMMARY

- *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*

Bacterial spot of tomato, caused by one of four species of *Xanthomonas*, is a limiting factor in the production of fresh market and processing tomatoes in Indiana. It is estimated that in 2014 almost a third of the 9,000 processing acres in Indiana were severely affected by bacterial spot, causing losses of $1,000 to $2,000 per acre in yield or fruit value (Steve Smith, Red Gold Executive Director, personal communication), for a total loss of $3 to $6 million. Tomatoes produced for fresh market are similarly affected; due to unsightly lesions, fruit produced on affected fresh market plants are perhaps more susceptible to being unmarketable than those produced on processing tomatoes.

Management of bacterial spot has, for many years, depended on copper applications. Copper, often in the form of copper sulfate or copper hydroxide, can be applied to the plant surface where it acts to inhibit the bacteria that cause bacterial spot. However, with the increased use of copper products for bacterial spot control, *Xanthomonas* spp. are increasingly found that are resistant to copper (Stall et al., 1986). More recently, data has been produced to indicate that application of copper products, in some circumstances, actually makes bacterial spot more severe (Boyd, 2014).

- *Describe the importance and timeliness of the project.*

Tomato production is critical for the economy of Indiana and an important component of healthier Hoosier diets. In most years, Indiana processing tomato production is second in the nation, with a value of $32 million in 2013. Fresh market tomato production takes place on a smaller scale, but was worth $11.7 million in 2013 (Census of Agriculture, March 2014). In addition to bringing money and jobs into Indiana, tomatoes are a good source of vitamin C, potassium, folic acid and carotenoids (Perveen et al, 2015).

- *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.*

N/A

PROJECT APPROACH

- *Briefly summarize activities and tasks performed during the entire grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Specifically, discuss the tasks provided in the* ***Work Plan*** *of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

Field trials were conducted at the SW Purdue Ag Center in the summers of 2016 & 2017. Side-by-side trials in commercial tomato fields monitored in 2016 and 2017. %0 strains of Xanthomonas were collected and analyzed over 2 years. The conclusions:

1) The most common strain of *Xanthomonas* in Indiana is *X. perforans* with 78% of the total. These strains do not cause symptoms on pepper. Symptoms on leaf often include a shot-hole appearance.
2) *X. gardneri* strains were more frequent in northern Indiana counties; this species has been shown to be favored by cool weather. *X. gardneri* was slightly more frequently isolated from processing tomatoes than fresh market tomatoes. *X. gardneri* may go to pepper as well.
3) 84% of all strains collected were resistant (insensitive) to copper. 39% of all strains collected were resistant to streptomycin.
4) Agri-phage never out performed copper products for management of bacterial spot. However, there were usually no statistical differences between Agriphage and copper (Agriphage usually did no worse than copper). Serenade Opti usually underperformed copper and Agriphage.

- *If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops*.

N/A

- *Present the significant contributions and role of project partners in the project.*

1) Jeff Jones, University of Florida- Together with technician Jerry Minsavage, Jeff completed analysis of 26 strains of the bacterial pathogen in 2017.
2) Elizabeth Maynard-Liz was instrumental in collecting strains for the survey from northern Indiana.
3) Tom Creswell and Gail Ruhl-The PPDL staff isolated from the tomato samples submitted, confirmed they were Xanthomonas and sent them onto to the University of Florida.
4) Dan Egel is grant PI. He coordinated the trials described above and the bacterial spot survey. Curt Marchino assisted Dan in these projects as a technician.

GOALS AND OUTCOMES ACHIEVED

- *Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments.*

Because copper-tolerant strains are predominant among the xanthomonads strains collected from Indiana, copper-based bactericides should not be relied upon for management. Because there are relatively more strains that are sensitive to streptomycin, applications of streptomycin-based product in the greenhouse on tomato transplants may help lessen bacterial spot severity. Field applications of streptomycin are not labeled. It is clear that practices other than applying streptomycin or copper will be required for efficient management of bacterial spot in Indiana. It was determined that tomato growers in the northern Midwest will require a breeding program for two different species of xanthomonads causing bacteria spot of tomato.

Since most strains of *Xanthomonas* in Indiana are not resistant to streptomycin, use products with streptomycin in the greenhouse when possible (streptomycin is not labeled for field use). Although most strains of *Xanthomonas* are resistant to copper, I still recommend copper products because: If used with mancozeb products so that the availability of copper is increased on the surface of the plant, copper may still help to lessen the severity of bacterial spot. Note that the term insensitive to copper refers to a specific level of copper. Concentrations of copper over that level may help to lessen bacterial spot severity. It is possible that one or more of the strains of *Xanthomonas* in your field are sensitive to copper. There are not many options open to growers beside copper. If the decision to use Agriphage is made, apply a copper product early, apply Agriphage 3 to 4 times after first bloom, continue with copper applications. Do not replace any of the products in the Red Gold schedule except copper for those 3 to 4 applications.

The goal to lower the losses growers suffer due to bacterial spot.
The losses occur directly as a result of damage from infection from Xanthomonas spp. Or as a result of using management methods that are not effective. Over a 2-year people, samples of tomatoes suspected of being infected with bacterial spolts were collected across Indiana and sent to Purdue. They were screened for symptons of bacterial spots and made isolations on Kings medium B agar. Single-Colony gram negative strains showing yellow colonies of Xanthomonas were selected. 16S rRNA from these strains was amplified using 27F and 1492R primer set and the products were sequenced to confirm they were in the Xanthomonas. A total of 49 strains were collected over 2 years:

- *If outcome measures were long term, summarize the progress that has been made towards achievement.*

A total of 49 strains were collected over 2 years: 22 from fresh market, 24 from processing and 3 from unspecified tomato fields. No meaningful differences were observed in fresh market versus processing tomatoes; no data to show the difference. The Xanthomonas strains were then processed for taxonomic identification, race determination, and sensitivity to copper at 50 ppm and streptomycin at 200ppm. Sensitivity to streptomycin and copper was assayed by streaking the strains on nutrient agar ame3nded with streptomycin sulfate at 200 ug/ml or CuSO4 5H2O at

200 ug/ml. Race was determinate by measuring hypersensitive reason of several tomato cultivars including Hawaii.

Tomato growers are now more familiar with sustainable and possibly more effective management techniques for bacterial spot of tomato. These growers now have an understanding of how Agriphage in particular might fit into a disease management program and what limits this product might have.

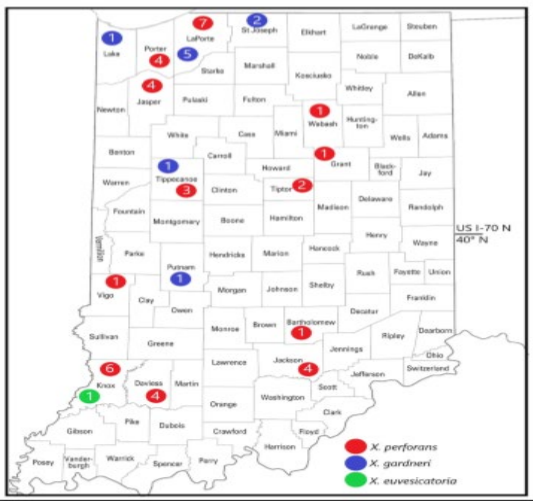
- *Provide a comparison of actual accomplishments with the goals established for the reporting period.*

In the 2016 field trial, no disease was observed. However, disease was observed in 2017 and in the commercial side-by-side trials. The survey was completed as planned. Xanthomonas bacteria survey-tomato fields were sampled from across Indiana to collect strains of the bacterial spot pathogen. Preliminary results follow. 26 Xanthomonas bacterial strains were processed by the Purdue Plant and Pest Diagnostic Laboratory and sent to Dr. Jeff Jones at the University of Florida for characterization. The predominant bacterium causing bacterial spot was X. perforans with 20 strains followed by X. gardneri with 5 strains and X. euvesicatoria with 1 strain. 16 strains were resistant to both copper and streptomycin, indicating these strains would be difficult to control using standard disease control practices. Only 3 of the strains were sensitive to both streptomycin and copper. Only 1 strain was sensitive to streptomycin and resistant to copper. 6 strains were observed that were resistant to streptomycin and susceptible to copper. See Table 1 below:

TABLE 1
Taxonomic designations and reaction to copper (50 ppm) and streptomycin (200 ppm) of *Xanthomonas* strains causing bacterial spot on tomato surveyed across Indiana over the 2016 and 2017 seasons[a]

Species	Race	Number of strains	Streptomycin		Copper	
			Insensitive	Sensitive	Insensitive	Sensitive
X. euvesicatoria	T1P3	1	0 (0)	1 (100)	0 (0)	1 (100)
X. gardneri	T2	10	7 (70)	3 (30)	9 (90)	1 (10)
X. perforans	T3	6	0 (0)	6 (100)	4 (67)	2 (33)
X. perforans	T4	32	21 (66)	11 (34)	28 (88)	4 (12)
Total	---	49	28 (57)	21 (43)	41 (84)	8 (16)

[a] Percentages of insensitive or sensitive strains within each species are shown in parentheses. Note that number of strains for each species can be totaled by adding insensitive and sensitive strains for either streptomycin or copper.



The species designations of the strain of Xanthomonas causing bacterial spot of tomato collected in a survey across Indiana in 2016 and 2017. Numbers in each dot indicated the number of strains of each species collected in that county. Colors of dots indicated the species.

- *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

Characterization of bacterial strains was completed; 2 field trials were completed; commercial field trials were completed (although this was not included in the grant); a greenhouse trial completed (although this was not included in the grant).

- *Highlight the major successful outcomes of the project in quantifiable terms.*

50 strains of *Xanthomonas* spp. were collected over 2 years and characterized. 2 field trials and several commercial side-by-side trails completed; 1 greenhouse trial completed.

- *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.*

1. Red Gold processing tomato.
2. Fresh market tomato growers across Indiana
3. Indiana Vegetable Growers Association which represents a diverse cross section of growers in Indiana
4. University specialists in adjacent states who will benefit from the research conducted here.
5. University of Florida researchers who participated in this research.
6. Plant and Pest Diagnostic Lab at Purdue who now better understand bacterial spot of tomato.

- *Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

Benchmark: It is estimated that there are 554 fresh market tomato growers and 64 processing tomato growers in Indiana. All will benefit from this project. All targets were achieved. Because copper-tolerant strains are predominant among the Xanthomonas strains collected from Indiana, copper-based bactericides should not be relied upon for management. Because there are relatively more strains that are sensitive to streptomycin, applications of streptomycin-cased product in the greenhouse on tomato transplants may help lessen bacterial spot severity. Field applications of streptomycin are not labeled. It was clear that practices other than applying streptomycin or copper will be required for efficient management of bacterial spot in Indiana.

LESSONS LEARNED

- *Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.*

Methods for inoculating tomatoes with the bacterial spot pathogen were modified and improved by the staff at the Southwest Purdue Ag Center. The second year of field trial was more effective due to this learning process.

Staff at the Purdue Plant and Pest Diagnostic Lab improved poison plate assays.

- *Describe unexpected outcomes or results that were an effect of implementing this project.*

The first year of field trial did result in any significant data because bacterial infection was not observed. Although this was in part due to the weather, the second year was an improvement due to a learning process.

- *If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.*

N/A

- *Lessons learned should draw on positive experiences (i.e., good ideas that improve project efficiency or save money) and negative experiences (i.e., lessons learned about what did not go well and what needs to be changed).*

Although not specifically called for in the proposal, side-by-side trials in commercial fields were monitored in 2016 and 2017. In 2017, not as many trials were attempted by commercial growers. Perhaps more education about the trials could have helped increase the number of commercial grower trials in 2017.

ADDITIONAL INFORMATION

Figure 1: A tomato leaf with lesions of bacterial spot caused by *Xanthomonas perforans*. This species was the predominant one found in the survey performed in the summer of 2017. *X. perforans* tends to form lesions that cause holes in the leaves.

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Management of Bacterial spot of Tomato caused by Diverse Strains of *Xanthomonas* spp.

BUDGET:

Account Summary - Grant View
For: 02/2018 Generated On: 02/06/2018

Account Summary Detail | Expenditure History | Payroll Summary | Transaction Listing | Payroll Transaction Listing | Budget Transaction Listing | Commitment Transaction Listing | Equipment Transaction Listing

Grant: 208966 — Change Month

Title:	Management of Bacterial Spot of Tomato Caused by Diverse Strains of Xanthomonas spp				
Grant RCC:	4011012000 - Botany And Plant Pat				
Grant Status:	Award	**User Status:**	Expired	**PI Name:**	Egel, Daniel
Sponsor:	In State Department Of Agriculture	**Prime Sponsor:**	AGRICULTURE, U.S. DEPT OF		
Grant External Fund:	42010000 - State/Local Govt	**Award Number:**	EDS# A337-16-SCBG-15-003		
Grant Project Period:	01/01/2016 - 12/31/2017	**F&A Base:**	Total Direct Cost		
EVERIFY:	N	**Equipment Ownership:**	Purchase of Equipment Not Authorized		
Travel Restriction:	Foreign	**Travel Pre-Approval:**	Y		

	Life-To-Date Budget	Month-To-Date Expenses	Life-To-Date Expenses	Open Commitments	Available Balance	% Expended
Salaries and Wages						
Service Salaries	39,566.00	0.00	42,369.79	0.00	(2,803.79)	107.1%
Total Salaries and Wages	**39,566.00**	**0.00**	**42,369.79**	**0.00**	**(2,803.79)**	**107.1%**
Fringe Benefits						
Fringe Benefits	18,674.00	0.00	21,034.90	0.00	(2,360.90)	112.6%
Total Fringe Benefits	**18,674.00**	**0.00**	**21,034.90**	**0.00**	**(2,360.90)**	**112.6%**
Total S&W and Fringe Benefits	**58,240.00**	**0.00**	**63,404.69**	**0.00**	**(5,164.69)**	**108.9%**
Supplies and Expenses						
Consultants	5,000.00	0.00	0.00	0.00	5,000.00	0.0%
Communications	0.00	0.00	151.81	0.00	(151.81)	0.0%
Travel	845.00	0.00	62.78	0.00	782.22	7.4%
Other S&E	1,000.00	0.00	1,465.77	0.00	(465.77)	146.6%
Total Supplies and Expenses	**6,845.00**	**0.00**	**1,680.36**	**0.00**	**5,164.64**	**24.5%**
Total Direct Costs	**65,085.00**	**0.00**	**65,085.05**	**0.00**	**(0.05)**	**100.0%**
Indirect Costs	1,952.55	0.00	1,952.51	(0.18)	0.22	100.0%
Total Indirect Costs	**1,952.55**	**0.00**	**1,952.51**	**(0.18)**	**0.22**	**100.0%**
Total	**67,037.55**	**0.00**	**67,037.56**	**(0.18)**	**0.17**	**100.0%**

Sponsored Program Number	Co-PI Name
8000073338	Egel, Daniel

Project Title: Facilitating Development of a Sustainable Local Hop Industry

PROJECT SUMMARY

- *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*

Rapid growth in the craft brewing industry has created an opportunity for Indiana farmers to start growing hops (*Humulus lupulus*). The cones or female flowers from this high-value crop are used to flavor and stabilize beer. Indiana farmers have begun installing hop yards and establishing relationships with local craft breweries to meet this demand. However, while hops were historical grown in the U.S. Midwest, most of this production moved to the Pacific Northwest (PNW) in the early 20th century because of lower summer rainfall that reduces disease pressure. Consequently, there has been virtually no research conducted in the Midwest U.S. over the last century to identify best management practices for Indiana's soil and climatic conditions, or determine the scale at which the new industry could be most profitable. Consequently, the goal of this project was to overcome this challenge by: 1) identifying hop varieties and trellis systems that are most productive under Indiana's soil and climatic conditions, 2) quantifying the economic costs and benefits, opportunities and challenges associated with development of a local hop industry, 3) increasing the visibility of the local hop industry and the amount of locally grown hops in Indiana beer, 4) training Extension educators and existing growers in hop management practices as well as providing opportunities for training in advanced hop production, and 5) increasing the practice of on-farm participatory research on hop farms.

- *Describe the importance and timeliness of the project.*

Spurred by rapid growth in the local craft brewing industry, Indiana farmers starting growing hops again starting in 2011, and we estimate that since this time, at least 50 growers have entered the industry and local hop production has increased by at least 600%. These growers need recommendations for best varieties and pest management practices to support the growing local hop industry, as well as economic information that can be used to ensure that this industry will be sustainable over the long-term.

- *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.*

This project built on a previous IN-SCBGP funded project titled 'Breaking new ground with hops in Indiana: varieties, trellis systems and participatory networks'. During this previous project, we established a hop advisory board to help direct our hop research and outreach efforts, had the funds needed to collect data from our experimental hopyard at Purdue's Meigs Research Farm during its second in production, quantified all of the costs needed to establish and manage

a hopyard in Indiana, created a list-serve called 'growINhops' to support communication within the local hop industry, held a workshop with national speakers to train hop growers and Purdue Extension educators about hop production, and published an extension publication on integrated pest management in hops. The current project built on this previous project by allowing us to complete a third and final year of research in our experimental hop yard, conduct additional research on hop economics, and provide advanced training in hop production and how to conduct on-farm research to a small set of growers and educators.

PROJECT APPROACH

- *Briefly summarize activities and tasks performed during the entire grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Specifically, discuss the tasks provided in the **Work Plan** of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

To achieve our 1st goal of '*identifying hop varieties and trellis systems that are most productive under Indiana's soil and climatic conditions'*, we continued to manage and collect data in our research hop yard at Purdue's Meigs Farm near Lafayette, IN, for the third and final year of this field project. This allowed us to determine how this perennial crop could perform once it reached maturity. Data collected in this field trial included winter survival of the 6 hop varieties that were planted in both tall and dwarf trellis production systems, and identification of pest incidence and severity, yield and quality (essential oil profile) of hop cones in each variety X management system. Results of these trials indicated that many insect pests such as spider mites and Japanese beetles, as well as pathogens that cause wilts and mildews (see Fig. 1), will be problematic in Indiana hop yards and growers must have proactive pest management plans in place to deal with these issues. Some hop varieties, especially Cascade, are well-adapted to Indiana's climactic conditions and can produce yields and hop cone quality that are equal to other Midwest states (see Fig. 2). Establishment and management costs are much cheaper in dwarf trellis production systems compared to traditional tall trellis production systems and yields are greater (see Fig. 2), but small-scale harvest equipment for dwarf trellis systems are not yet available in the Midwest. Additional research to develop this equipment is highly recommended. Results of our field trials were shared with our advisory committee two times each year; at two workshops held at the Indiana Small Farm Conference during 2016 and 2017; at two field days held at our research hop yard in 2016; on our website; and, at professional scientific meetings such as the Soil, Crop and Agronomy Societies of American meeting (see Fig. 2). A scientific publication summarizing results from these trials has been drafted and is undergoing revision before being submitting for publication in a scientific journal such as HortScience.

To achieve our second goal of '*quantifying the economic costs and benefits, opportunities and challenges associated with development of a local hop industry*', we updated two enterprise budgets developed in our first IN-SCBG grant for the tall and dwarf trellis production systems,

and developed two surveys, one targeting craft beer consumers and the other targeting craft beer producers. Results of these assays indicated that the costs and returns associated with growing hops in a traditional tall trellis production system in Indiana are comparable to other Midwest states such as Michigan, which is approximately $10,000 per acre for establishment, and $5,500 per acre returns at maturity, indicating that this can be a profitable crop for the state. Growing estimate that growing hops in dwarf trellis production system would be more profitable than the traditional tall trellis production system if growers could have access to small-scale, mechanized harvesting machinery. The consumer survey was conducted during March-April 2017, with a panel representative of the Indiana population 21 years and older. Data were from 231 respondents. Results of this survey indicated that Indiana beer consumers are willing to pay a price premium for craft beer that is labeled brewed in-state and made with hops produced in-state. However, only experienced craft beer drinkers are willing to pay extra for both dimensions of localness. The average consumer will only pay extra for either brewery localness or hop localness, but not both. This indicates that additional outreach is needed to promote the local hop industry. The brewer survey was completed, but was not deployed for reasons provided below. Results of all the economic and survey work were shared with our advisory board during two meetings each year; at two hop workshops held at the Indiana Small Farm Conference during 2016 and 2017; at the Northeastern Agricultural and Resource Economics Associated meetings in DC in June 2017; and, the Agricultural and Applied Economics meetings in Chicago in August 2017.

To achieve our 3rd goal of '*increasing the visibility of the local hop industry and the amount of locally grown hops in Indiana beer*', we worked with Purdue Extension educator, Kathleen Sprouse, to develop a story board for the video and flyer. Indiana hop grower and videographer, Mr. James Kennedy filmed our field days and sites during our tour of PNW hopyards. However, the video and promotion flyer were not completed due to reasons discussed below. Pictures from our field day and PNW tour were made available on our previous Purdue Horticulture Department supported website.

To achieve our 4th goal of '*training Extension educators and existing growers in hop management practices as well as providing opportunities for training in advanced hop production'*, we conducted three field days during 2016 at commercial hop farms around Indiana. Each field day focused on a different topic including bine training, disease management, and harvest. We also conducted two full-day workshops at the Indiana Small Farm Conference during March 2016 and March 2017. Results of our agronomic and economic research were discussed, and national experts were brought in from the PNW to provide further insights about hop best management practices. We also took a group of existing Indiana hop growers (Spencer Gray, Mike Brooks, Wes LaRue, Ryan Hammer, Steve Howe, James Kennedy), Indiana extension Educators (Lindsey Ploehn, Amy Thompson, James Wolf, Diane Turner), and Purdue employees who were actively working on various aspects of the project (Judith Martin, Kim Ha, Lori Hoagland, Tamara Benjamin and Jeanette Jensen) to Washington and Oregon State to tour multi-generation hop farms and processing facilities to receive advanced training in hop best management practices and marketing strategies. All of the participants indicated that they

significantly increased their knowledge of hop production, from 50-300%, in response to attending these events.

To achieve our 5th goal of '*increasing the practice of on-farm participatory research on hop farms*' we conducted trials at three farms (north, central and south IN) to determine the best bine training date, which is a significant component of hop yield and quality, but can vary dramatically given site-specific environmental conditions. The trials were conducted at Wes LaRue's hop yard with the help of Purdue Extension educator James Wolff, at Ryan Hammer's hop yard with the help of Purdue Extension educator Diane Turner, and at Mike Brook's hopyard with the help of Purdue Extension educator Amy Thompson. Results of these trials demonstrated that hops should be trained earlier as you go south in the state, and that both hop growers and Extension educators felt their understanding of how to conduct on-farm research to improve management practices increased by at least 300%.

- *If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops*.

N/A - All of the activities associated with this project solely supported the local hop industry, as all of our research and outreach activities were exclusively focused on hops.

- *Present the significant contributions and role of project partners in the project.*

Dr. Hoagland, an Associate Professor in the Dept. of Horticulture and Landscape Architecture at Purdue University, led and participated in all activities associated with the project. Under her supervision, her laboratory research technicians, Natasha Cerruti, Judith Martin and Xiaojun Zhao, managed the experimental hopyard at the Meigs Farm, collected all of the agronomic and pest data associated with the project, and participated in the training and outreach efforts. Five undergraduate and three graduate students in Dr. Hoagland's lab also helped manage and collect data from the field trials. Dr. Shady Atallah and his graduate student, Kim Ha, conducted the economic surveys and presented the data to growers and the scientific community.

Hop growers (Spencer Gray, Mike Brooks, Wes LaRue, Ryan Hammer, Steve Howe, James Kennedy) and Purdue Extension educators (Lindsey Ploehn, Amy Thompson, James Wolf, Diane Turner), participated in the tour to the PNW to learn more about hop production, participated in field days, and assisted with the on-farm trials designed to identify an ideal planting date for hops. Dr. Tamara Benjamin (Purdue Extension) attended the field tour in the PNW, and helped coordinate field days associated with the project. Jeanette Jensen, an employee of the hop testing laboratory in the Dept. of Food Science at Purdue, participated in the tour of the PNW, and helped with the hop quality analyses conducted at the research hop yard. Mr.

James Kennedy, IN hop grower and videographer, shot videos of the hop tour and field days for our promotional video. Ms. Kathleen Sprouse, former Purdue Extension educator, created the story board for the flyer.

GOALS AND OUTCOMES ACHIEVED

- *Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments*

The activities that were completed to meet each of our goals is described above. How we did in terms of meeting our goals and measurable outcomes is described below.

Our target for our 1st goal **'***identifying hop varieties and trellis systems that are most productive under Indiana's soil and climatic conditions',* was to increase knowledge of these factors in Indiana by 100%. Similar studies in neighboring states such as Michican was our benchmark. We are confident we met this goal given survey responses at field days and workshops we conducted. We are also confident that while pests are a significant issue in Indiana, with timely management, some hop varieties can perform just as well in Indiana as they can in other Midwest states. Pests are similar.

Our target for our 2nd goal *'quantifying the economic costs and benefits, opportunities and challenges associated with development of a local hop industry'* was to increase knowledge of these factors in Indiana by 100%. We are confident we met this goal given survey responses at field days and workshops we conducted. We are also confident that consumers are supportive of the local hop industry in Indiana, and it can be economically viable, though further education is needed.

Out target for our 3rd goal *'increasing the visibility of the local hop industry and the amount of locally grown hops in Indiana beer'* was to increase awareness of the local hop industry among brewers and consumers by 50%, and increase purchases of locally grown hops by Indiana brewers by 200%. While we were not able to complete the promotional video or flyers as proposed, we believe that we were able to meet our targets, as news articles featuring our field days and workshops were widely disseminated, and Indiana hop growers have reported that most of the local breweries are purchasing their hops.

Our target for our 4th goal *'training Extension educators and existing growers in hop management practices as well as providing opportunities for training in advanced hop production'* was to increase knowledge by 500%. We believe we met this goal, based on the many activities we performed, and responses to our surveys of participants in these events.

Our target for our 5th goal *'increasing the practice of on-farm participatory research on hop farms'* was ti increase knowledge by 300%. We believe we met this goal, based on the surveys of the growers and Extension educators who participated in these efforts.

- *If outcome measures were long term, summarize the progress that has been made towards achievemen*

Most of the outcome measures we proposed were short-term, with the exception of increasing awareness of the local hop industry among consumers and brewers. We expect that this will continue to grow over time, especially as the Extension team on this project received a subsequent grant from the IN-SCBGP to provide additional educational activities.

- *Provide a comparison of actual accomplishments with the goals established for the reporting period.*

As discussed above, we are confident that we were able to meet our goals for this project, with the exception of completed the brewer survey, and the flyer and promotional video.

- *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

As discussed in our initial grant proposal, since hops had not been grown in Indiana for a century, there was virtually no information on how to grow them in Indiana, or how to promote the industry. Over the course of our project, we collected a tremendous amount of agronomic and economic data about local hop production, shared information about these results along with other related information, and have helped promote the local industry overall. Consequently, we are confident that we made a significant amount of progress in meeting our goals to promote the local hop industry.

- *Highlight the major successful outcomes of the project in quantifiable terms.*

  - ❖ Knowledge of the costs to install and manage hop yards in Indiana, the most problematic pests growers can expect to encounter, and hop varieties that will perform best in Indiana was dramatically increased a result of this project.
  - ❖ Dwarf trellis production systems could be more productive and profitable in Indiana if mechanical harvest options are developed.
  - ❖ Indiana consumers are willing to pay more for local hops, but need additional education to appreciate the value of both local hops and local beer production.
  - ❖ Indiana brewers are supportive of the local hop industry and at half of the brewers are using locally produced hops.

- ❖ Indiana hop growers and Purdue Extension educators are better connected and informed of best management practices for hops in Indiana, and how to further improve production using on-farm trials.

- *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments*.

Indiana hop growers, other growers who were thinking, or are continuing to think about growing hops, Purdue Extension specialists and educators, Purdue undergraduate and graduate students, Purdue Scientists and administrators, scientists, economists and students at professional meetings where results of agronomic and economic studies were presented, Indiana brewers and consumer, and Indiana reporters learned about hop challenges, best management practices, and potential for further growth as a result of this project.

- *Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

We estimate that at least 400 people attended our field days and workshops, at least 500 people viewed our website, at least 1000 received updates via our growINhops list serve, and at least 500 people viewed presentations of our results at scientific conference. In addition, 231 respondents participated in our consumer survey, and we expect at least 1000 people likely read news reports associated with our events.

LESSONS LEARNED

Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project

We conclude that hops are a viable, but challenging crop to grow in Indiana. They require high start-up costs and annual labor to manage hop yards. A number of pathogen and insect pests are problematic in our region due to high rainfall and humidity. Growers must be prepared to know how to identify pests and have a pro-active management plan to prevent damage by these pests when they occur. Hop production is not economically feasible if growers do not have access to mechanical harvesting equipment. When using adapted varieties and a proactive pest management plan in place, growers can make a profit from hop production in Indiana. Dwarf trellis production systems are an attractive alternative to traditional tall trellis production systems and should be further explored. Local consumers and brewers are supportive of the local hop industry, though further outreach efforts to promote this fledgling industry are needed to ensure its success. The amount of local hop production should not exceed the amount of hops needed by

local breweries, as it is unlikely that Indiana growers will be able to compete with growers in the PNW at a national scale. Projects that actively engage growers and extension Educators are important for ensuring dissemination of relevant results, and ensuring that these groups are prepared to continue to develop improved practices beyond the scope of short-term trials like this. Turnover among Purdue Extension educators, growers, students and technical research staff is a challenge to projects such as this.

- *Describe unexpected outcomes or results that were an effect of implementing this project*

Indiana hop growers are likely to be interested in other specialty crops such as local vegetable production, and networks developed as a result of this project could aid in these efforts. Growing interest in the hop industry, and results from this project, contributed to the development of a hop testing lab in Purdue's Food Science Dept., and a new fermentation major. While all growers who start growing hops in the state are not likely to be successful, their appreciation for local hop production is maintained and they will continue to support this industry. By learning about the value of local hops, consumers and also likely to increase their appreciation of other local specialty crops.

- *If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.*

Unfortunately, we were not able to complete our flyer or promotional video, as Ms. Kathleen Sprouse and Mr. James Kennedy left Purdue/hop industry and moved on to other positions, and we were not able to identify new people with the needed skill sets to complete these activities. We were also not able to complete the brewer survey, as Dr. Attalah moved to UNH, and his graduate student, Ms. Kim Ha, accepted a position in Washington D.C. There was not enough time or resources to hire a new student to complete the survey, and Dr. Attalah become too busy with new projects at UNH. Finally, turnover of research technicians in the Hoagland Lab, slowed progress with analyses of data collected in the field trial. We recommend that future grant recipients identify alternative personal ahead of time, in case unforeseen movement of participants occurs as it did with our project. We also recommend that future grant recipients prepare their budgets carefully, as expenses can often account to more than expected.

- *Lessons learned should draw on positive experiences (i.e., good ideas that improve project efficiency or save money) and negative experiences (i.e., lessons learned about what did not go well and what needs to be changed).*

The most positive aspect of this project, was that it involved a large group of research and extension faculty/staff with diverse backgrounds, which enabled us to work together

synergistically to complete a lot more than we would have been able to do on our own. It also allowed us all to learn about different fields. At the same time, growers were intimately involved in all aspects of the project, from inception to evaluation of the final results. This ensured that our project was uniquely relevant to addressing their needs, and that the results were disseminated to the audience that needed them most. As discussed above, the negative aspects of this project is that we were delayed in completing our tasks and were not able to complete everything we proposed, due to changes in personnel associated with the project. Sadly, this is not uncommon, thought could be overcome in the future by identifying alternative collaborators ahead of time. Finally, careful accounting of the budget is essential. Several of our tasks ended up costing more than we anticipated, though fortunately, we were able to pull resources from other related projects. Ensuring that projects proposed to the IN-SCBGP build on and support other on-going projects will help with this challenge in the future.

BUDGET

Items:	**Paid:**	**Allotted:**
Personnel	34762.27	35,152
Travel	20996.55	22,324
Equipment	0	0
Supplies	9970.63	8106
Contractual	10894.78	9000
Other	1500	1500

Total Spent: **$78,124.23**

CONTACT PERSON

- *Name the Contact Person for the Project:* Lori Hoagland
- *Telephone Number:* 765-494-1426
- *Email Address:* lhoaglan@purdue.edu

ADDITIONAL INFORMATION

- Our project website - https://ag.purdue.edu/hla/extension/pages/hops.aspx
- Poster presented at the national agronomy society meeting in Phoenix, AZ in Nov. 2017

Breaking Ground in Indiana Hop Cultivation

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[1]Department of Horticulture and Landscape Architecture

Introduction

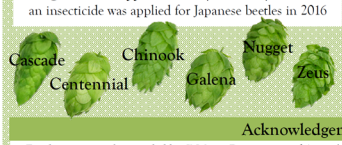
Rapid growth in the craft beer industry and rising interest in the use of locally sourced ingredients has created an opportunity for hop production in Indiana. Currently, there are 120 microbreweries in the state. Indiana growers have started installing hop yards, though hops have not been commercially grown in the state for over a century and there are currently no recommendations to guide growers in best management practices.

Objectives

- Identify the most problematic pests in IN hop yards
- Identify varieties that perform well in IN
- Quantify differences in costs and varietal performance in dwarf and tall trellis production systems

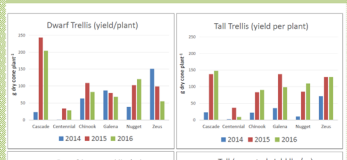
Materials & Methods

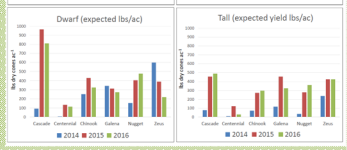
- Hop yards were established in spring 2014
- Six hop varieties were transplanted (7 plants/variety) into each trellis system in a randomized complete block design with three replicates
- Dwarf trellis system: 10 ft. tall, with 3 ft. between plants and 45 ft. between poles
- Tall trellis system: 18 ft. tall, with 3.5 ft. between plants and 50 ft. between poles
- Nutrients & water were managed using standard practices recommended for hops in the PNW
- Fungicides were applied annually for downy mildew & an insecticide was applied for Japanese beetles in 2016



Results & Discussion

Yields





Quality

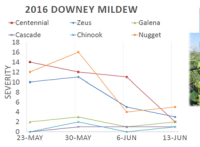
	Cascade Tall	Cascade Dwarf	Industry Standard
Alpha Acid	5.87	4.71	4.5-7.0
Beta Acid	5.44	5.37	4.8-7.0
Cohumulone	29.50	29.67	33-40
Essential Oils mL/100g	1.98	1.23	0.7-1.4
Caryophyllene	16.41	15.44	3.5-5.5
Farnesene	10.25	9.78	3.0-7.0
Humulene	27.08	33.41	8.0-13.0
Myrocene	42.08	40.99	45.0-60.0

Key Pests

Potato Leafhopper (*Empoasca fabae*)

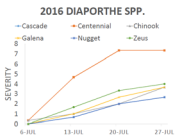
Aphid (*Phorodon humuli*)

Japanese Beetle (*Popillia japonica*)



Downy Mildew (*Pseudoperonospora humuli*)

Diaporthe spp.



Conclusion

- Hops can be grown in Indiana and meet end-use quality characteristics
- Pests are a problem and control strategies for Diaporthe spp. are needed
- Dwarf trellises can be productive, but mechanical harvest methods are needed
- Cascade had the best disease resistance and performed well in both systems

Acknowledgements

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