Missouri Department of Agriculture
Susan Bennett, SCBGP Program Coordinator
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Final Report
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Project 1: Growing Blackberry Production and Sales in Missouri

Webb City Farmers Market
Eileen Nichols
Final Performance Report

Project Summary

In Southwest Missouri demand for blackberries exceeds supply. Increasing blackberry production and sales offers opportunities for farmers and increased supply for consumers. Growing Blackberry Production and Sales in Missouri addressed these opportunities through a series of workshops centered on blackberry production and introducing the newly-developed Rotating Cross Arm Trellis and more winter hardy blackberry varieties to Missouri farmers. A blackberry educational site (aka the demonstration plot) was established using the RCA-system and incorporating seven varieties of blackberries. The plot was used during most workshops and research was conducted during 2017 and 2018 when harvests were weighed and tracked by variety. Thirteen workshops were held - ten at the MU Mt Vernon Research Center where the plot is located. And workshops were also held in St. Joseph, Arnold, and Farmington. Curriculum was developed for use in central and southern Missouri and a presentation on research conducted was given at the 2018 Great Plains Conference. Promotion of blackberry sales at the Webb City Farmers Market was undertaken and demonstrations at the market informed consumers of ways to incorporate blackberries into home cooking.

Project Approach

1) Blackberry sales data at the Webb City Farmers Market were collected by year and by farmer and is attached to this report. The data reveals useful information:

Demand for blackberries is strong. Unsold blackberries in 2016 was 6.5% of that brought to market, in 2017 it was 5.8%, and in 2018 it was 2.3%.

As noted in the comments, blackberry production varied significantly due to weather and pest pressures.

The value of using the market farmers as an indicator of the success of the project was limited due to the lack of participation by those farmers in the workshops. Only one of those listed attended any of the workshops, though all benefited from the knowledge gained by the workshop trainer who consulted on their farm and by phone as part of routine extension activities.

2) The demonstration plot was planted, maintained, and harvested. Data regarding harvests in 2017 and 2018 was collected. A graph showing 2017 data is attached, as are tables from 2017 and 2018. The following is from Patrick Byers, our MU lead who oversaw the research project:

"The RCA trellis/thornless cultivar blackberry planting at the MU Southwest Center, established in 2016, effectively demonstrated the utility of this approach to blackberry production over the 3 years of the project. Improved efficiency as a result of utilizing the RCA trellis was evident, and enterprise budget comparisons of this trellis design with other trellis designs demonstrated the potential of improved profitability. The replicated thornless cultivar trial superimposed on the RCA trellis provided data to guide the choice of blackberry cultivars for Missouri farmers.

Tables 1 and 2 (below) provide evidence that the floricane crop of 'Triple Crown', 'Natchez', and 'Traveler' on the RCA trellis was statistically superior to that of the other cultivars. The primocane fruiting cultivars in the trial, while providing fruit during the non-traditional blackberry season, had a disappointing performance and are not currently recommended for field production in Missouri."

Table 1. 2017 primocane and floricane yield and berry size for seven thornless blackberry cultivars, University of Missouri Southwest Research Center (SWRC), Mount Vernon, MO USA.

Plant Type	Cultivar	Mean Floricane Yield per Plant (kg)	Floricane Berry Size (g)	Mean Primocane Yield per Plant (kg)	Primocane Berry Size (g)	Mean Total Yield per Plant (kg)	Overall Mean Berry Size (g)
Primocane	**Prime-Ark® Freedom**	0.47 e *	8.8 a	1.91 b	7.8 a	2.82 e	7.5 ab
	Prime-Ark® Traveler	6.69 ab	4.9 e	3.32 a	4.9 b	9.94 a	4.9 c
Floricane	**Apache**	4.32 d	8.1 b	-	-	4.32 de	8.1 a
	Natchez	7.62 a	7.4 c	-	-	7.62 b	7.4 ab
	Osage	4.70 cd	5.1 e	-	-	4.70 cd	5.1 c
	Ouachita	6.20 abc	6.2 d	-	-	6.20 bc	6.2 bc
	Triple Crown	5.17 bcd	4.6 e	-	-	5.17 cd	4.6 c

* Means within columns with the same letters are not different according to Fisher's Least Significant Difference test ($P < 0.05$)

Table 2. 2018 floricane yield and berry size for seven thornless blackberry cultivars, University of Missouri Southwest Research Center (SWRC), Mount Vernon, MO USA.

Plant Type	Cultivar	Mean Floricane Yield per Plant (kg)	Floricane Berry Size (g)		
Primocane	**Prime-Ark® Freedom**	3.51 d *	7.3 a		
	Prime-Ark® Traveler	7.84 ab	4.0 c		
Floricane	**Apache**	4.83 cd	6.4 ab	-	-
	Natchez	9.22 a	6.2 b	-	-
	Osage	7.10 abc	4.7 c	-	-
	Ouachita	5.53 bcd	4.5 c	-	-
	Triple Crown	9.23 a	4.0 c	-	-

* Means within columns with the same letters are not different according to Fisher's Least Significant Difference test ($P < 0.05$)

Project partners - MU Extension specialist Patrick Byers provided the majority of organizing, planning and presenting at the workshops, as well as the surveying and analysis of surveys. He and Andy Thomas, also of MU, provided the bulk of harvest and weighing supervision, though all partners provided supervision numerous times each season. Andy also supervised the maintenance of the demonstration plot and recruited Master Gardeners to assist with harvest.

Above from left to right – Patrick Byers and a volunteer Master Gardener weigh berries in the demonstration plot, The Market Lady shares blackberry tea and blackberry lemonade, an enthusiastic future customer gobbles up blackberries from the demonstration plot at a free kids breakfast (note the blackberry parfait), & a lunch served at the Free Kids Meal including blackberries from the demonstration plot & other fresh produce from the farmers of the Webb City Farmers Market.

3) Customer education and "freezing bees" had to be revamped during the first year of the project due to 1) lack of participation in classes and 2) lack of surplus berries for freezing. To address the first issue, we received state permission to switch the classes to demonstrations during market which reached hundreds of customers and increased blackberry sales (we repeatedly watched customers sample the product and go directly to a blackberry grower to buy the ingredients). In addition to 12 blackberry recipe demonstrations by our Market Lady which were funded by the grant, nutrition educators gave numerous demonstrations using berries from the demonstration plot. The freezing bees were eliminated from the project. However, blackberries harvested from the demonstration plot offered a new education opportunity. Gallons of blackberries were incorporated into the Free Kids Meals served by the market during the summer. During 2017 and 2018 when the plot was in production, hundreds of children enjoyed fresh local blackberries. A favorite was blackberry parfait served with breakfast. Fresh blackberries were a favorite at lunch and dinner.

An activity not originally planned was inviting our state representatives to visit the demonstration plot, as well as the market and the site of another specialty crops project providing training on year-round production. (photo – State Representative Charlie Davis at the demonstration plot)

An unexpected opportunity arose when we conducted several tasting sessions. Some were conducted at the workshops while others were conducted at the farmers market. At all, farmers were particularly interested in comparing the seven varieties grown. Customers, especially customers who were considering growing blackberries, were eager to try the varieties, though they were even more eager to buy them since we had sold out of blackberries earlier in the day. The results of one of the tastings is attached (only the five varieties in season were tasted).

4) Newspaper ads and banners promoted the availability of blackberries at the Webb City Farmers Market. Their impact could not be determined, though as noted below, the percentage of berries remaining unsold diminished during the period of the grant.

5) Thirteen workshops were held with an average attendance of 28 farmers. Surveys were conducted at each workshop and are attached. The surveys show strong attendee satisfaction and consistent increase in knowledge. Responses were also useful in determining interests and needs that should be addressed by workshops as we progressed through the grant period. Three of the workshops were held outside of southwest Missouri. The field days were held in conjunction with these workshops, as well as a field day that was held at Braker Farm, which belongs to one of the market's farmers.

6) Results of the first harvest were shared by our MU Extension lead in a presentation to the Great Plains Growers Conference in 2018. Through three years of workshops, curriculum was developed that can be used throughout central and southern Missouri.

Goals and Outcomes Achieved

Of our goals, only one was truly measurable, the increase of knowledge by 50% of grower participants. According to survey responses, 97% of attendees reported an increase in knowledge.

We hoped to show an increase of blackberry acreage by 10% in Southwest Missouri, however we have only the anecdotal evidence from our surveys. In surveys that asked if the attendee planned to plant blackberries, 58% of attendees responded in the affirmative. In addition, numerous attendees noted in their comments that they were beginner blackberry growers.

Using sales at the Webb City Farmers Market as an indicator, we exceeded our goal of an increase in direct sales of 10%. Sales in 2018 were 15% higher than those in our base year 2015. However an examination of sales of all the years indicates a great deal of variability. Our farmers indicated that pest and weather pressures continue to impact harvests. Consumer impact results can be drawn from the fact that despite an increase in sales of 15% from 2015 to 2018, the percentage of quarts unsold fell from 6.5% in 2016 to 2.3% in 2018.

Beneficiaries

Workshops were attended by more than 300 farmers, most of whom were growing or planning to grow blackberries. The vast majority indicated that they had learned valuable information and most planned to implement at least part of the knowledge they gained.

Many additional farmers received benefits through Extension expertise gained through the project and shared by Extension on the farm or by phone. One example would be Owen Detweiler, an Amish farmer for whom attending the workshops would have been too costly, who was visited by the Webb City Farmers Market inspection team which included the workshop instructor. The instructor worked with him one-on-one to address issues with weather and pest pressures on his blackberries.

Hundreds of customers benefited from education about preparing blackberry dishes, as well as from sampling the end product, through demonstrations at the Webb City Farmers Market. Hundreds of children benefited by eating blackberries harvested from the educational site at the Free Kids Meal served at the Webb City Farmers Market. Introducing adult to new ways of preparing blackberries and children to the flavor of blackberries should result in healthier diets and more consumption/sales of blackberries. We did not, however, develop a sufficient method to determine the increase in knowledge by consumers because our method of conveying information was changed from the initial proposal. Such surveying was simple when done in a classroom setting, however with only two students attending the first class, no significant data could be collected. Moving to demonstrations in the market multiplied the number of consumers involved exponentially but the setting and sheer numbers did not allow for surveying.

It is not possible to determine the precise economic impact of the project.

Lessons Learned

1) There remains strong interest from farmers for information about growing blackberries and strong demand for blackberries by consumers in Southwest Missouri.

2) Charging a small fee ($10) seemed to encourage attendance and not only covered costs such as refreshments but will allow the project to continue for one year without grant funding. This farmer-based funding will let us continue research so we have a total of three seasons to base recommendations on and provide at least one additional workshop.

3) We need to better educate our representatives. Neither knew of the existence of the MU Research Center even though it was in the district of one, nor were they aware that a blackberry research project for Southwest Missouri was underway (one of several at the center), nor were they aware of specialty crops grants or the work of the Missouri Department of Agriculture in Southwest Missouri. With all new representatives in 2019, we will work to make sure they are well informed on agricultural research and education efforts in their districts.

4) We were unable to attract our Hmong farmers to the workshops despite offering translation. We do not know if this lack of interest is culturally based. The learning curve may seem too daunting for our first generation farmers. The initial investment and the delayed return on investment might also cause pause. Land ownership may be an issue. And finally, fruit production may just seem too alien and unfamiliar. This is an area that we need to further explore as our Hmong farmers rely heavily on growing vegetables but have expressed interest in fruits.

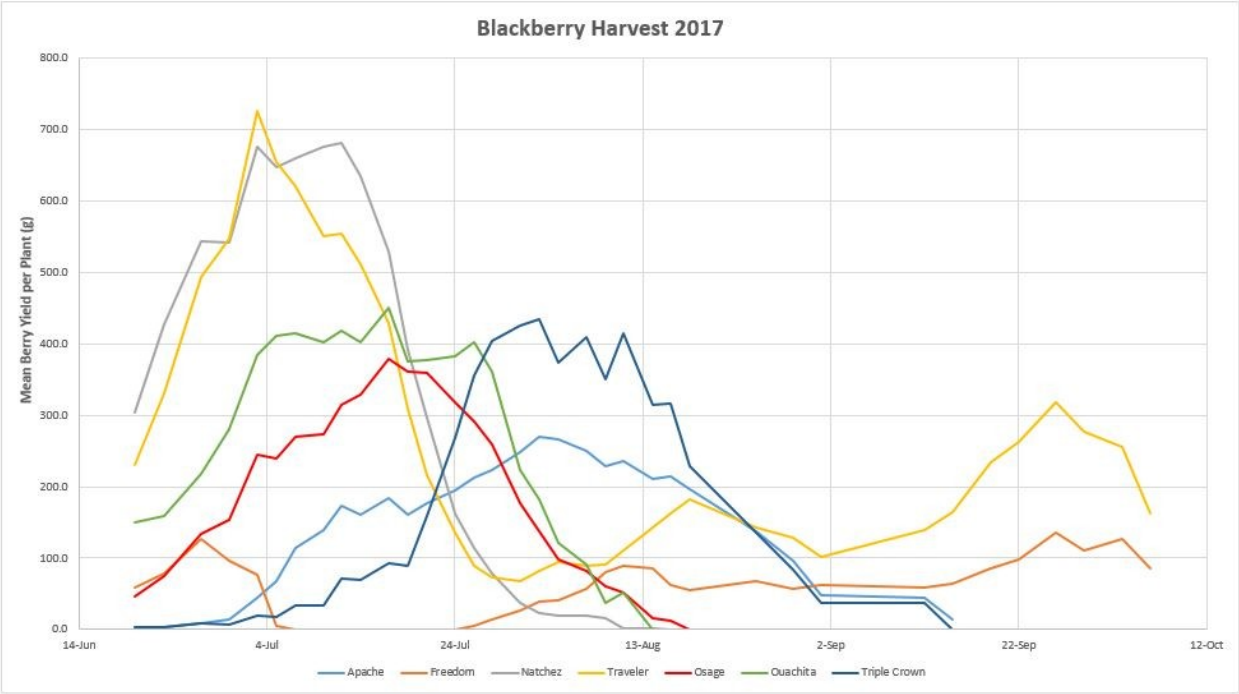
5) Our team consisting of the market, MU Extension and LU Cooperative Extension work well together and hope to continue our partnership.

Contact Person

Eileen Nichols
417 483-8139
eileennichols@sbcglobal.net

Additional Information

Blackberry Harvest:



Workshop Fliers:

Workshops

Food Safety from Farm to Market Cost of $5 covers lunch. Registration is required. Wednesday, February 22, 9:30 to 4:30, at the Webb City Library, 101 South Liberty. Contact Eileen to register - 417 483-8139 or eileennichols@sbcglobal.net

Seed Treatment Workshop - 6 pm to 9 pm, Monday, March 6, at 5 South Pennsylvania, Central United Methodist Church, Webb City. Cost $10
To register, call David Hill at 417 499-4831

Sell More at the Market Workshop – Saturday, April 15, 1 pm at the Webb City Library, 101 S. Liberty - No charge but reservations are appreciated Contact Eileen to register - 417 483-8139 or eileennichols@sbcglobal.net

Topics –

How to sample effectively (and safely and legally) at markets
We know that sampling at the market can increase sales and customer loyalty but it must be done right to protect you and your customers
Post Production Handling and Storage How to keep your produce safe and fresh so your top quality fruits and veggies pay off

Braker Berry Farm Tour - 3:15 - 5 Saturday, April 15, no reservations required. **941 SW 90th Lane, Oronogo, MO 64855** Tour includes:

- Garlic, including the MSU/MU garlic planting date study
- Blackberries, growing on the innovative rotating cross arm trellis
- Blueberries, including recently developed cultivars
- Hydroponic vegetable production
- High tunnel vegetable production

Blackberry Production - workshops at a demonstration plot featuring the new shift trellis design and new more winter hardy cultivars at the Mt. Vernon MU research center. Cost $10 each

1. Spring workshop – April 26, 1-5pm - Mount Vernon Research Center
2. June 21 – Hmong workshop, 1 – 5 – Mount Vernon Research Center
3. June 28 - Jefferson County
4. Summer workshop – July 26, 1-5pm - Mount Vernon Research Center
5. Fall/Winter workshop – November 15, 1-5pm - Mount Vernon Research Center

Contact Eileen to register or for more information.

Contact information: Eileen Nichols, 417 483-1839 eileennichols@sbcglobal.net

David Hill, 417 499-4831 dhill2213@gmail.com

Growing Blackberry Production and Sales in Missouri

2016 Blackberry Workshop Schedule:

April 20, 1:00-4:00pm
MU Southwest Research Center, Mt Vernon.

June 29, 1:00-4:00pm
Buchanan County Extension Office, St. Joseph.

September 14, 1:00-4:00pm
MU Southwest Research Center, Mt Vernon.

November 16, 1:00-4:00pm
MU Southwest Research Center, Mt Vernon.

For workshop information, contact:
Patrick Byers
MU Extension—Greene County
417.881.8909
Byerspl@missouri.edu

Workshop registration is $10 per attendee.

For registration information:
Webb City Farmers Market
417.483.8139
eileennichols@sbcglobal.net; or visit
www.webbcityfarmersmarket.com

The Webb City Farmers Market
Eat local – Eat fresh

1866 - 2016 150 YEARS LINCOLN UNIVERSITY COOPERATIVE EXTENSION

MISSOURI AGRICULTURE

Blackberries offer huge potential for Missouri farmers. Though a challenging crop to produce, blackberries are in high demand for many markets. The "Growing Blackberry Production and Sales in Missouri" project will offer educational sessions and tours of innovative blackberry farms. Join local and nationally known blackberry specialists and farmers to gain expertise on a wide range of blackberry topics, including:

- The blackberry shift trellis
- Establishing new blackberry plantings
- Blackberry production practices
- Blackberry weed management, including recent advances
- Update on blackberry insect issues, including spotted wing drosophila, broad mite, and brown marmorated stink bug
- Creative marketing strategies for blackberries
- Processing blackberries into value-added products
- Blackberry growers profiles
- On-farm tours of innovative blackberry producers

UNIVERSITY OF MISSOURI Extension

2016 Workshop Information

April 20, 1:00-4:00pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712

Blackberry planting site preparation, installing the shift trellis, planting, blackberry culture. $10 registration per attendee.

June 29, 1:00-4:00pm. Buchanan County Extension Office, 4125 Mitchell Ave, St Joseph, MO 64507

Blackberry harvest, spotted wing drosophila management, shift trellis management. $10 registration per attendee.

September 14, 1:00-4:00pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712

Fall management of the shift trellis, blackberry insect and disease management. $10 registration per attendee.

November 16, 1:00-4:00pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712

Winter management of the shift trellis, choosing blackberry cultivars. $10 registration per attendee.

Organizing committee for the Growing Blackberry Production and Sales in Missouri program:

Eileen Nichols, Webb City Farmers Market
Patrick Byers, MU Extension
Robert Balek, MU Extension
Nahshon Bishop, Lincoln University
Randy Garrett, Lincoln University
David Middleton, Lincoln University
Andrew Thomas, University of Missouri

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The "Growing Blackberry Production and Sales in Missouri" project is funded through a Missouri Department of Agriculture Specialty Crops Block Grant.

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MISSOURI AGRICULTURE

Growing Blackberry Production and Sales in Missouri

2017 Blackberry Workshop Schedule:

April 26, 1:00—4:00pm
MU Southwest Research Center, Mt Vernon.

June 21, 1:00—4:00pm
MU Southwest Research Center, Mt Vernon. Hmong translation.

June 28, 1:00—4:00 pm
Jefferson College, Arnold, Mo.

July 26, 1:00—4:00 pm
MU Southwest Research Center, Mt Vernon.

November 15, 1:00—4:00pm
MU Southwest Research Center, Mt Vernon.

For workshop information, contact:
Patrick Byers
MU Extension—Greene County
417.881.8909
Byerspl@missouri.edu

Workshop registration is $10 per attendee.

For registration information:
Webb City Farmers Market
417.483.8139
eileennichols@sbcglobal.net; or visit
www.webbcityfarmersmarket.com

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- The blackberry shift trellis
- Establishing new blackberry plantings
- Blackberry production practices
- Blackberry weed management, including recent advances
- Update on blackberry insect issues, including spotted wing drosophila, broad mite, and brown marmorated stink bug
- Creative marketing strategies for blackberries
- Processing blackberries into value-added products
- Blackberry growers profiles
- On-farm tours of innovative blackberry producers

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MISSOURI AGRICULTURE

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2017 Workshop Information

April 26, 1:00—4:00 pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712—Spring management of the RCA trellis and blackberry culture. $10 registration per attendee.

June 21, 1:00—4 :00 pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712—This workshop will be fully translated into Hmong. Blackberry production, blackberry harvest, spotted wing drosophila management and RCA trellis management. $10 registration per attendee.

June 28, 1:00—4:00 pm. Jefferson College, 687 Missouri State Road, Arnold MO 63010 and Belleville, IL - Blackberry harvest, spotted wing drosophila management, RCA trellis management and a visit to a commercial blackberry farm.

July 26, 1:00—4:00 pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712—Transition of primocanes to the RCA trellis and blackberry insect and disease management. $10 registration per attendee.

November 15, 1:00—4:00pm. MU Southwest Research Center, 14548 State Rd H, Mt Vernon, MO 65712—Fall/winter management of the RCA trellis and economics of blackberry production. $10 registration per attendee.

Organizing committee for the Growing Blackberry Production and Sales in Missouri program:

Eileen Nichols, Webb City Farmers Market
Patrick Byers, MU Extension
Robert Balek, MU Extension
Nahshon Bishop, Lincoln University
Randy Garrett, Lincoln University
David Middleton, Lincoln University
Andrew Thomas, University of Missouri

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The "Growing Blackberry Production and Sales in Missouri" project is funded through a Missouri Department of Agriculture Specialty Crops Block Grant.

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LINCOLN UNIVERSITY MISSOURI COOPERATIVE EXTENSION

MISSOURI AGRICULTURE

Growing Blackberry Production and Sales in Missouri

2018 Blackberry Workshop Schedule:

April 25, 1:00-4:00pm
MU Southwest Research Center, Mt Vernon.

April 26, 1:00-4:00pm
Farmington Community Library and area blackberry farm, Farmington, MO.

June 27, 1:00-4:00pm
MU Southwest Research Center, Mt Vernon.

Workshop registration is $10 per attendee.

For registration information:
Webb City Farmers Market
417.483.8139
eileennichols@sbcglobal.net; or visit
http://www.webbcityfarmersmarket.com/grower-training.html

For workshop information, contact:
Patrick Byers, MU Extension Webster County
417.859.2044
Byerspl@missouri.edu

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MISSOURI AGRICULTURE

Blackberries offer huge potential for Missouri farmers. Production is straightforward, and blackberries are in high demand for many markets. The "Growing Blackberry Production and Sales in Missouri" project will offer educational sessions and tours of innovative blackberry farms. Join local and nationally known blackberry specialists and farmers to gain expertise on a wide range of blackberry topics, including:

- The blackberry rotating cross arm trellis
- Establishing new blackberry plantings
- Blackberry production practices
- Blackberry weed management, including recent advances
- Update on blackberry insect issues, including spotted wing drosophila, broad mite, and brown marmorated stink bug
- Creative marketing strategies for blackberries
- Processing blackberries into value-added products
- Blackberry growers profiles
- On-farm tours of innovative blackberry producers

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2018 Workshop Information

April 25, 1:00-4:00pm. MU Southwest Research Center, 14548 Highway H, Mt Vernon, MO 65712

Overview of blackberry production, RCA trellis and thornless blackberry research, with first year results, Blackberry pest management with an emphasis on spotted wing drosophila. $10 registration per attendee.

April 26, 1:00-4:00pm. Farmington Community Library, 23500 Liberty Street, Farmington, MO and area blackberry farm

Overview of blackberry production, RCA trellis and thornless blackberry research, with first year results, Blackberry pest management with an emphasis on spotted wing drosophila. $10 registration per attendee.

June 27, 1:00-4:00pm. MU Southwest Research Center, 14548 Highway H, Mt Vernon, MO 65712

Blackberry harvest management, broad mite and spotted wing drosophila management, RCA trellis management. $10 registration per attendee.

The Webb City Farmers Market

Eat local – Eat fresh

Organizing committee:
Patrick Byers, Robert Balek, Andrew Thomas - University of Missouri
Nahshon Bishop, David Middleton, Randy Garret—Lincoln University
Eileen Nichols, Webb City Farmers Market

The "Growing Blackberry Production and Sales in Missouri" project is funded through a Missouri Department of Agriculture Specialty Crops Block Grant and supports the USDA-NRCS funded MO Strike Force Project.

UNIVERSITY OF MISSOURI Extension

Project 2: Establishing a Hands-on Winter Production and Season Extension Education Site

Webb City Farmers Market
Eileen Nichols
Final Performance Report

Project Summary

Establishing a hands-on winter production and season extension education site was a collaborative approach to effectively guide and educate farmers regarding season extension and winter production of specialty crops by hands-on group and individual training. Season extension and winter production have become financially important activities for many specialty crops growers in Southwest Missouri, but Hmong farmers in the region have struggled to take advantage of these opportunities. This project was designed for Hmong farmers but was available to and valuable for many other farmers in the region. The need for this project became evident as a result of training efforts by previous Specialty Crops-funded projects, particularly the market's Winter Production Conferences. We found that conventional conference presentations proved ineffective for the Hmong growers. Hands-on and on-site training were required.

The objective of this project was to establish a winter production and season extension education site on a Hmong farm that provided hands-on learning opportunities to Hmong farmers and others interested in expanding their fall, winter and/or spring production.

The site was established and hosted multiple workshops during the grant period and was also be available for individual visits. (Below – one of the Twilight Tunnel Tours)

Project Approach

The project team ordered materials and held initial workshops in the fall of 2015. Three workshops/workdays were held to put up the seed starting structure and the two high tunnels. Members of about 10 Hmong farming families and five native-born farm families participated in one or more of the workshops. At least four of the Hmong families put up their own seed starting structures the following year and two added a high tunnel to their operation and another hopes to do so. (right – Hmong farmers work on the high tunnel)

Eight events were held in 2016. Two seed starting workshops were held, one for English-speaking farmers, one for Hmong speakers (left). We began the Twilight Tunnel Walks which monthly from April through September, 2016, took farmers and prospective farmers through the center's structures. Extension specialists and center manager Fue Yang showed various aspects of the structures, discussed growing techniques as well as problems such as pests. Attendance typically ranged from 10 to 20 at each walk.

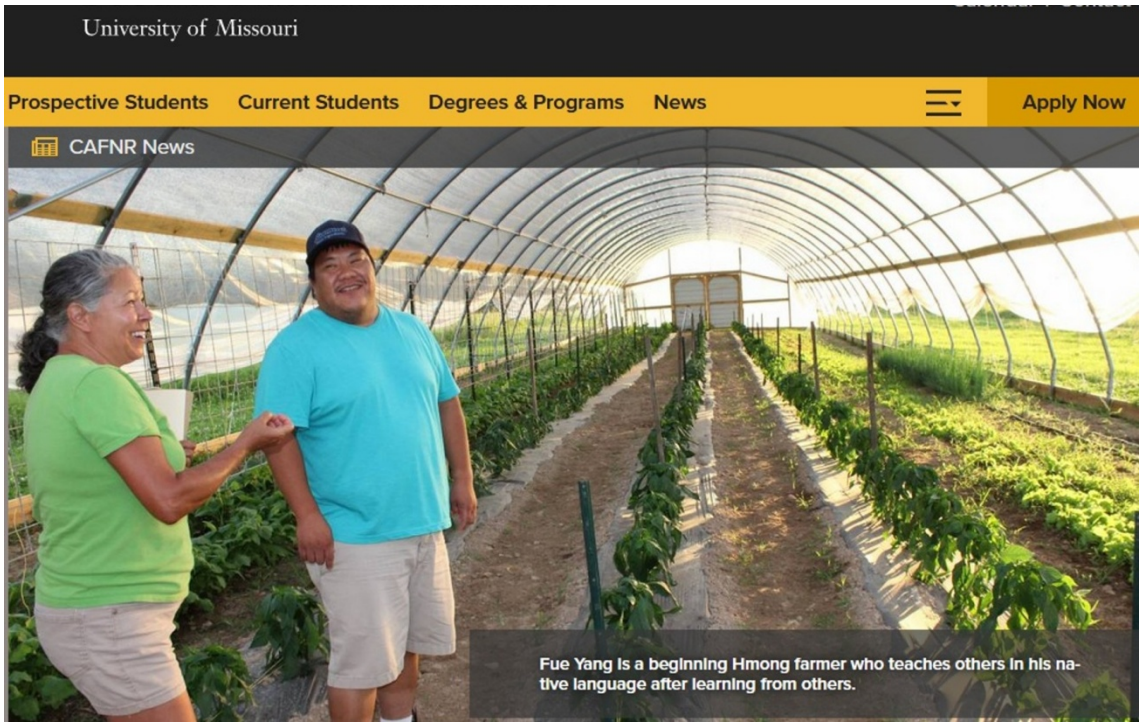
Throughout the project, the project mentor and our extension partners worked closely with center manager Fue Yang, who by the end of the project became proficient in protected growing. In year two of the grant, Fue completed his business ag degree with Crowder College having used this project as his formal internship requirement. His report is attached. Fue kept careful records as to planting and maintenance schedules as well as harvesting and sales information. Copies of the latter records were provided to Extension for analysis.

In 2017, there were only two formal educational activities at the center: a Twilight Tunnel Walk in April with 18 attendees and a field day for horticulture students from three area high school held in May (right).

Southern blight was discovered in the heated tunnel during the summer of 2017 and tours had to be suspended to prevent spread of the disease to other farms. The project team worked with regional and national experts to determine the best way forward. In the meantime, the team

adopted wearing disposable boots on all farm visits to avoid spreading this disease which is becoming increasingly common in Southwest Missouri.

In 2018, two workshops were held both focusing on the solution of using tomato bags in the heated tunnel.



Throughout the project, our Extension partners took the lead in providing guidance and education during events at the tunnel. Our initial mentor Hector Troyer moved midway through the project and was replaced by Karen Scott (above with Fue), an experienced high tunnel grower. Both mentors brought important strengths to the project – Hector in siting and installing the structures, Karen in record-keeping and in planning such as sequential planting. Center manager Fue Yang became proficient at at sharing his knowledge. Since he is not a clan leader, he was unaccustomed to speaking before the public. During each Twilight Tunnel Walk he spoke, briefly at the beginning of the project and more confidently as the project continued. At the field day for students he, for the first time, did a presentation completely on his own, discussing with each group what brought his family to farming in Southwest Missouri and how he had adapted to new technology (left). Though he confessed afterward that he was terribly nervous, the post-workshop survey showed his audience found him to be an excellent presenter. He has since been hired part-time by Lincoln University Co-operative Extension to work with their team

on advising Hmong farmers in Southwest Missouri. He has also served as a resource at the market's regional Tomato School. He was featured by the Farmers Market Coalition (attached) https://farmersmarketcoalition.org/meet-fue-yang-yang-family-vegetables/

The Education Center and Fue also triggered other stories:

https://www.columbiamissourian.com/news/higher_education/traditional-hmong-farmers-in-missouri-embrace-new-techniques/article_cb8067b2-72ca-11e7-99fb-4fd3d5768de1.html

https://cafnr.missouri.edu/2017/07/growing-knowledge-among-hmong-farmers/

https://www.missourilife.com/hmong-people-get-back-roots/

https://www.morningagclips.com/twilight-tunnel-walk-june-11/

Click here to meet Fue on video: https://www.fourstateshomepage.com/news/farmer-uses-hist-cultural-roots-to-educate-immigrants-on-farming/781654115

Goals and Outcomes Achieved

Surveys were conducted at the end of workshops and are attached. One hundred percent of those responding felt the workshops were helpful to them as small farmers. Of those who responded to surveys of the most recent two workshops, some responses include: 67% planned to erect a high tunnel, 89% planned to implement growing techniques they learned, 89% will follow-up on available resources, 100% will keep in touch with a grower they meet at the workshop, and 94% stated that the overall workshop fully met or exceeded expectations.

Follow up surveys to those attending workshops proved to be impractical as many did not read English and others had no email access. We know from routine farm visits made for the market that a number of seed houses were built after workshops and at least four high tunnels have been erected with one more planned that we know of.

Initial surveys of Hmong farmers were done at the Education Center with the assistance of translators. Few of the Hmong have internet access, nor are they good about checking and reading their mail. We have found that the best way to communicate is in person with a fluent translator which was not possible for follow-up surveying. Another barrier is cultural. Lost in translation is a real thing. During the translation process, the Hmong determine as best they can what answer we prefer and give that response rather than their own opinion. There is a saying among those of us who work with the Hmong. "Yes, means yes, or no, or maybe." It is simply uncourteous to not respond in the positive. And, frankly, sometimes the question just didn't make sense once translated to the Hmong farmer. Given those

barriers, we believe the anecdotal evidence we witnessed during on-farm visits provided the best evaluation of the benefits of the project.

Three regional winter markets were surveyed to determine whether the number of farms participating in winter production had increased:

Greater Springfield did not show an increase, having about 6 to 8 farms each of the three years. However, they anticipate an increase in 2019 because they are moving the market inside for winter. Their board believes they have potential to significantly increase their winter produce sales but until now could not entice growers to sell on their open parking lot site where produce would actually freeze during market because of low temperatures.

Farmers Market of the Ozarks

2015 – 2016 winter season – 4 farms selling their own produce

2016 – 2017 winter season – 7 farmers selling their own produce 2017 – 2018 winter season – 10 farmers selling their own produce

Webb City Farmers Market

2015 – 2016 winter season – 6 farms selling their own produce

2016 - 2017 winter season – 8 farms selling their own produce (left – December 10, 2016, - even when Santa visits, veggies are still the star of the market - left)

2017 – 2018 winter season – 10 farms selling their own produce

Winter sales at the Webb City Farmers Market showed initial increase but leveled off. This is likely due to two experienced farmers, who did not participate in training, having complete failures in their tunnels.

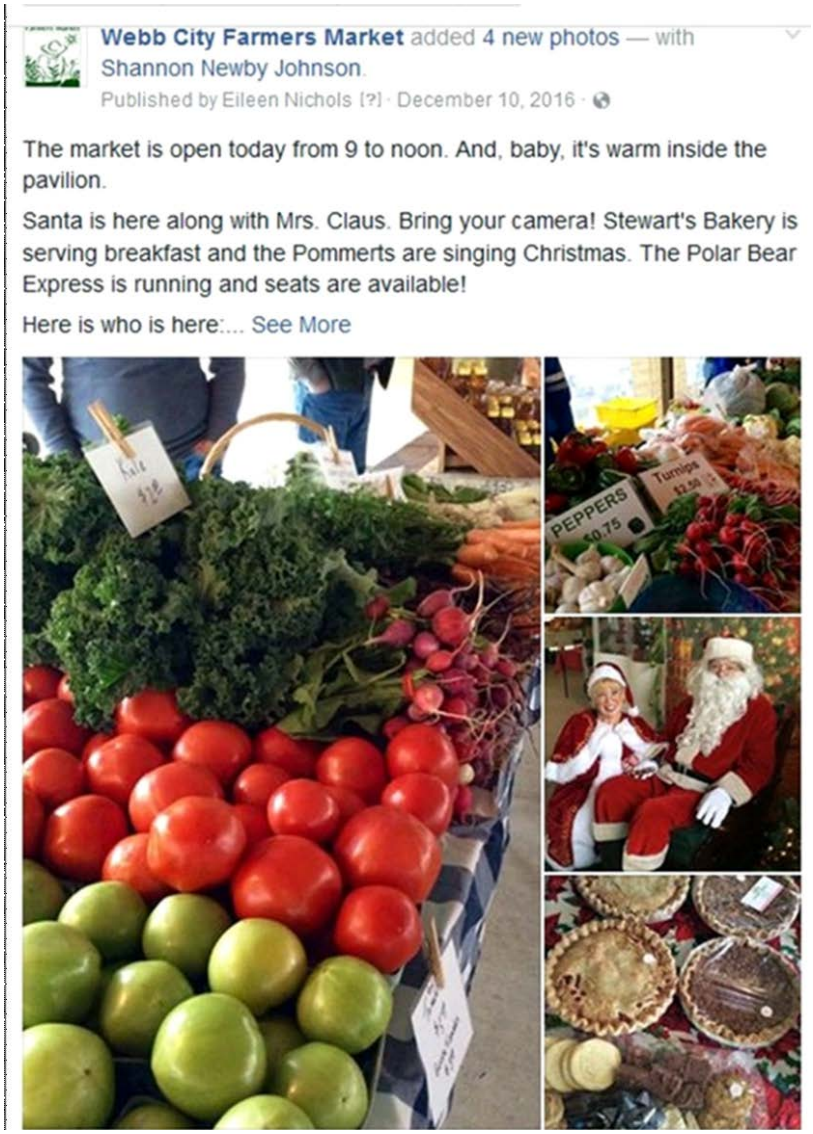
November 2015, through mid-April 2016 - $106,111

November 2016, through mid-April 2017 - $132,456

November 2017, through mid-April 2018 – $131,504

It was the goal of this project to show a 25% increase between November 2013 season and November 2017 season. That goal was missed by 1%. The increase was 24%.

All project activities solely involved the production of specialty crops, in particular cool weather crops like greens and high value crops like tomatoes and peppers.



Beneficiaries

According to Patrick Byers, MU Extension partner: *The Year Round Production Farm project was a valuable learning tool for all involved parties. Fue Yang, the center manager, took on a leadership role among the Hmong farming community, enhanced his specialty crop production skills, and through his efforts achieved a greater level of sustainably and profitability as farmer. Attendees at the numerous workshops and twilight walks gained valuable farming skills (as evidenced in impact surveys) in an atmosphere designed to appeal to adult learners. The extension leadership team that planned and implemented this project learned a great deal about establishing the infrastructure of a successful specialty crop farm. Equally important, the leadership team developed proficiency in effective extension outreach education techniques; examples include:*

1. *Implementation of the principles of andragogy, especially the use of result demonstration as a learning environment*

2. *The use of peer-to-peer knowledge/experience transfer as an impactful training method*

3. *The development of hands-on exercises and workshops, as an effective training tool for adult audiences*

4. *Effective implementation of culturally appropriate training environments for diverse audiences*

Approximately 300 persons attended the workshops and surveys showed that most benefited from increased knowledge as well as acquiring resources for improving and/or expanding their operations. Many more will benefit from skills and information gained by the project partners – Fue Yang, center manager, Patrick Byers and Robert Balak, MU Extension and Shon Bishop and David Middleton, Lincoln University Cooperative Extension (project partners shown below).

In addition, consumers in Southwest Missouri benefited from availability of locally grown produce during the winter months. The Webb City Farmers Market estimates that approximately 13,000 visits were made to the market during the 2017-2018 winter season alone.

We do not have a way to determine the economic impact of the project though interest in winter produce remains strong both among growers and consumers.

<u>Lessons Learned</u>

Perhaps the first and most important lesson we learned was that there is more to starting a winter production operation than ordering tunnel kits. Even though our Extension colleagues had assisted in raising several high tunnels, they had not been responsible for overseeing the complete project. Nor had they typically worked with a demographic that had no experience in undertaking such a project. While time consuming and sometimes stressful to avoid exceeding budgets, the knowledge gained by

Extension and by the farmers we worked with was invaluable. A number of farmers have successfully erected tunnels on their own after learning through this project. These farmers will in turn help others, as is traditional in the Hmong community. Our Extension colleagues can now offer practical and tested advice when working with farmers on season extension and winter production.

We also learned the importance of sanitation during farm visits. Bringing hundreds of people onto a farm incurs risk which must be mitigated by proper precautions such as disposable boots and gloves. (Right - Fue Yang, under the guidance of collaborator Patrick Byers, examines plant roots infected by Southern Blight)

We learned to look beyond the traditional. As a teaching site we saw the need to use both traditional and non-traditional methods - such as using equipment normally used in poultry houses like heaters and mechanisms for lifting side walls. We installed a jet fan heating system in the unheated tunnel to evaluate its efficiency and its effectiveness in increasing air circulation. (The center will continue to be used as an education site after the end of this grant as long as the Yang family continue using the tunnels. They have added their own unheated tunnel, allowing us to covert the center's unheated tunnel to a heated one to expand demonstration and research opportunities while still having an unheated tunnel available for training.)

We found that follow-up surveying was impractical because of cultural barriers and lack of internet access. For future projects, we must develop other methods to determine mid- and/or long term impacts.

Contact Person

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Additional Information

Surveys, Press releases, Internship report

WEBB CITY FARMERS MARKET INTERNSHIP

FUE YANG
SPRING 2017
INSTRUCTOR: JAY WILKINS
Internship Supervisor: Eileen Nichols

Agriculture has always been familiar to me. My childhood pretty much revolved around agriculture. My parents had various agricultural jobs throughout my childhood. I remember my mom and dad working as cucumber pickers in Wisconsin during the summers. There were rows after rows of pickling cucumbers growing in what seemed like an endless field. When we lived in Massachusetts my mom would pick us up after school and go straight to the apple orchards where my dad worked as an apple picker. I can remember sitting in between the rows of apple trees doing homework and watching my dad work while chewing on a freshly picked apple and enjoying the light breeze blowing.

From what I can remember we had always grown our own vegetables throughout my childhood. From mustard greens to cucumbers to corn, we had it growing in our garden. I remember being taught how to use a garden hoe to weed and dig holes to plant seeds. That little vegetable garden that we had would eventually grow into a small business we called Yang Family Vegetables, which we started in Massachusetts around 2003-2004

In 2006 my dad started making preparations to retire. We came to Southwest Missouri to look for, and ultimately purchase, a small 43-acre cattle farm. In February of 2007 my wife and I, along with our two young daughters, moved here to live on the farm. My parents retired in 2010, relocated here, and wanted to continue vegetable farming. In late 2011 I quit my job at La-Z-Boy in Neosho, Missouri, and picked up farming again in the spring of 2012. During this time I debated whether or not I wanted to do this for a living. If I did then I wanted to go back to school because I thought that by going back to school I could learn new ways to farm. I wanted learn some of today's technology and utilize it on the farm and try to make it more efficient. I finally made the decision to go back to school in the fall of 2015 and enrolled as a business ag major at Crowder College. Well, I say I made the decision but it was actually my wife who enrolled me, so I couldn't exactly turn back now.

A couple of weeks after I received my acceptance letter from Crowder, I got a phone call from Eileen Nichols (Webb City Farmers Market Master and supervisor for this internship). That one phone call would completely change the way Yang Family Vegetables operates today. She was working on a grant to establish an education center that consisted of two high tunnels and a seed starting greenhouse. The education center was going to be focused on season extension and winter production. There would also be monthly walkthroughs and various workshops throughout the year.

I was very excited about the project but kind of nervous at the same time. It would provide the technology that I had wanted to learn about. I would be working with the Webb City Farmers Market, Lincoln University Extension, and University of Missouri Extension, as well as having a farmer mentor to learn from. But I would also be going to school at the same time and was afraid I that had chewed off more than I could handle. My dad also was very hesitant about the project because of the added workload and he was skeptical as how it would improve our farming practices. Most importantly, he didn't want to let everyone down if things didn't go the way it should. I am happy to say that the Education Center is in its second year of operation and accomplishing its goals.

This year has been tough out in the field. In fact, in all the years that we have been farming here I have never seen it as bad as this year. My Troybilt tiller died and had to be resurrected and my tractor was down for a little while as well. Our well pump also died for a bit. Then we got hit with rain, wind, and hail that pretty much destroyed everything out in the field. My green onions, sweet onions, and snap peas that were in the field looked like someone had laid a 2 by 6 on top of them and pushed them down flat onto the ground. My lettuce, spinach, green beans, cucumbers, zucchini, and summer squash were ripped to shreds by the hail. We had to replant most of the plants and the plants we didn't are still trying to recover. The plastic on tunnels on one side are full of little welts, divots, and holes but it did protect the tomatoes and other plants I had in there. Not a single plant in the tunnels was affected by the storms.

My internship revolved around working in the high tunnels as well as out in the fields. My daily activities included watering the seedlings in the seed starting greenhouse and monitoring for pests and diseases, planting, transplanting, weeding, irrigation, fertilization, tilling, etc. Over the course of my internship, I acquired a lot of information that I will use on my farm. One of the things I learned is the importance of planning. We had always guess-timated everything. My mentor, Karen Scott of Oakwood Farms in Granby, showed me her planning schedule. I was absolutely amazed at all the information she had. She had her whole year planned out in weeks. Each week consisted of different things she had to get done in that week. She also had her planting schedule, including the specific cultivar, mapped out for the year. Since she practiced succession planting, her plan consisted of plantings every three weeks. She has specific dates on when to plant, what to plant and how much to plant whereas for us it was "I think this is enough," or "the plants are fruiting so it's time to replant." The result of that is sometimes we plant enough and sometimes we don't. Sometimes we replant too early and most of the time we replant too late. I will continue to write in my journal as suggested by Eileen after my internship is over and use it as a starting template.

Last year we planted 2 rows of tomatoes and one double row with each plant being 18 inches apart in the heated tunnel. We had pesticide damage last year so the leaves and branches weren't that big. This year we decided to do 3 double rows to save space since last year's double row wasn't too bad. So instead of having a tunnel full of tomatoes we would have two rows left to plant zucchini and cucumbers. We transplanted the tomatoes at 18 inches apart like last year but this year the tomatoes are growing to be bigger than we had anticipated because we grew a different cultivar of tomatoes in hopes of decreasing the chances of pesticide damage. Even with all the pruning, the plants are still a pretty good size and the leaves from different plants are overlapping seem to be a little over crowded. Next year I am going to plant them about two feet apart to help with the crowding. I will get fewer plants but there will be better air circulation, which should keep down diseases and plant stress. As of right now the tomato plants are about a good four and a half feet tall and have on average three to four cluster of tomatoes on each plant.

One of the things I wanted to include in this report was the education part of this project. One of project's main goal is to teach other farmers and the community about season extension and winter production through the use of the high tunnels and the seed starting greenhouse. Every fourth Thursday beginning in April and ending in October, Lincoln, MU Extension, and the Webb City Farmers Market holds a Twilight Tunnel Walk that's open to the public. This walk-through is designed as an introduction into the usage and benefits of the tunnels and the greenhouse. It also shows the progress of our produce as it is growing, the problems and pests that we might have.

This year they decided to do a pilot field day for high school kids. Two week before the field day I was asked to do a presentation. I have never done a presentation before and was pretty nervous about it. Karen and I met and discussed what I was going to talk about and made up a general a list but I still didn't know what I was going to say. I ended up asking if there was anything in particular that they wanted me to talk about and Randy with LU Extension responded saying to talk about my experience with the tunnels and the project.

When it was my turn to present, I took a deep breath and told myself it'll be ok, just go slow. As I looked at the kids looking at me, a sense of calmness kind of took over me. I was still pretty nervous but I opened my mouth and the words just started to come out. I talked about where we came from, about how I grew up around agriculture, how my parents farmed during their time in Laos (methods we still use here), about how we started Yang Family Vegetables, and about how I tried to walk away from farming but ended up coming back to it. The farther I tried to get away from it the deeper I became involved. Now I embrace it with arms wide open.

Throughout my time at Crowder and my involvement in the education center, along with this internship, the experience has really opened my eyes. I learned in school that we live in a society where food is readily available. A society where being hungry means a trip to the grocery store, or even easier, a trip to McDonald's. I realized with the education center that there is useful technology out there, but it takes farmers like my parents longer to see the need for change because their set ways have been passed down from generation to generation. I'm starting to notice that there are big differences when working in the tunnels vs. the fields. The tunnels are a lot easier, they are less labor intensive, and the growth and production so far has been better than the field. This internship helped me start collecting data via a journal that will be useful later on. I have seed starting dates, transplanting dates, and now harvesting dates that I will always have on hand and available when I need them for reference.

My goal is to pass on the knowledge of what I have and will learn in the coming years. The world is changing and we need to change with it. The average farmer today is at or near the age of retirement. Farmlands all over the world are being developed and the population is ever growing. The decisions we make today will impact the lives of our children, their children and their children's children. I am choosing to go backwards to move forward. Backwards in the sense of small local farmers growing for their families and their surrounding community. Forward in the sense that one day, with enough small local farmers, we might just feed the world, or at least our part of it.

FOR IMMEDIATE RELEASE
July 24, 2016

For more information, contact,
Eileen Nichols - 417 483-8139

Twilight Tunnel Walk on Thursday

A Twilight Tunnel Walk is set for Thursday, July 28, starting at 7 pm at the market's Winter Production Education Center located on the Yang Farm, 1213 Route U, Rocky Comfort (1.77 miles south of the intersection of State Highway 76 & Route U).

The free event offers walks through the Center's two high tunnels that were planted this summer with tomatoes, peppers, cucumbers, and egg plant. High tunnels look like Quonset huts covered in clear plastic where the plants are planted directly in the ground. They are used for season extension (planting earlier and/or harvesting later than usual), for winter production, and for protected production during the regular growing season. Extension educators and experienced farmers will lead the walk. (photo – during the June twilight walk, Fue Yang site manager, answers questions from Tuoa Lee of Seneca who will be installing a high tunnel on his farm this fall.)

Specific topics and demonstrations include disease and insect problems, an update on income from the tunnels, fertility additions to be made before fall planting, preparing for winter production, & comments from the site manager.

The walk is open to growers and the general public. A walk-around supper of hot dog, chips and drink will be available for $4. (This is primarily so farmers who typically work from dawn to nightfall during the growing season can attend and take care of eating at the same time.)

The Twilight Tunnel Walks will take place on the fourth Thursday of each month through September.

The Winter Production Education Center is a project of the Webb City Farmers Market, University of Missouri Extension and Lincoln University Extension. It is funded in part by a specialty crops grant from the Missouri Department of Agriculture. For directions or questions, call 417 483-8139.

FOR IMMEDIATE RELEASE
May 21, 2017

For more information, contact,
Eileen Nichols - 417 483-8139

Twilight Tunnel Walk this Thursday, May 25

The May Twilight Tunnel Walk is set for this Thursday, May 25, starting at 7 pm at the market's Year-Round Education Center located on the Yang Farm, 1213 Route U, Rocky Comfort (1.77 miles south of the intersection of State Highway 76 & Route U).

Walk through the Center's two high tunnels with Extension experts and experienced farmers. The monthly walks focus on growth stages, pests, yield and other issues in each of the two tunnels. The heated high tunnel is devoted to tomatoes, along with some zucchini and cucumbers. Protected growing allows these crops to be up to six weeks earlier than field crops. In the unheated tunnel, visitors can see the transitioning of crops from the cool weather crops such as peas, broccoli and lettuce planted for spring to hot weather crops like eggplant being planted for summer.

The walk is free and open to growers and the general public. No reservations are needed and no fee is charged. The Twilight Tunnel Walk takes place on the fourth Thursday through September.

The Year-Round Education Center is a project of the Webb City Farmers Market, University of Missouri Extension, Lincoln University Extension, and the Yang Family Farm. It is funded in part by a specialty crops grant from the Missouri Department of Agriculture. For directions or questions, call 417 483-8139.

(left, center manager Fue Yang speaks to high school students during a recent field day)

FOR IMMEDIATE RELEASE
May 29, 2018

For more information, contact,
Eileen Nichols - 417 483-8139

Twilight Tunnel Walk Features High Tech and Low Tech Tools
From the Webb City Farmers Market's Jesup Wagon 2.0

A Twilight Tunnel Walk is set for Monday, June 11, starting at 7 pm at the Year-Round Education Center located on the Yang Farm, 1213 Route U, Rocky Comfort (1.77 miles south of the intersection of State Highway 76 & Route U).

The walk, led by horticulture educators from University of Missouri Extension and Lincoln Co-operative Extension and Center manager Fue Yang, will provide hands on training on:

- High tunnel hand tools
- Sprayer calibration
- Irrigation
- BSC tractor and attachments – this small walk-behind tractor is well suited for the confines of a high tunnel.
- Bag system for growing tomatoes

The walk is free and open to growers and the general public. No reservations are needed and no fee is charged.

The Year-Round Education Center hosts two high tunnels use for year-round production and a seed starting house. It is a project of the Webb City Farmers Market, University of Missouri Extension and Lincoln University Co-operative Extension. It is funded in part by a specialty crops grant from the Missouri Department of Agriculture.

This workshop, and one slated for September, features the market's Jesup Wagon 2.0 kits. The kits are named after George Washington Carver's innovative Jesup Wagons which served as moveable schools for his assistants to introduce rural farmers to newly developed tools, fertilizers and other agricultural innovations. The September workshop will feature drone technology, low tunnels, and caterpillar tunnels.

For directions or questions, call 417 483-8139.

StrikeForce Evaluation: Twilight Tour – Rocky Comfort – 20 September 2018

Program Impact Report

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1. How well were your expectations met in this program?

Category	*n=*	*percent*
I have unmet expectations	0	0%
Below my expectations	0	0%
Somewhat met my expectations	0	0%
Fully met my expectations	6	75%
Exceeded my expectations	2	25%

Explain _____

- meeting other growers, learning about high tunnel production & disease management
- every topic listed was discussed, plus

2. Overall, after completing this workshop, to what level has your knowledge increased:

Category	*n=*	*percent*
Not at all	0	0%
I have learned information I did not know	2	25%
I am confident I can implement practices introduced in this workshop	6	75%
I have gained a mastery of topics covered	0	0%
I now feel I could teach this to someone else	0	0%

Comments below .....

- I will share this information with growers at my market
- This was a very wide ranging but concise presentation. Very informative.

3. Listed below are the topics presented during this workshop. On the left, circle your knowledge of each topic BEFORE the workshop. On the right, circle your knowledge of each topic AFTER the workshop.

How confident you are in using these practices or researching information after the workshop:

	Question:	*Non-existent*	*Minimal*	*Moderate*	*Considerable*
		%	%	%	%
1	Growing vegetables in a high tunnel	0	0	43	57
2	Growing Tomatoes in bags	0	0	57	43
3	Pest control in the high tunnel	0	17	33	50
4	Using irrigation technology	0	17	33	50
5	Fall/winter vegetable production	0	0	50	50
	Overall	0	6	44	50

Please complete side 2

Knowledge gain

	Question:	*Pre Evaluation score*	*Post Evaluation score*	*Knowledge gain (1-4 Likert Scale)*
1	Growing vegetables in a high tunnel	2.857142857	3.571428571	0.714285714
2	Growing Tomatoes in bags	2.142857143	3.428571429	1.285714286
3	Pest control in the high tunnel	2.833333333	3.333333333	0.5
4	Using irrigation technology	3	3.333333333	0.333333333
5	Fall/winter vegetable production	2.833333333	3.5	0.666666667
	Average knowledge gain	2.733333333	3.433333333	0.7

4. What about this program would you pass on to other growers?

- low-cost and flexibility of low tunnels
- low tunnels
- The grow bags are an innovative solution to soil-borne diseases
- year round growing seasons
- come and visit
- bio security and market timing importance

6. **What will you do differently as a result of this program?**			
	Yes (%)	*Don't plan to (%)*	*Need more training (%)*
Will evaluate and update my vegetable production practices	100	0	0
Will improve my pest management practices	100	0	0
Will consider fall/winter vegetable production	83	0	17
Will implement new production skills.	86	0	14
Will follow-up on available resources.	100	0	0
Will look for new marketing opportunities.	60	40	0
Will attend additional trainings	100	0	0
Will keep in touch with a grower I met at the program.	100	0	0
Comments below …… • When is the next local event?			

7. What topics would be of interest to you in future workshops?

Topic	*n=*	*Topic*	*n=*
Bedding plants	2	High tunnel training	2
Diabetes self-management	0	Meat production	1
Financial management	1	Retail farm to market	3
Health insurance options	0	Sust Ag/Research Ed funding	0
How to start farming	0	Vegetable production	3
Organic production	4	Chronic disease self-management	0
Social media marketing	2	Farm succession	1
USDA funding programs	1	Fruit production	3
Building a business plan	1	Home food preservation	1

Farm to school interest	0	NRCS funding programs	1
Food safety training	1	Selling local foods	1

Program Impact Summary

When asked to consider the program as a whole, the attendees who responded to the survey (n=8) reported: I have learned information I did not know, 25%; and I am confident I can implement practices introduced in this workshop, 75%. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: Growing vegetables in a high tunnel, .714; Growing Tomatoes in bags, 1.286; Pest control in the high tunnel, .5; Using irrigation technology, .333; and Fall/winter vegetable production, .667. **The overall knowledge gain was 0.7; average knowledge level improved from 2.733 to 3.433 on a 1-4 Likert Scale**. Following the program, attendees reported confidence in understanding workshop topics at a considerable level, 50%, and a moderate level, 44%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following activities were planned:
Will evaluate and update my vegetable production practices, 100%; will improve my pest management practices, 100%; will consider fall/winter vegetable production, 83%; will implement new production skills, 86; will follow-up on available resources, 100; will look for new marketing opportunities, 60; will attend additional trainings, 100; and will keep in touch with a grower I met at the program, 100. Of attendees who responded to the survey, 100% stated that the overall program fully met or exceeded expectations.

StrikeForce Evaluation: Learning Farm Tour – Rocky Comfort, MO – 11 June 2018

Program Impact Report

1. **How well were your expectations met in this program?**

Category	*n=*	*percent*
I have unmet expectations	*0*	0%
Below my expectations	*0*	0%
Somewhat met my expectations	*1*	11%
Fully met my expectations	*4*	44%
Exceeded my expectations	*4*	44%

Explain _____

- excellent information on high tunnels and needed tools
- would like to actually use BCS tractor

2. **Overall, after completing this workshop, to what level has your knowledge increased:**

Category	*n=*	*percent*
Not at all	0	0%
I have learned information I did not know	4	44%
I am confident I can implement practices introduced in this workshop	3	33%
I have gained a mastery of topics covered	2	22%
I now feel I could teach this to someone else	0	0%

Comments below .....

3. **Listed below are the topics presented during this workshop. On the left, circle your knowledge of each topic BEFORE the workshop. On the right, circle your knowledge of each topic AFTER the workshop.**

How confident you are in using these practices or researching information after the workshop:

	Question:	*Non-existent*	*Minimal*	*Moderate*	*Considerable*
		%	%	%	%
1	Growing vegetables in a high tunnel	0.0	11.1	33.3	55.6
2	Growing tomatoes in bags	0.0	11.1	44.4	44.4
3	Using BCS technology	0.0	0.0	33.3	66.7
4	Using irrigation technology	0.0	11.1	22.2	66.7
5	High tunnel hand tools	0.0	0.0	44.4	55.6
	Overall	0.0	6.7	35.6	57.8

Please complete side 2

Knowledge gain

	Question:	*Pre Evaluation score*	*Post Evaluation score*	*Knowledge gain (1-4 Likert Scale)*
1	Growing vegetables in a high tunnel	2.333333333	3.444444444	1.111111111
2	Growing tomatoes in bags	1.5	3.333333333	1.833333333
3	Using BCS technology	2	3.666666667	1.666666667
4	Using irrigation technology	2.555555556	3.555555556	1
5	High tunnel hand tools	2.222222222	3.555555556	1.333333333
	Average knowledge gain	2.122222	3.511111	1.388889

4. What about this program would you pass on to other growers?

- irrigation, bag growing
- go to everything available, ask questions

6. **What will you do differently as a result of this program?**			
	Yes (%)	*Don't plan to (%)*	*Need more training (%)*
Will change something about the way I grow vegetables	88.9	0.0	11.1
Will erect a high tunnel	66.7	11.1	22.2
Will implement one or more of the growing techniques I learned about today	88.9	11.1	0.0
Will follow-up on available resources	100.0	0.0	0.0
Will look for new marketing opportunities	66.7	22.2	11.1
Will attend additional trainings	100.0	0.0	0.0
Will keep in touch with a grower I met at the program.	87.5	12.5	0.0
Comments below …… • very good information presented that I had little experience in or knew about			

Program Impact Summary

When asked to consider the program as a whole, the attendees who responded to the survey (n=9) reported: I have learned information I did not know, 44%; I am confident I can implement practices introduced in this workshop, 33%; and I have gained a mastery of topics covered, 22%. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: Growing vegetables in a high tunnel, 1.111; Growing tomatoes in bags, 1.833; Using BCS technology, 1.667; Using irrigation technology, 1.000; and High tunnel hand tools, 1.333.**The overall knowledge gain was 1.389; average knowledge level improved from 2.122 to 3.511 on a 1-4 Likert Scale**. Following the program, attendees reported confidence in understanding workshop topics at a considerable level, 58%, and a moderate level, 36%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following activities were planned: Will change something about the way I grow vegetables, 89%; Will erect a high tunnel, 67%; Will implement one or more of the growing techniques I learned about today, 89%; Will follow-up on available resources, 100%; Will look for new marketing opportunities, 67%; Will attend additional trainings, 100%; and Will keep in touch with a grower I met at the program, 88%. Of attendees who responded to the survey, 88% stated that the overall program fully met or exceeded expectations.

Evalutation for High Tunnel Field Day Pilot Program - May 5th 2017

Scale 1-5 (1 being least to 5 being greater) Averages

Topic - High Tunnel Diseases and Pests - Patrick Byers

Knowledge Before Presentaiton	Knowledge After Presentation	Growth
1.5	3.38	1.88

Topic - High Tunnel Experience - Fue Yang

Knowledge Before Presentaiton	Knowledge After Presentation	Growth
1	3.53	2.53

Topic - High Tunnel Equipment - David Middleton

Knowledge Before Presentaiton	Knowledge After Presentation	Growth
1.42	3.19	1.77

Topic - Plant Scheduling - Shon Bishop

Knowledge Before Presentaiton	Knowledge After Presentation	Growth
1.38	3.26	1.88

Topic - Seeding Hourse - Robert Balek

Knowledge Before Presentaiton	Knowledge After Presentation	Growth
1.42	3.42	2

Comments

1. Great Experience.

2. Great Experience. I am glad I came

3. I really enjoyed the learning experience. Thank your for taking time for us.

4. You guys did a wonderful job.

5. I know some before but after I was told almost everything I need to know more for the basics.

6. I learned a lot about how it works and how much you can benefit from it.

7. This was excellent. Please do this at a different time of the year, might get more students and schools.

8. I think it's very interesting and cool how you can make a living off plants.

9. This is pretty cool.

Survey results – 12/4/15 seed starting structure workshop – English & Hmong

Before workshop:

Rate your knowledge about seed starting structures:

Poor	Fair	Good	Excellent
8		3	

Rate your ability to secure materials and build a seed starting structure:

Poor	Fair	Good	Excellent
9			2

After workshop:

Rate your knowledge about seed starting structures:

Poor	Fair	Good	Excellent	More Excellent (write in)
	3	5	2	1

Rate your ability to secure materials and build a seed starting structure:

Poor	Fair	Good	Excellent	More Excellent (write in)
	3	3	4	1

Comments: Would like to have learned more about the heating system and associated equipment.

We are fortunate to have this opportunity to learn more about seed starting. This is something that will increase our production capability on our farm. Looking forward to more field days and workshops at the Yang Farm.

A verbal survey was conducted after Hmong workshop with enthusiastic responses.

Educational Walk Through High Tunnel Tour And Workshop (September 22, 2016)
UMC/Lincoln Cooperative Extension
Evaluation Summary

I. EVALUATION OF TOPICS

Please rate your degree of knowledge about each topic before and after listening to speakers.

Ratings:

1 = No knowledge
2 = Little knowledge
3 = Some knowledge
4 = Knowledgeable
5 = Very knowledgeable

TOPIC	Avg. Before	Avg. After	Knowledge Gained
EXAMPLE	**2**	**4**	**OMIT**
1. Knowledge of high tunnel temperature control.	1.16	3.16	2.0
2. Knowledge of planting dates and cultural techniques of high tunnel crops.	1.66	3.33	1.67
3. Knowledge of improving soil fertility and transplanting within a high tunnel.	1.5	3.66	2.16

TOPIC	Yes	No
Was this workshop helpful to you as a small farmer in Missouri?	100%	
Are you more aware of SARE, AgrAbility , and NRCS EQUIP	5 Yes	1 No Late

II. Overall Workshop Evaluation

Did you find the presentation style, room layout, and speaker arrangement, added to your learning experience in a positive way?

1. Yes
2. Yes, very well presented and interesting.
3. Yes

Additional comments:
1 .Very Interesting.
2. Ability to ask spontaneous questions.
3. This was so interesting.

I would like to have Lincoln University ISFOP or UMC Extension to (Shon, Randy, David, Patrick or Robert) call me
YES_____ NO_____

Name_____ Phone #_____

Email _____

Webb City Farmers Market Educational Walk Through High Tunnel (June 23, 2016)
UMC/Lincoln Cooperative Extension
Evaluation Summary

I. EVALUATION OF TOPICS

Please rate your degree of knowledge about each topic before and after listening to speakers.

Ratings:

1 = No knowledge
2 = Little knowledge
3 = Some knowledge
4 = Knowledgeable
5 = Very knowledgeable

TOPIC	Avg. Before	Avg. After	Knowledge Gained
EXAMPLE	**2**	**4**	**OMIT**
1. I have learned various skills in high tunnel production this evening	1.6	4.0	2.5

TOPIC	Yes	No
3. Was this workshop helpful to you as a small farmer in Missouri?	100%	

II. Overall Workshop Evaluation

Did you find the presentation style, room layout, and speaker arrangement, added to your learning experience in a positive way?

1. Very Educational
2. Yes
3. Yes

Additional comments:

I would like to have Lincoln University ISFOP or UMC Extension to (Randy, David, Patrick or Robert) call me
YES_____ NO_____

Name_____ Phone #_____

Email _____

Webb City Farmers Market Educational Walk Through High Tunnel (July 28, 2016)
UMC/Lincoln Cooperative Extension
Evaluation Summary

I. EVALUATION OF TOPICS

Please rate your degree of knowledge about each topic before and after listening to speakers.

Ratings:

1 = No knowledge
2 = Little knowledge
3 = Some knowledge
4 = Knowledgeable
5 = Very knowledgeable

TOPIC	Avg. Before	Avg. After	Knowledge Gained
EXAMPLE	**2**	**4**	**OMIT**
1. I have learned various skills in high tunnel production this evening	1.2	3.7	2.5

TOPIC	Yes	No
3. Was this workshop helpful to you as a small farmer in Missouri?	100%	

II. Overall Workshop Evaluation

Did you find the presentation style, room layout, and speaker arrangement, added to your learning experience in a positive way?

1. **Yes**
2. **Fabulous**
3. **The walking tour was so enjoyable vs. a classroom setting.**
4. **I really enjoyed the speakers.**

Additional comments:
We were able to see how the plants grow and see problems. Answers to problems were given. Speakers were very knowledgeable and complimented each other

I would like to have Lincoln University ISFOP or UMC Extension to (Shon, Randy, David, Patrick or Robert) call me
YES_____ NO_____

Name_____ Phone #_____

Email _____

Educational Walk Through High Tunnel Tour And Workshop (August 25, 2016)
UMC/Lincoln Cooperative Extension
Evaluation Summary

I. EVALUATION OF TOPICS

Please rate your degree of knowledge about each topic before and after listening to speakers.

Ratings:

1 = No knowledge
2 = Little knowledge
3 = Some knowledge
4 = Knowledgeable
5 = Very knowledgeable

TOPIC	Avg. Before	Avg. After	Knowledge Gained
EXAMPLE	**2**	**4**	**OMIT**
1. Knowledge on fall season production and season extension.	2.4	4.4	2.0
2. Planting dates and cultural techniques of high tunnel crops.	2.1	4.5	2.4

TOPIC	Yes	No
3. Was this workshop helpful to you as a small farmer in Missouri?	100%	
4. Do you currently have a seed starting greenhouse?	1 Yes	10 No

II. Overall Workshop Evaluation

Did you find the presentation style, room layout, and speaker arrangement, added to your learning experience in a positive way?

1. **Yes**
2. **Excellent hands-on opportunity.**
3. **Great, Everything exciting.**
4. **Absolutely – Love the hands on aspect of program.**
5. **Yes**
6. **Yes, as always, a professional presentation.**
7. **Yes!**
8. **Yes**

Additional comments:

I would like to have Lincoln University ISFOP or UMC Extension to (Shon, Randy, David, Patrick or Robert) call me
YES_____ NO_____

Name_____ Phone #_____

Email _____

High Tunnel Workshop, March 23rd, 2016
Evaluation Summary

I. EVALUATION OF TOPICS

Please rate your degree of knowledge about each topic before and after listening to speakers.

Ratings:

1 = No knowledge
2 = Little knowledge
3 = Some knowledge
4 = Knowledgeable
5 = Very knowledgeable

TOPIC	Avg. Before	Avg. After	Knowledge Gained
EXAMPLE	**2**	**4**	
1. Understanding the value of a high tunnel.	2.22	3.33	1.11
2. Taking a soil test and appreciating productive soil.	1.66	3.11	1.45
3. Teng Yang's – Cultural methods and techniques in high tunnels.	2.22	3.44	1.22

TOPIC	Yes	No
4. Was this workshop helpful to you as a small farmer in Missouri?	100%	

II. Overall Workshop Evaluation

Did you find the presentation style, room layout, and speaker arrangement, added to your learning experience in a positive way?

1. Yes
2. Yes
3. Yes, very helpful.
4. Yes, very helpful.
5. Yes
6. Yes
7. Yes

Additional comments:

1. Thank you for your presentation.
2. I appreciate the networking with other farmers to learn from them.

Project 3: Cooking Classes, Demonstrations and Market Introductions for Low-Income Families

Columbia Center for Urban Agriculture
Billy Polansky
Final Performance Report

Project Summary

Low fruit and vegetable consumption and plateauing farmers market sales trends nationwide are showing a need for new marketing channels to be used to promote specialty crops. Simultaneously there is a surge in efforts to attract low-income families to shop at farmers markets with programs that accept SNAP and WIC and programs that match SNAP and WIC dollars. Through a collaboration of community stakeholders (including the Columbia Center for Urban Agriculture, the culinary arts programs at *Columbia Public Schools*, the *University of Missouri Extension's Family Impact Center*, and the *Columbia Farmers Market)* this project provided Columbia Farmers Market tours, group cooking demonstrations, and home cooking instruction to enhance the participation of families living with limited resources in consuming local foods in Columbia, Missouri. The project was needed and timely to address local and national trends of low fruit and vegetable consumption and plateauing farmers market sales, and to increase the utilization of SNAP and SNAP matching programs available at the Columbia Farmers Market.

Project Approach

This project aimed to improve the collaborative efforts of involved partners to provide access to and education about healthful specialty crop options for families seeking healthier diets that included Missouri specialty crops available at the Columbia Farmers' Market.

Project partner's roles were executed as follows:

Columbia Center for Urban Agriculture: Coordinated project activities, conducted group and home cooking classes, managed the Opportunity Gardens Program, and performed outcome measurement

The culinary arts programs at Columbia Public Schools: Provided cooking demonstrations at area food pantries, farmers markets, and community events

The University of Missouri Extension's Family Impact Center: Hosted group cooking classes

The Columbia Farmers Market: Conducted farmers market tours

Work Plan Activities:	Performance:
Field Trips to the Columbia Farmer's Market	• 289 field trips were held in this grant period (for est. 607 participants). "Ambassadors" at the farmers market gave tours to first-time visitors helping them navigate the market and feel more comfortable shopping for specialty crops, using SNAP benefits, and asking questions of farmers.

Cooking Demonstrations	• 3 cooking demonstrations at the Family Impact Center (for 107 participants). CCUA staff hosted hands-on cooking classes that featured Missouri specialty crops for low-income community members. • 12 cooking demonstrations at area pantries (for est. 600 participants). CCUA partnered with the Columbia Area Career Center to have high school students provide demonstrations at a local food pantry where CCUA donates fresh vegetables. Students demonstrated a recipe featuring specialty crops at the pantry, distributed samples of the dish, and distributed a recipe card for the dish prepared. All recipe ingredients were available at the food pantry that day. • 2 cooking demonstrations at the Hootenanny (for est. 1650 participants). CCUA partnered with the Columbia Area Career Center to have high school students provide demonstrations at CCUA's annual Harvest Hootenanny community dinner. Students demonstrated a recipe featuring specialty crops at the event, distributed samples of the dish, and distributed a recipe card for the dish prepared. • 6 cooking demonstrations at the farmers' market (for est. 700 participants). CCUA partnered with the Columbia Area Career Center to have high school students provide demonstrations at the Columbia Farmers Market. Students demonstrated a recipe featuring specialty crops at the event, distributed samples of the dish, and distributed a recipe card for the dish prepared.
Home Cooking Classes	• 21 home cooking classes were conducted in this grant period (for 106 participants). CCUA staff taught hands-on cooking classes that featured Missouri specialty crops in the homes of low-income families.

Goals and Outcomes Achieved

		Children help me in the garden.	I cook meals at home.	The meals I cook include fruits and vegetables from my garden.	I have fresh fruit and vegetables to eat.	I eat pre-packaged meals (frozen, canned, boxed).	I eat fast food.	I go to the food bank at least once per month.	I buy food from Farmer's Markets.	I eat the food I grow in my garden.	I leave the food I grow in my garden on the plant or in the garden.	I spend less money on food because I eat from my garden.	I use the "Garden Guide Book" provided by CCUA.	I eat more vegetables than I did before I had a garden.
# of answers		83	86	86	85	85	82	86	86	83	85	85	85	84
# of 3	Always	23	67	36	46	9	5	27	9	54	8	36	26	45
# of 2	Sometimes	41	19	35	36	60	64	28	52	15	23	27	34	19
# of 1	Never	11	0	2	2	16	13	30	25	3	41	9	9	5
% of 3	Always	28%	78%	42%	54%	11%	6%	31%	10%	65%	9%	42%	31%	54%
% of 2	Sometimes	49%	22%	41%	42%	71%	78%	33%	60%	18%	27%	32%	40%	23%
% of 1	Never	13%	0%	2%	2%	19%	16%	35%	29%	4%	48%	11%	11%	6%

Goal	*Benchmark*	*Target*	*Performance Measure*	*Outcome*
Increase attendance at Columbia	18% of CCUA's Opportunity Gardens	75% of field trip attendees will report attending	Surveys will be given to field trip participants at	All tour participants signed up for CFM

Farmer's Market by low-income families.	Participants report shopping at the farmer's market regularly.	the Columbia Farmers Market.	the end of each year.	newsletters and attended the market.
Increase use of Missouri specialty crops in meals prepared by low-income families.	A pre-test will determine how likely participants are to prepare meals with Missouri specialty crops.	75% of cooking class participants will report being more likely to prepare meals with Missouri specialty crops.	Pre/post surveys will be given to cooking class participants.	42% of respondents reported "always", and 41% of respondents reported "sometimes" including vegetables in meals cooked at home.

Performance measures were met by project participants. Tours, demonstrations, and home cooking classes engaging participants in CCUA's Opportunity Gardens (serving families living with low income) increased cooking at home and consuming a healthy amount of specialty crop vegetables in their diets. CCUA expects that continued participation will lead to further increases in healthy lifestyle choices about consuming specialty crop vegetables and enhanced participation in the Columbia Farmers Market.

Beneficiaries

This project benefited new visitors to the Columbia Farmers' Markets, people receiving food benefits from area food banks/pantries, and low-income participants in CCUA's Opportunity Gardens Program.

How many benefited from the project? 3,770 Columbia residents participated directly in this project

How did they benefit from the project? Overall, this project helped participants become more comfortable accessing the Columbia Farmers Market and learn new skills for utilizing specialty crops in their home kitchens.

Describe the potential economic impact of the project. The 3,770 participants were more likely to prepare meals using specialty crops. This project brought 580 new customers, or customers who purchase more of Missouri Specialty Crops, to the Columbia Farmers Market. The numbers of people indirectly impacted by this project were difficult to calculate, but it is obvious that there are additional positive economic outcomes resulting from participants in this program who share with their friends and families the information they acquire as a part of their participation in this project.

Lessons Learned

The initial project outcomes included collecting photos from program participants. We found that survey data collection was more approachable and were not able to use that metric.

The project had a budget change which eliminated the van rental expense (originally intended to bring low-income community members to the market and give them private tours) and added an expense to hire "ambassadors" at Columbia Farmers market to provide tours to new market visitors. The participants did not want to ride in the van to the farmers market. We later realized that many people were coming to the market one time, and never coming back. So this budget change helped retain first-

time visitors instead of creating one-time visitors. Partnering with the Columbia Farmer's Market to provide market tours was far more effective than providing transportation to families to come to the market. Numbers of participants surged after making that change.

Contact Person

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Project 4: Raspberry Production and Insect Protection inside a Moveable High Tunnel

The Curators of the University of Missouri
Tim Reinbott
Final Performance Report

Project Summary

Raspberries are a high dollar crop and with a market demand that has never been higher, raspberries can provide vital income for the Missouri fruit grower. However, plants and crops are vulnerable to environmental problems and with weather fluctuations, high winds, and heavy rains common in Missouri, growing marketable raspberries can be a difficult endeavor. Another obstacle for raspberry growers is the recent introduction of the Spotted Wing Drosophila (SWD) in Missouri. Increasing populations of SWD have caused severe damage to bramble crops, resulting in half to total loss of marketable berries. Much is still unknown about best management practices of this new pest.

With a movable high tunnel system, there is an opportunity to not only provide weather and insect protection for raspberries, but also possible to earn extra income by using the valuable space to grow other high-value crops when the tunnel isn't used for raspberries.

A movable high tunnel can be successfully utilized throughout the year including cold crops, summer vegetables and raspberries. Keeping raspberries protected from SWD with a movable high tunnel equipped with insect screen requires scouting and utilizing sticky traps since insect screen reduces air flow and results in higher temperatures in the hoop house.

Project Approach

Two movable high tunnels were constructed: at Jefferson Farm and Garden and at the South Farm Research Center. In addition, a caterpillar house was constructed at Happy Hollow Farm under the direction of Liz Graznak. Each was constructed to demonstrate how it could be used for exclusion of the SWD. After completion, raspberries were planted in 2017 in the caterpillar house and the movable high tunnels and then raspberries replanted in the movable high tunnels in 2018. At each location four varieties of raspberries were purchased from Norse Nurseries: Joan J, Josephine, Polka, and Caroline and delivered in early April. In 2016 and 2017 raspberries were placed in a cold room for up to two weeks before planting with poor success. In 2018, within a few days after arrival bare root raspberries were planted in soil that had been treated with composted manure, tilled, and then laid with weed barrier. Water drip lines were placed on five ft centers and raspberries were planted in groups of five of each cultivar with a 2 ft spacing of each plant. There was nearly 100% survival of raspberries and any that did not live were replaced with those that had been heeled in for this purpose. Prior to blooming raspberries were covered by the movable high tunnel and openings covered with insect guard netting. At Happy Hollow insect guard was placed over the caterpillar tunnel.

Movable high tunnels can also be used for extending the growing season year around. In January 2018 cold crops including leaf lettuce, head lettuce, broccoli, radish, and beet were planted in the high tunnel in rows five feet apart at Bradford in order to demonstrate the feasibility of utilizing movable high tunnels all four seasons. Weeds had often been a problem in high tunnel vegetable and fruit production and the use of weed mat is an alternative to pesticides. A drip line for irrigation was placed under each vegetable row. Row covers were used to protect vegetables during periods of cold weather and would sometimes be used several concurrent days and sometimes only at night (Figure 1). Several days at or

below zero were recorded and the combination of the high tunnel and row covers protected plants. The only vegetable damaged by cold weather was broccoli. Some lettuce varieties began being harvested in early March and all continued through May. After the hoop house was moved (Figure 2) to the tomato area vegetable growth slowed down due to cold weather (Figure 3) but leaf lettuce in particular was outstanding in yield and taste. Throughout the planting and growth of the cold crops photos were taken and shared on the South Farm Facebook page which drew much attention during the winter and early spring.

Tomato plants were started indoors in mid-February to be transplanted into the high tunnels. In mid-March both high tunnels were moved over soil that had been tilled and mixed with composted manure. After 10 days for the soil had warmed and weed barrier with drip line was put down and four varieties of tomatoes were planted: Cherokee Purple, Better Boy, Super Sweet 100's and Early Girl. Each row was five feet apart and plants planted 2 ft apart within row (Figure 4). Tomatoes grew off well in both high tunnels and row covers had to be used on occasion. On April 7 an extremely cold wind blew and some of the tomatoes on the edges at the Jefferson Farm and Garden frosted back whereas those at South Farm did not. The difference was that the hoop house at Jefferson Farm is on top of a hill and the wind was able to get under the plastic whereas the South Farm tunnel was protected on the north by trees. However, most of the tomatoes grew back from the frost. Tomatoes in both locations grew off well the rest of April despite the fourth coldest April on record. Following a very cold April there was a record warm May and the tomatoes quickly grew and began to set on fruit with cherry tomatoes maturing by early June.

In August 2017 a Vegetable field day was held at the Bradford Research Center and the South Farm Research Center with the movable high tunnels as the feature attraction at South Farm with 40 participants. The high tunnel had already been moved over the raspberries and issues were discussed including culture and the heat trapped by the insect barrier cloth. Another field day was on July 12th 2018 as part of a Gardening Field Day (Figure 5) and a main highlight was the high tunnel being moved from over tomatoes to over the raspberries. A video was taken and recently put on the South Farm Facebook page and YouTube (Figure 6). The field day was in conjunction with Dr. Dave Trinklein's summer Master Gardener Training. We had 30 from the class room portion attend plus 10 others who came for the outside portion only. Many came just for the movable high tunnel demonstration and were very pleased. I spoke on the movable high tunnel and how it can be used throughout the year and summarized the results of the cold crops and tomatoes. I then spoke about the issue of the SWD and discussed options including insecticides and their drawbacks and the alternative way of excluding the insects through a movable high tunnel or caterpillar house equipped with insect screen. Many of the participants were aware of the spotted wing Drosophila and its damage and were interested in alternatives to insecticides. We then discussed how the movable high tunnel could be used year around and other possible vegetables and small fruits that could be used. Since then the raspberries have set a few berries on during this first year of establishment (Figure 7) with a full crop expected next year.

Happy Hollow Farm has dozens of visitors each year and the caterpillar tunnel and raspberries is demonstrated in organic production. This is important to show how only through exclusion that raspberries can successfully be produced without the use of pesticides. However, scouting is a must to know when protection methods of SWD must be taken.

Goals and Outcomes

GOAL 1: Increase grower knowledge of high tunnel raspberry production and the economic viability of using movable high tunnels by demonstrating controlled growing conditions and insect protection and disseminating information at field days, two workshops, and two different growers conferences.
Outcome: This was accomplished in 2017 (tomato and raspberry crop) and fully in 2018 with winter crop, tomato crop, and raspberry crop. In 2017, 40 visitors attended the vegetable tour and in 2018, 35 attended the gardening tour. We were able to further the outreach through Facebook and YouTube. In March 2017 and 2018 this research was discussed at the Horticulture College at Rolla MO with 30 attending each time. Passive educational outreach was accomplished through posters at the South Farm Showcase each year that is attended by several thousand persons interested in learning more about agriculture. Each year Happy Hollow farm has dozens of visitors and customers who get firsthand knowledge of organic vegetable and small fruit production.

Follow up: We will work with Dr. Dave Trinklein and Dr. Maryann Gowdy to identify a student to collect raspberry data in 2019 as part of their Capstone Project that is needed to graduate in Plant Sciences. In 2017 and 2018 this project was part of two student's capstone projects, Tanner Leslie in 2017 and Travis Molitor in 2018. They developed proper cultural practices for the raspberries and exclusion of the SWD. Future Capstone Projects will concentrate on production throughout the growing season.

GOAL 2: Increase adoption of techniques for organically managing Spotted Wing Drosophila for bramble crops.
Outcome: It was surprising how few gardeners knew about the Spotted Wing Drosophila (SWD) although they were aware of fruit damage to brambles. Commercial growers were much more aware of the issues with SWD and were interested in different techniques. Most were concerned about using insecticides as a means of SWD control and were interested in exclusion techniques that the moveable high tunnel offered as well as other exclusion techniques. This project was successful in bringing the source for the problem to the attention of growers and demonstrating techniques that can be used. As a result more home gardeners and commercial growers will use scouting techniques and exclusion as a means of controlling SWD.

Beneficiaries

Those that benefited from this project were commercial small fruit growers and home gardeners and MU Horticulture students. They benefited in several ways:

-many were interested in the construction, cost, and usability of the movable high tunnels

-increased knowledge of the SWD and its management, many knew that their small fruits had been destroyed but did not know why

-use of movable high tunnel throughout the year

-cultural methods of raspberries

-the use of a caterpillar house in organic production of raspberries

Those that benefited from this project received the information from the two field days that we had in 2017 and 2018, Master Gardener talk at Rolla in 2018, and through farm visits at Happy Hollow Farm. Also, MU Students learned about the movable high tunnels through work experience and presentation

in class as part of their capstone project. In addition, in 2018 social media (South Farm Facebook) was utilized to demonstrate the use of the movable high tunnel during the winter and early spring with cold crops and vegetables and then later on with raspberries. A video was placed on the South Farm Facebook page showing moving the high tunnel from tomatoes to raspberries and an explanation of the protection again the SWD.

The two field days had a total of 75 participants. The South Farm Facebook video had 11 shares and reached 484 people directly. Earlier posts highlighting the cold crops and tomatoes reached 2,116 people. The Happy Hollow web site and Facebook page describes many aspects of the farm and has photos of caterpillar tunnels.

Gardeners and commercial growers will continue to be reached through field days and social media as we continue to utilize the movable high tunnels for the next several years. We hope to summarize our findings for a poster or presentation at the annual Great Plains Growers Conference in 2019.

Economic Impact: It is difficult to measure the economic impact directly since many farmers and gardeners take the information learned from field days and social media tailor it to their particular farming operation. However, being able to have a multi-season hoop house enables farmers to grow vegetable and/or fruit crops year around, often when prices are higher. As we have MU Plant Sciences Capstone projects involved in the next few years to quantify the harvest we should have a better understanding of the economic impact.

Although less expensive caterpillar tunnels can only be utilized for a single crop. However, intercropping other high dollar crops within the raspberries could be valuable to create additional income.

Lessons Learned

Movable high tunnels and caterpillar tunnels equipped with insect screen can be an effective means of excluding the two spotted wing Drosophila (SWD) from raspberry and other soft fruits. The largest issue is that an insect screen which is small enough to exclude the fly will block a significant amount of air movement causing temperatures to rise. This is particularly an issue during the hottest portion of summer when raspberries are blooming and setting on fruit. Part of this issue of heat entrapment can be addressed by opening and covering the top vents with insect screen in order to allow for air circulation. Scouting for the Drosophila including the use of sticky traps outside and inside the high tunnel can be an effective decision tool to when to utilize the insect screen during those critical times when the SWD is present.

The value of the movable high tunnels is further enhanced by utilizing it throughout the year by producing cold crops in the late fall and winter, tomatoes or another high value warm season crop in the spring and early summer and then protecting raspberries from SWD in the summer. In each case not only is year around vegetable production increased by vegetable and fruit quality increased. Other possibilities of utilizing the movable high tunnel when protection of the raspberries is not required include strawberries, cut flowers (annual and perennial), melons, and other cucurbits. Insect exclusion for cucurbits can be done in a similar way as with the raspberries to protect from cucumber beetles and stink bugs in the early summer.

Although movable high tunnels are relative simple to operate care must be taken to keep the tunnels operational. Selecting the correct sight is important. The high tunnel at JFG is on the highest spot on the farm and is subjected to more wind damage and in 2018 wind swept under the bottom plastic and

frosted tomatoes even when underneath row covers. In contrast, the high tunnel at South Farm is in a protected area near a tree line on the north side and tomato plants were not damaged from the wind.

Movable high tunnels can easily be moved by two people if the tracks are free of soil and debris. It usually takes about 30 minutes to prepare for moving and cinching back down including cleaning tracks, removing and replacing sand bags and turn buckles.

Raspberry survival issues that resulted in poor survival of raspberries were overcome by planting within a few days of arrival. In the past bare root plants were put in a cold room for a few weeks. This caused undue stress on the plants and resulted in poor survival. Also, by using weed mat in the raspberry planting not only were weeds controlled but moisture seemed to be more even and abundant.

Contact Person

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Additional Information

Video of Movable High Tunnel:
https://www.youtube.com/watch?v=qavxHCVbSXU

Photos and videos of the movable high tunnel and caterpillar tunnel can be seen at these social media sights.

South Farm Facebook
https://www.facebook.com/musouthfarm/

Happy Hollow Web Site:
https://www.happyhollowfarm-mo.com/

Happy Hollow Facebook
https://www.facebook.com/OrganicFarmHer/

Project 5: Determining and Mitigating the Potential Occurrence of Cyanide in Elderberries

The Curators of the University of Missouri
Dr. Andrew Thomas
Final Performance Report

Project Summary

The University of Missouri successfully conducted an important research project to understand the potential occurrence of poisonous cyanide within elderberries, elderberry products, and specific components of elderberry fruits (seed, skins, pulp, juice, stems). Until now, the potential (or perceived) occurrence of cyanide within elderberries and elderberry products was hindering the growth of this burgeoning industry. Meanwhile, if, in fact, cyanide was found to be a concern in elderberries, we needed to understand how best to remediate such occurrence in a safe manner. A number of laboratory experiments were conducted on various elderberry fruit components and commercial products using both the inexpensive picrate paper method and extremely sensitive instruments at the MU Proteomics Center. Apple seeds (which contain cyanide) and commercial apple juice were used as benchmarks for comparing our results from elderberry. The results are definitive. Cyanide is not a concern in fresh ripe elderberries, juice, or processed products. While elderberry indeed contains a variety of organic compounds called cyanogenic glycosides (which hold a tightly bound cyanide ion), the levels are very low and are of no threat to consumers; in fact, levels found were much lower than levels found in commercial apple juice. Elderberry stems and unripe (green) berries do contain higher levels of cyanogenic glycosides, and so should be excluded from elderberry products as possible. These results open the door for significant advances in elderberry cultivation and processing in the U.S., as well as increased consumption as a dietary supplement taken for its significant health benefits.

Project Approach

The project involved scientific research using both a simple, inexpensive method (picrate paper test) to test various elderberry materials and products for cyanide, as well as extremely sensitive, advanced instrumentation (liquid chromatography and mass spectrometry) in the MU Proteomics Center. With both approaches, we first developed methods for testing elderberries and elderberry products for cyanide, and then evaluated a variety of elderberry components (seeds, skin, juice, pulp, stems) and commercial products for cyanide in detail. To prepare the samples, the fruit of multiple cultivars was produced in the field, and, upon harvest, cleaned, de-stemmed, sorted, and frozen. Thereafter, thousands of individual berries were painstakingly separated into seeds, skin, juice, pulp, and stems for detailed quantification of cyanide (if any) in each berry component. We needed to know if cyanide occurs in any of these individual berry components (for example, the seeds), so that its occurrence could be mitigated during product processing. Berries from several genetically distinct cultivars were analyzed to ensure our results applied “across the board”. Apple seeds (which contain cyanide) and commercial apple juice were used as benchmarks for comparing our results from elderberry. Commercial elderberry products on the market were also purchased and analyzed for cyanide. The project also involved outreach to elderberry producers and processors as the results of the project were widely disseminated at multiple meetings and venues. These included three presentations at The Great Plains Growers Conference, St. Joseph, MO, January, 2017, 2018, 2019; two presentations at the annual Comprehensive Elderberry Workshop (with international attendance) in Jefferson City, MO, June 2017, 2018; and significant discussion of the project at the annual University of Missouri Southwest Research Center Field Days, September 2017, 2018. The project results were also presented to the scientific community

at the Midwest Regional Meeting of the American Chemical Society, Ames, Iowa, October, 2018. The results will also be published in a scientific journal, and can thereafter be cited by producers and processors as needed.

Project partners included Andrew Thomas, Michael Greenlief, Michael Appenteng, and several seasonal students (Jill Boydston, Emily Couture, and Patrick Mahoney) from Missouri State University who assisted with field work, harvest, and sample preparation. Thomas oversaw all field work and sample preparation, Greenlief oversaw and guided the laboratory component, and Appenteng (PhD student) conducted the laboratory research, and complied and analyzed the data. Appenteng is also leading the effort to publish the results in a prestigious scientific journal.

Goals and Outcomes Achieved

We successfully developed both inexpensive (picrate paper test) and highly sensitive laboratory methods (LC-MS/ MS) for quantifying cyanide in elderberry. After painstakingly preparing samples of individual berry components (seeds, skin, juice, pulp, stems), we definitively showed that cyanide is not a concern in ripe elderberries, but that stems and unripe berries may contain trace levels of cyanide and should be avoided if possible. We also evaluated commercial elderberry products and confirmed that the levels of cyanide contained therein (if any) are below routine detection level and at or below that of commercial apple juice. Because cyanide was determined not to be of concern in elderberry, we did not need to develop processing methods to safely remove cyanide from finished products or processing facilities.

The results of this project were highly anticipated (and very well-received) by elderberry growers, processors, and consumers. The project results have been presented widely to elderberry producers and processors at multiple meetings and conferences. We will present this work again at the Great Plains Growers Conference in St. Joseph, MO, January, 2019 (now accomplished). Ultimately, the results will be published in a scientific journal as a peer-reviewed paper. This paper is currently in active preparation and we anticipate publication in 2019. Once published, it will become a landmark paper that is definitive and citable by producers, processors, and consumers of elderberry. The paper will be freely available on the internet, with links to it posted on the websites of numerous elderberry producers and processors (such as River Hills Harvest, Norm's Farms, etc.).

Beneficiaries

The beneficiaries of this project are elderberry producers, processor, marketers, and consumers. Now that the "gray cloud" surrounding the potential occurrence of cyanide in elderberry has been definitively resolved, the entire industry can move forward in full confidence. We estimate the number of elderberry producers and processors directly benefited to be 400; the number of current and new elderberry product consumers to be limitless.

Lessons Learned

This very straightforward project was a terrific example of using cutting-edge technology and extremely sensitive laboratory instruments at University of Missouri to answer basic questions that are critically important to Specialty Crops producers, processors, and consumers in Missouri and beyond. This model could / should be used for other similar projects.

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Project 6: Expanding Educational Opportunities for Specialty Crop Farmers and Market Managers

Missouri Farmers Market Association
Eileen Nichols
Final Performance Report – April 14, 2018

Project Summary

The problem – The Missouri Farmers Market Association had found that moving their annual conference to different locations that were hosted by the local market improved both the conference and attendee interest. The primary drawback of this approach is funding. Very few Missouri markets had the resources and donors to underwrite the costs of the meeting. Most markets have very limited financial resources and cannot commit the funds needed to put on all aspects of the meeting. Registration costs covered some of the expenses but not all. Thus, the pool of markets able to serve as meeting hosts was small and the ability to fund top quality education tracks was very limited.

This project was particularly timely given the experience of the 2015 annual meeting which was held in Columbia, Missouri, by the Columbia Farmers Market. Despite the market being one of the largest in the state, it was unable to secure adequate funding to provide a full complement of high quality programming. It was imperative that the Association offer a high caliber set of tracks for specialty crops growers and market managers at the 2016 meeting so the Association continued to attract growers and managers from across the state for training purposes.

The project - "Expanding Educational Opportunities for Specialty Crop Farmers and Market Managers" provided funding to enable the Missouri Farmers Market Association to hold three annual meetings, underwriting the travel and fee costs of presenters and the cost of a bus tour at each meeting. This support was critical to bring regional and national presenters to the participants of the meetings and to move the location of the meetings to different parts of the state to make attendance less costly and time consuming for participants. The three meetings were held in Webb City (2016) in Southwest Missouri, St. Louis (2017) in Eastern Missouri and Jefferson City (2018) in Central Missouri.

Project Purpose

The Missouri Farmers Market Association has held annual meetings since its inception in 2001 however Association resources were too limited to bring in regionally and nationally recognized presenters. Typically Missouri farmers' market managers also have very limited resources to devote to education since most are volunteers and few markets in the state have much in the way of budget.

The need for additional funding was made evident by the annual meeting in 2015 when one of the largest and best funded markets in the state hosted the meeting and yet was unable to attract enough resources to provide a full complement of high quality programming. Securing the grant for the 2016 annual meeting allowed the association to provide the training that should be expected from a state market organization.

The project did not build on a previously funded project with the SCBGP or SCBGP-FB.

Project Approach

The Association successfully planned and held three annual meeting with high quality training for farmers' market managers and the specialty crops farmers selling at their markets. (Please see next section for specific topics and attendee and non-attendee responses) As proposed the meetings were held in three geographically separated locations – Webb City in Southwest Missouri, St. Louis in East Missouri and Jefferson City in Central Missouri. Changing the location did not affect attendance to the extent expected. Generally about half of the same attendees came regardless of the location. More surprisingly, attendance did not build has expected. The 2017 conference in St. Louis was the best attended which is not surprising given the abundance of farmers markets in the St. Louis area. More surprising was that our goal of building conference attendance did not materialize. None of the conferences were attended as well as the three conferences immediately prior to the grant period (2014, 2015, and 2016) and the last (2018) had the smallest attendance of all.

The board suspects the poor attendance in 2018 may have been the result of inadequate publicity and undertook much earlier and broader publicity for the 2019. While the 2019 meeting has been rescheduled due to weather, registrations are more than double what they were in 2018 leading to the conclusion that adequate advance publicity is a critical component of success.

Match funding in the amount of $1,500.00 was included in this proposal to cover any non-specialty crops beneficiaries resulting from this project. Typically, non-specialty crops market vendors attending the meeting comprise less than 5% of the attendees. By the same token, the majority of vendors at most Missouri farmers markets are specialty crops growers, so training market managers results in significant benefits to those growers. Since this grant paid for less than 50% of the total cost of the conferences with other costs being paid by the association, any costs associated with non-specialty crops vendors were covered by the association share.

Partners - University of Missouri Extension and the Missouri Department of Agriculture and Association member market managers and specialty crops growers participated in planning of this project as well as providing information and presentations during the conferences.

Goals and Outcomes Achieved

All three annual meetings, with bus tours, were held. While attendance did meet expectations initially, it did not grow significantly has hoped. The number of markets participating in the meetings ranged from 41 managers representing 14 markets in 2016, to 53 managers representing 20 markets in 2017, to 21 managers representing 18 markets in 2018. Some markets attended all the meetings, but most attended only the meeting held closest to them which was one of the reasons to move the meetings to different locations. A total of 30 markets had representatives at one or more meetings.

2016 meeting in Webb City - topics

Farm tour - Amos Apiaries, Keltoi Winery, & Braker Farm

- Cultivating Strong Communities through Farmers Markets

- Retail Farm Market School
- Post Harvest Cleaning & Sanitation
- Tour of the market & the commercial kitchen at the Webb City Farmers Market
- Managing Volunteers
- Expanding SNAP Usage at Your Farmers Market
- Succession Planning or Preparing your Market for Transitions in Leadership
- Organic Pest Management
- Healthy Soils
- Value-added Grants for Farmers Panel
- Webb City Farmers Market presentation
- State News
- Power of Produce
- Collecting & Sharing Market Data to Measure & Promote Growth
- Food Safety
- FSMA/GAP Updates
- Selling to Restaurants: Getting Your Foot in the Door & Maintaining Long-Term Relationships
- Round Table discussions

2017 meeting in St. Louis - topics

Farm tour – Earth Dance, an urban garden, SLU Kitchen

- *They* don't want to eat healthy," or "*They* just need to be educated" and other myths unearthed in an urban food swamp
- 2BuyAg: Using Tech to expand market farmers' customers reach
- Urban Agriculture Act of 2016
- Weighing, Measuring, and Packaging Market Produce
- How the Fresh Stop Market movement is changing the lives of small, organic farmers and eaters in Kentucky
- SLU Innovation Kitchen
- Farm-based CSA and Apprentice Program
- SNAP and Nutrition Incentives at Farmers Markets Panel
- Community Food Processing Centers
- Value Added Producer Grants Federal versus State
- Cost Share Grants and Marketing
- Kids Market Programming & How to Host a Farm to Table
- Chef's Cook Real Challenges and Guest Chefs at Market
- Value-Added Producer Panel
- Round Table discussions

2018 Jefferson City - topics

Farm tour – Sellmeyer Farm, Lincoln Kitchen/Dan Kuebler

- New AgriMissouri Market Handbook
- FSMA update
- Farmers Market Coalition Data Collection Tools
- Ivanhoe Farmers Market presentation
- Farmers Market Coalition Legal Toolkit

While no base-line data was available a survey was conducted by email and phone to secure feedback regarding the meetings. 50% of attending markets responded.

Did you learn anything at the meeting(s) you attended: 100% yes?

Did you implement anything that you learned at the meeting(s): 93% yes 7% no?

If you implemented anything, did it increase your sales: most were unable to quantify any increase with one guessing 15% - 20% increase and one stating that sales did not increase?

Regarding sales increase, this proved to be a difficult question to quantify for several reasons, the most basic being that many markets do not collect or maintain vendor sales records. Another barrier is the direct correlation of implementation and results. There does not seem to be a way to determine, for example, whether implementing an improved SNAP reimbursement system directly resulted in additional sales. Attendees could state that information learned resulted in reduced labor on their part but not on whether sales were increased.

Specific comments included:

"I took away a lot of good information and excellent ideas to incorporate in our local market."

"I learned so much. I particularly enjoyed the variety of the different Urban Farms, Rural Farms, and Sustainable Food Industry projects. I have incorporated many of the things I've learned into my farmer/vendor training."

From a farmer/manager "I found the information given to be quite helpful, especially that about tools. While I cannot ascribe an increase in my crop production to the meeting, I can certainly say that my labor cost decreased as a result of the information I received. Keep up the good work!"

This from a professional market manager "The 2018 Conference was particularly educational for me. The Legal Toolkit and Data Collection tools presented by the Farmers Market Coalition provided many tools that I will take into this year's season. Additionally, I gained knowledge in the FSMA course and the AgriMO handbook course that I can use to help my vendors be in compliance with state and federal regulations."

"OH, YES, I learned a lot. Put that in all capitals! We implemented what we learned in Webb City especially from the transition presentation. We put together an action calendar with dates and contacts so the market could operate smoothly. Ironically the manager was out of action the entire next year due to heart surgery but the market did fine because all the information was in place."

"Yes, all the meetings were filled with information which I have shared with vendors and other market managers."

"Learning at the Webb City meeting about vendor forms for reporting SNAP sales was revolutionary for us. We had been using a receipt system that was cumbersome in the extreme. We have implemented the new vendor form system and it is like night and day."

"Even though I have been involved in growing and market management for many years I always come across little gems at the annual meeting that either I'd forgotten or I didn't know."

Managers who did not attend the meetings listed the following reasons: too far, did not know about it, information was not relevant.

Beneficiaries

As stated above, 30 markets had representation at the meetings (often with several persons attending for each market). These markets host close to 1,000 specialty crops farmers and many thousand customers. As demonstrated by survey comments above, participants in the annual meetings not only implemented what they learned into market operations, benefiting both farmers and customers, but also shared information with their farmers regarding best practices and shared with other market managers, extending the knowledge gained far beyond the attendees.

In addition at the Webb City annual meeting presentations (Organic Pest Management, Healthy Soils, and Value-added Grants for Farmers Panel) were made specifically to specialty crops farmers. These presentations were attended by about 40 farmers. Attendees of these presentations were not separately surveyed. In retrospect, they should have been.

Lessons Learned

Developing valuable programming for such a diverse group is challenging. Association market members range from a large public market with professional management to very small 4 to 7 farm markets with volunteer management. The resources, the missions, the opportunities and the constraints of member markets run the gamut.

Nevertheless facilitating connections between markets and allowing time to develop relationships can be among the most valuable aspects of a statewide meeting. Regardless of the size and resources of markets, almost all are managed by people passionate about farmers markets. Connecting these people so they can share ideas and experiences, as well as reinvigorating their enthusiasm for a new year is an important component of an annual meeting.

Distance is a big factor in meeting attendance. Most market managers in Missouri have no budget for travel and often have full time jobs which means they would have to take time off from work to attend a week day meeting or to travel across the state to a Saturday meeting. Managers are sometimes also farmers and leaving the farm overnight can be a problem if there are morning and evening chores to attend to. The association is working with the Missouri Department of Agriculture to establish a series of workshops for market managers to be held throughout the state in hopes of reaching more market managers.

Bus tours of farms and value-added operations became less valuable as meetings were repeated. Many market managers already visit their own vendors so taking time to see similar operations in other parts

of the state became of less interest. The association has decided that future meetings will not include tours.

Better attention to surveying should have been given. Our plan called for pre- and post-surveys for farmer and manager attendees and this was not done. Post- surveys were conducted at the end of each conference and also by phone and email at the end of the project. Participation at the end of the conference was fair, but did not include all the farmers who attended the specific farming sessions as those took place midway in the conference program and most had left before the conference ended. Follow up surveying resulted in poor responses, hence the phone calling, but since the farmer sessions were open to the public we did not have attendance contact information for walk-ins. Nor did we have a method to determine who attended which of the tracks. In other words, we neither developed the method or the follow-through necessary to secure the data we wanted. Clearly, more work is needed in this area, as well as clearer communication with the person in charge of surveys.

Given that there does not seem to be a good way to determine increased sales as a direct result of the grant activities that will not be one of the goals of any future proposed project, though we believe it will still be one of the results.

Contact Person

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Additional information

2016 Missouri Farmers Market Association Conference
January 22nd & 23rd, 2016
Route 66 Event Center – 21 South Webb Street
Webb City Public Library – 101 South Liberty
Webb City, Missouri

Friday, January 22nd
8:30 - 9:00 am – Bus Tour Registration – Route 66 Event Center
9:00 am - 12:00 pm – Farm Tour – visits to include a winter production farm with heated and unheated tunnels and a hydroponic lettuce tunnel, a winery and an apiary.
12:00 - 12:50 pm – Lunch for bus tour participants only – Central United Methodist Church, 6 South Pennsylvania
12:00 - 1:00 pm – Conference registration at Route 66 Event Center

Friday	
1:00	**Cultivating Strong Communities through Farmers Markets** - *Dru Montri*
2:00	**Mini-sessions –discussions on a wide range of topics led by experts – pick two**
3:00	**Retail Farm Market School –** *Cleaning & Sanitation – Debi Kelly*

4:00 - 5:00 pm – MFMA Board of Directors Meeting - Route 66 Event Center
6:30 - 8:30 pm – come & go - Tour the historic Webb House – Broadway & Webb - and enjoy a reception at the Middlewest Building – 1 South Main, enter from the alley behind the building.

Saturday, January 23rd
8:30 - 9:30 am – Registration at Webb City Farmers Market & the Route 66 Event Center
8:30 am – Presentation by USDA RD & Webb City Winter Farmers Market Tour – at the market

All Market Management Tracks take place at the Route 66 Event Center. All Vendor Tracks take place at the Webb City Public Library

Saturday	Market Management Track	Vendor Track
9:30	**Managing Volunteers** *Columbia Center for Urban Agriculture*	**Organic Pest Management** *Adam Montri*
10:30	**Expanding SNAP Usage at Your Farmers Market** - *Eva Agudelo* Wholesome Wave	**Healthy Soils** *David Yarrow*
11:30	**Succession Planning or Preparing your Market for Transitions in Leadership** *Dru Montri*	**Value-Added Grants for Farmers Panel** *Matt Moore,* Rural Development & *Marla Young,* MO Dept of Ag

12:30-1:15 pm – Lunch at the Route 66 Event Center –*Webb City Farmers Market presentation*
1:15-1:45 pm – State News – *Missouri Department of Agriculture*

Saturday	Market Manager Track	Vendor Track
2:00	**Power of Produce** *Angela Foley*	**Food Safety - FSMA/GAP Updates** *Patrick Byers*
3:00	**Collecting & Sharing Market Data to Measure & Promote Growth** *Dru Montri*	**Selling to Restaurants: Getting Your Foot in the Door and Maintaining Long-Term Relationships** *Adam Montri*

Program subject to change.

2017 Missouri Farmers Market Association Conference
January 20th & 21st 2017
Il Monastero ~ Saint Louis University
St. Louis, Missouri

Thursday, January 19th
5:00 – 7:00 pm Happy Hour with MFMA Board of Directors at Basso (At Cheshire Hotel)
Friday, January 20th
8:00am - 12:00 pm Pre-Conference Bus Tour(Earthdance, Bee Simple, SLU Innovation Kitchen, & more)*
12:00 – 1:00 pm Lunch (Included with Pre-Conference Tour)
12:00 pm – Early Registration *Begins*

Friday	
1:00	**Keynote: Fresh Stop Markets** – *Karyn Moskowitz, New Roots (Louisville, KY)*
2:10	**2BuyAg: Using tech to expand market farmers' customer reach**– *Kim Harrison &Olivia Vann*
3:20	**Urban Agriculture Act of 2016** – *Beth Low-Smith, KC Healthy Kids*
4:30	**Host Market Presentation / Round Table Discussion** – *Facilitated by MFMA Board of Directors*

6:00 pm – 8:00 pm – Social @ the Schlafly Taproom

Saturday, January 24th
8:00 am - 9:00 am – Conference Registration

Saturday	Vendor Track	Market Manager Track		Value-Added Track
9:00	**Weighing, Measuring, and Packaging Market Produce** *MO Dept. of Ag*	**Fresh Stop Markets** *Karyn Moskowitz*		**SLU Innovation Kitchen**
10:10	**Farm-based CSA and Apprentice Program** *Kris and Stacey Larson* *Riverbend Roots Farm*	**SNAP/Double Up Food Bucks Panel** *Fair Food Network, USDA, FNS, MO Foundation for Health*		**Commercial Kitchen Information** *Debi Kelly – MU Extension*
11:20	**Value-Added Grants** *USDA and Missouri Agricultural and Small Business Development Authority*	**How to Host a Farm to Table Dinner**	**Kids Farmers Market Programs**	**Value-Added Grants** *USDA and Missouri Agricultural and Small Business Development Authority*
		Corrina Smith – Columbia Farmers Market		

12:20 pm - 1:20 pm – Lunch

Saturday	Vendor Track	Market Manager Track	Value-Added Track
1:30	**Cost Share Grants and Marketing** *MO Dept. of Ag*	**Chef's Cook Real Challenges and Guest Chefs at Market** *Deb Henderson – Midtown Farmers Market* *& Chef Cassy Vires – Companion Bakery*	
2:40	**Value-Added Producer Panel** *Facilitated by Deb Connors – City Market*		
3:40-4:00	**Closing – Final Remarks and Sendoff**		

*Separate Registration Required
**Schedule and speakers subject to change

Featured Market

The Ivanhoe Farmers' Market began in 2012 in response to limited fresh food options available in the Ivanhoe Neighborhood. The community decided that there weren't enough fresh fruits and vegetables in their neighborhood and therefore organized community gardens and urban farmers to respond to the demand for fresh produce. What began as a program called Grown in Ivanhoe, which gave technical assistance and helped develop growers, quickly developed into a Farmers' Market. In its beginning the vendors were mostly those growing in the neighborhood but now have vendors from all over the Kansas City Metro and offers not only fresh fruits and vegetables, but also baked goods, shaved ice, soap, honey and a variety of other products. The Ivanhoe Farmers' Market is not only a place for residents of the neighborhood to access fresh fruits and vegetables it is also a place where friends and families can spend their evenings talking with neighbors and building community.

The **Missouri Farmers Market Association** is a group of markets, market managers, market supporters and vendors working together to make Missouri farmers markets healthful, vibrant and vital parts of their communities.

Mission Statement: To connect the Farmers Markets of Missouri with resources and access to partnerships in order to build healthy, sustainable and vibrant local food systems in their communities.

Vision Statement: Create an organization with a statewide footprint to educate, advocate and promote Missouri's Farmers Markets in a sustainable and resourceful manner creating vibrant partnerships with stakeholders.

MFMA Board of Directors

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MISSOURI Farmers Market ASSOCIATION

2018 ANNUAL CONFERENCE JANUARY 19 & 20, 2018

LINCOLN UNIVERSITY SCRUGGS CENTER 819 CHESTNUT ST., JEFFERSON CITY

IVANHOE FARMERS' MARKET
3700.woodland.ave.64109

MISSOURI Grown USA

LINCOLN UNIVERSITY MISSOURI COOPERATIVE EXTENSION

co-sponsors

Schedule

Friday

1:00 – 4:00 pm Tours (Sellmeyer Farms, Fulton, MO; Lincoln University Commercial Kitchen with Dan Kuebler; Farm Inspection Q&A, Quality Inn & Suites Hospitality Room)
5:00 – 6:00 pm MFMA Board Meeting (Quality Inn & Suites Hospitality Room)
6:30 – 9:00 pm Meet and Greet (Quality Inn & Suites Hospitality Room)

Saturday

8:00 am Registration
9:00 am Welcome/Introductions (Rene Sackett, MFMA Board President)
9:30 – 11:45 am Agri MO Farmers Market Handbooks (MO Dept of Ag)
12:00 – 12:30 pm FSMA Tips for Market Managers (James Quinn, MU Extension)
12:30 – 1:30 pm Lunch
1:30 – 2:30 pm FMC Data Collection (Jen Cheek, FMC)
2:30 – 3:20 pm Featured Market (Ivanhoe Farmers' Market- Neil Rudisill)
3:30 – 4:30 pm Hot Topics (choose three tables, 20 minutes each)
4:30 – 5:30 pm FMC Legal Toolkit (Jen Cheek, FMC)
5:30 pm Closing Comments

Keynote Speaker

Jen Cheek is the Executive Director of the Farmers Market Coalition (FMC), a national nonprofit dedicated to strengthening farmers markets so that they can serve as community assets while providing real income opportunities for farmers. Over the past four years, Jen has been working to fulfill FMC's mission to document and publicize the triumphs of farmers markets, while responding to the training, networking, and advocacy needs of the growing farmers market community. During her tenure at FMC, projects have included the development of the Free SNAP EBT Equipment Program in partnership with the USDA Food and Nutrition Service, research into data collection and communication models for farmers markets, and surveying food safety practices at the local level. Jen believes that in addition to serving as important economic and agricultural incubators, community centers, and platforms for food education, farmers markets are the happiest places on earth.

Previously working in urban planning, Jen collaborated with numerous municipalities and government agencies to create civic meeting spaces, preserve natural areas, and design parks and gardens all over the U.S. Specializing in communication design and outreach, she worked closely with community stakeholders to research and distill data, build consensus, create educational materials, and craft plans and policies. She holds a Master of Urban and Environmental Planning degree from the University of Virginia, and a Bachelor of Fine Arts from the University of Michigan.

Bios

The Missouri Department of Agriculture is dedicated to the promotion and protection of the state's agriculture industry. With nearly 100,000 farms on more than 28 million acres of farmland, agriculture contributes $88.4 billion to the state's economy. Missouri Grown, MDA's branded program and part of the Ag Business Development Division, works to connect producers with consumers. Missouri Grown Marketing Specialist Rachel Heimericks works in all areas of ag business development, but specifically with Missouri's farmers' markets and urban and nontraditional farming operations. Visit www.MissouriGrownUSA.com to learn more.

Neil Rudisill is the Health Initiatives Manager for the Ivanhoe Neighborhood Council and is also a resident and operates an Urban Farm in the neighborhood as well. Neil began his farming at Johnson County Community College where he completed the Sustainable Agriculture program in 2009. He went on to work on other farms in the area and finally ended up at Cultivate Kansas City where his understanding of Farmers' Markets began to develop. During this time he became interested in Public Health and maintains that healthy food choices are foundational for a healthy community. Wanting to pursue a career in building a healthy community, Neil went to Nursing school at the University of Missouri Kansas City where he received his BSN in 2016. After graduation he took the position at the Ivanhoe Neighborhood Council to help a community develop a healthy eating active living lifestyle. During this time he started Woodland City KC, a half-acre urban farm. Woodland City KC is a four season farm operation selling at the Ivanhoe Farmers' Market as well as to area restaurants.

James Quinn has been a Regional Horticulture Specialist for University of Missouri Extension in Jefferson City for 11 years. He was a wholesale greenhouse salad green and herb grower for 9 years in Michigan. Since moving to Missouri he has been involved in a wide range of agriculture projects, including greenhouses, vegetables, alternative agronomic crops, IPM, high tunnels, and medicinal herbs. In 2017 he became a Produce Safety Alliance Lead Trainer for the Food Safety Modernization Act (FSMA).

Rate on a scale of 1 to 5 with 5 being excellent your evaluatiion of the following presentations:

FARM TOUR	MARKET TOUR	MANAGING VOLUNTEERS	EBT PANEL	SUCCESSION PLANNING	ORGANIC PEST MGMT	HEALTHY SOILS	GRANTS	STATE NEWS	POP
5	5	4	4	4				5	5
4	5	4					3		
5	5	5	5	5				5	
		5	5	5				4	
5	5	5	5				5	5	5
5	5	5	5	5					3
5	5	5	5	5					5
5	5	5	5	5				5	5
		4					5	3	3
4		5		5				4	4
				4				3	
	3	3	4						
		5	4	5				3	
	5	5	5					4	5
5	5	5	5	5				5	5
4	4	3	4	4				4	3
		5	4	4				4	5
	5	5	5	5					5
5	5	3	5	3	5	5	5	5	5
4.7	**4.8**	**4.5**	**4.7**	**4.6**	**5.0**	**5.0**	**4.5**	**4.2**	**4.5**

MARKET DATA	FSMA/GAP UPDATES	SELLING TO RESTAURANTS
5		
5		
5	5	
5		
5		
5		
5		
5		
4		
5		
4	4	
	2	
	3	
5	5	
5		
3		
4		
5	3	3
4.7	**3.7**	**3.0**

2016 suggestions for 2017

Topics

Market Manager Training
Transitional Leadership
Conflict Training
Conflict Resolution - Mgmt to Vendors
Experts on Grants - how & where to find
Fruits & Veggies that are not as problematic as others
Fruits & Veggies best & worst sellers

Conference Improvements

Longer time for breakout sessions
Likes that each conference is unique to market hosting
Snacks/Coffee
Breakout sessions
Breakout sessions with moderators

MFMA more helpful

Provide more resources online
Put newsletter in MailChimp
Grant Resources
Farmer resources - seed/plant suppliers, etc

2015

Market Best Practices
Vendor Standards of Conduct
Open Discussion/Round Tables
MFMA Website Overview
Technology
Grant Writing

conflict mgmt
risk assesment
emergency preparedness
Ideas for Special Events
Programs like Power of Produce
More workshops at each time
Time Management
Volunteer Management
How to engage your board
Handling difficult customers/vendors
Partnerships
New Manager orientation
fundraising/sponsorship

Bigger Tradeshow
Scale Certification
New sessions, stop repeating
Dessert for meals
Discussions instead of lectures
Snacks, dark chocolate
Have markets bring samples of brochures/flyers/mailers/etc to display

Start-Up Checklist
Links on Website to Resources
Online resources
more educations opportunities all around state

2018 evaluations of presentations with 5 being most helpful				
FARM TOUR	**AGRI-MISSOURI HANDBOOK**	**FSMA TIPS FOR MANAGERS**	**FMC LEGAL TOOLKIT**	**FEATURED MARKET PRES.**
	5	5	5	5
4	4	3		4
3	4	4	2	3
	3	4	5	4
	3	5		5
4	5	4	5	5
	4	5	4	5
4	5	5	5	5
4	4	5	5	5
3.80	**4.11**	**4.44**	**4.43**	**4.56**
3.8	4.1	4.4	4.4	4.6

ROUNDTABLE DISCUSSIONS	FMC DATA COLLECTION
5	5
3	5
3	4
3	5
4	
5	5
4	5
5	5
3	5
3.89	**4.88**
3.9	4.9

2018 suggestions for 2019 conference

Topics	Conference Improvements
Attracting more vendors & customers	shorter day / 2 day event
	provide bottled water
specific grant opportunities	More time for Q & A / discussion
Vendor Development	don't begin on Friday
Building an Advisory Board	Move round tables to beginning of day for get-to-know-you
legal issues	more attendees
new ideas for your market	copy of handbook
child-based educational programs	smaller/fewer tables to facilitate networking
How to gain sponsors	hold featured market session sooner

MFMA more helpful

list services available
provide info on how to contact
provide contact info for other mkt managers
frequently needed state numbers / resources

provide contact info to make it easier to get info/mentor
resources like podcasts, books, etc
engage personally with markets via phone call or e-mail

Project 7: Effect of Rust on Elderberry Growth, Yield, and Juice Characteristics

The Curators of the University of Missouri
Dr. Michele Warmund
Final Performance Report

Project Summary

Interest in growing elderberry has surged in the past few years due to the potential for high economic returns for producers and increased consumer interest in health-promoting food products. As commercial growers expand their acreage and plantings mature, new production problems have been identified, including elderberry rust. This disease is caused by pathogenic fungi, *Puccinia bolleyana* and was described in 1861, but no additional research has been conducted on elderberry rust although it is common in Missouri. Thus, studies were conducted to ascertain if rust infections affect plant growth, fruiting, or berry puree quality. This work did not build on a previously funded project with SCBGP.

Rust symptoms were observed in early April 2016 at 9 to 18° C, ≥ 3 h leaf wetness, and ≥ 85% relative humidity. Vegetative growth and fruiting of young, container-grown 'Ozark' elderberry plants were not affected by *P. bolleyana* when plants averaged 3 rust pustules/plant. At a slightly higher infection level (6 rust pustules/plant), young 'Bob Gordon' elderberry plants had a 31% reduction in berry yield and berry weight compared with uninfected plants. In 2017, the same 'Bob Gordon' plants that had been previously infected with rust had reduced vegetative growth and fruiting was reduced by 36% even though plants were not re-infected with rust. Also, soluble solids and were lower and titratable acidity was greater in berry puree from plants that had been infected with rust in 2016 than that from uninfected plants. In a field-grown 'Wyldewood' plants with a high level of rust infection (averaging 146 pustules/plant), berry yield of canes was reduced by 47% and titratable acidity of elderberry puree was lower than that from control plants. Based on these findings, control strategies for *P. bolleyana* are recommended when ≥ 6 rust pustules/plant occur on elderberry plants, including organic and chemical options.

Project Approach

Experiment 1. This study was conducted to evaluate the effect of a natural rust infection on elderberry plants. 'Bob Gordon' elderberry plants were obtained from a commercial source (Botany Shop, Joplin, MO) on 11 Nov. 2015, transported to the University of Missouri Horticulture and Agroforestry Research Center and then transplanted into 8.5-L polyethylene containers using Pro-Mix BX on 14 Nov. 2015. On 20 Nov. 2015, plants were overwintered, using a polyethylene foam blanket and plastic sheeting for winter protection. Sedge plants were isolated from the elderberry plants during overwintering to prevent an early rust infection.

'Bob Gordon' plants were uncovered on 11 Mar. 2016, and arranged pot-to-pot as shown in Figure 1. Six experimental blocks were arranged with four *C. frankii* sedge plants centrally located within the block for rust infection and one block without the sedge was used for uninfected controls. Six experimental blocks were arranged with four, rust-infected *C. frankii* (sedge) plants centrally located within the block for rust infection and one block without the sedge was used as the uninfected controls. Each block had 'Bob Gordon' elderberry plants with three in each north, south, east, and west direction. For each direction, plants were arranged pot-to-pot, approximately 10 cm from each other. Also, each block

contained three 'Wyldewood' elderberry plants as pollinizers. A clear polyethylene curtain (3.7 m-tall) was placed between blocks with and without sedge plants to prevent rust infection of control plants.

Dormant oil (7.5 ml/L) was applied to plants on 22 Mar. and spirodiclofen (23 ml/L) on 29 Mar. for eriophyid mite control. Thereafter, spirodiclofen was applied to elderberry plants at 10 to 14 day intervals until 15 June. Each plant was pruned to six nodes and fertilized with 50 g Osmocote (15N-9P-12K) on 21 Mar. 2016. Plants were sub-irrigated by filling saucers underneath pots as needed.

The first date when pustules were observed on elderberry plants was recorded. On 29 April and 19 May, pustule number per leaf and plant were also recorded. The number of leaves/plant was recorded on 19 Aug. On 7 Oct., each plant pruned to 15 cm-tall and leaves and shoots were oven-dried at 65°C for 24 h to obtain dry weights. Date of flowering, number of cymes harvested, berry number, fruit weight per cyme, harvest dates, total yield per plant were evaluated in August. Immediately after each fruit harvest, fruit was de-stemmed and stored at -20°C. On 9 Nov. elderberry fruit from each plant was thawed and pH, soluble solids, and titratable acidity were recorded.

Micrometeorological data were recorded throughout the growing season on a U30 HOBO data logger remote monitoring system. Temperature, relative humidity, and leaf wetness were recorded at 10 s intervals, averaged, and logged at 10 min intervals. Temperatures > 8° C, relative humidity ≥ 85%, and leaf wetness periods ≥ 3 h were evaluated to determine infection periods.

After each fruit harvest, destemmed berries were stored at -22° C. For fruit compositional analyses, berries from each elderberry plant were pooled after thawing. A 50 g fruit sample from each plant was placed in a blender cup with 50 mL double distilled water and processed for 30 sec. Puree was then pressed through a mesh sieve to remove seeds. When harvested fruit was less than 50 g per plant, a 1 fruit: 1 double distilled water (w/v) sample was prepared. Soluble solids concentrations were determined with a digital refractometer, using a 0.3 mL aliquot of puree. For pH measurements, a 10 mL aliquot of puree was used. Another 2 mL aliquot of puree was mixed with 48 mL degassed deionized water and automatically titrated. Titratable acidity (TA), expressed as citric acid, was then calculated.

Because plants of the relatively low incidence of rust pustules on 'Bob Gordon' elderberry plants, the T TEST procedure of SAS was used to statistically analyze the effect of *P. bolleyana* on plant growth and fruiting. To test mean differences, a pooled test was used when variances were equal and the Satterthwaite test was used when variances were unequal, $P \leq 0.05$.

On March 1, 2017, 'Bob Gordon' elderberry plants that were naturally-infected with rust in 2016 were uncovered and were maintained without rust re-infection during the growing season. Fruit yield, plant dry weight, and juice characteristics were evaluated as previously described and data for uninfected plants and those with rust infection at low (1 to 5 pustules/plant) and medium (6 to 10 pustules/plant) levels were subjected to analysis of variance ANOVA using the PROC GLIMMIX procedure of SAS with mean separation by Fisher's protected least significant difference test, $P \leq 0.05$.

From the time elderberry plants were uncovered to 19 May 2016, there were 30 potential infection periods with ≥ 3 h of continuous leaf wetness and mean maximum hourly temperatures ranging from 9 to 17˚ C (Table 1). Also, 269 mm of rainfall was recorded during 13 precipitation events. A few rust pustules were first observed on four of 72 'Bob Gordon' elderberry plants on 5 Apr. 2016. However, by 29 Apr. 2016, 59 of 72 plants were infected with rust, with a total of 304 pustules. Rust infection continued and 63 of 72 elderberry plants with 350 total pustules were recorded on 19 May 2016.

‘Bob Gordon’ plants had relatively low levels of rust infection when evaluated on 29 Apr. 2016 (Table 2). However, elderberry plants spaced 10 cm from sedge had more infected leaves and leaflets, and a greater number of pustules per plant than those spaced at 20 cm and 30 cm. Also, the orientation of plants in each block (north, south, east, and west) did not affect the number of infected leaves or leaflets or pustules per plant. By 19 May 2016, the number of infected leaves, leaflets, and pustules per elderberry plant did not differ by plant spacing or orientation. However, when data for rust-infected plants were pooled, the number of pustules per plant ranged from one to 27 ($\bar{x}$= 6). Leaf number of rust-infected plants was also less than that of uninfected plants (Table 3).

The first dates of flowering were similar for all plants, occurring in the last week of June (Table 3). First and last harvest dates for rust-infected plants and uninfected plants were also similar. The mean number of cymes produced on rust-infected plants was three, averaging 761 berries, whereas the mean number of cymes for uninfected plants was two, averaging 930 berries. Mean berry weight from rust-infected plants was 11 mg less than that from uninfected plants (Table 3). On 19 Aug., leaf numbers were similar among infected and uninfected plants. However, shoot dry weight of rust-infected plants was greater than that of uninfected plants.

When berry puree characteristics were analyzed, there were no significant differences among treatments (Table 4). Numerically, soluble solid content was 0.6 ˚Brix lower and titratable acidity was 0.2 g/100 mL higher for rust-infected plants as compared to berry puree from uninfected plants (Table 4).

Experiment 2. This experiment was conducted to determine the effect of rust on plant growth and yield following an artificial inoculation. ‘Ozark’ plants were obtained from a commercial nursey, potted, and pruned back to six nodes per plant on 28 Mar. 2016, as described above. On 8 Apr., fifteen plants were inoculated with rust spores, using one-cm sections of rust-infected sections of sedge leaves. Immediately after inoculation, each plant was sealed in bags for 48 hrs at 20°C and then placed in a nursery area in a randomized complete block design and maintained as previously described. Plant infection data, fruiting, dry weights, and berry puree evaluations were recorded and data were analyzed as described above.

There were no significant differences in infection severity on elderberry plants among inoculation treatments at any evaluation date. One to five pustules ($\bar{x}$= 2.6) per plant were observed on 19 May 2016. Leaf numbers were similar among plants (only varying by one leaf) on 16 May 2016. When other vegetative and fruiting characteristics were analyzed, only the first flowering date was significant with rust-inoculated plants flowering nine days earlier than non-inoculated plants (Table 5). Plants with rust had a harvest period that was five days shorter than non-inoculated plants. Both rust-inoculated and non-inoculated plants had a mean cyme number of three per plant. Numerically, plants with rust produced more fruit and larger berries than those without rust. By 19 Aug. 2016, rust-inoculated plants generally had fewer leaves than non-inoculated plants but the shoot dry weights only varied by ≈ 2.5 g on 10 Oct. 2016. Berry puree characteristics were similar between the treatments, but soluble solids content of berry puree from rust-inoculated plants was generally lower (0.9 ˚Brix), than that from non-inoculated plants (Table 6).

Experiment 3. Three-year-old ‘Wyldewood’ elderberry plants growing in a Weller silt loam soil in a commercial planting near New Bloomfield, MO were used for this study. Eleven elderberry canes of each of three *P. sambuci* rust infection levels (high, medium, and low) were visually assessed and flagged on 18 May 2016. Eleven individual canes of each infection level and uninfected controls without rust were

also flagged in a completely randomized design. Total leaf number, number of *P. sambuci*-infected leaves, and number of pustules per leaf on each elderberry cane were recorded on 31 May 2016. The number of leaves on control canes was also recorded at this time.

Fruit harvest, berry number, and berry weight were recorded from 20 July 2016 to 23 Aug. 2016. Leaves of each cane were counted on 26 Aug. 2016. Canes were pruned to 10 cm and the plant material was harvested for dry weight measurements on 13 Oct. 2016. Fruit compositional analysis was performed as described above.

Elderberry plant growth, fruiting, and fruit compositional data were subjected to ANOVA, using the PROC GLM procedure of SAS. Because significant differences between levels of rust infection were not found, infection data were pooled and the T TEST procedure of SAS was used to analyze effects of rust on infected versus uninfected elderberry canes. To test mean differences, a pooled test was used when variances were equal and the Satterthwaite test was used when variances were unequal, $P \leq 0.05$.

Ranges of pustule numbers per cane for low, medium, and high infection levels were 10 – 99, 100 – 199, and 200 – 300, respectively, on 31 May 2016. Although pustule number varied, significant differences in vegetative and fruiting were not found among the three levels of rust infection. When data were pooled from rust- infected canes, the mean number of pustules was 137 pustules on 31 May 2016. Rust pustules were also observed on flower pedicels before bloom through harvest on 'Wyldewood' elderberry canes in the field planting (Figs. 2 and 3). Leaf numbers per cane were similar for all plants on 31 May (Table 7). Rust-infected canes averaged 8 cymes/cane and non-infected canes averaged 9 cymes/cane. First and last fruit harvest dates for rust-infected canes were earlier than those for uninfected canes. Berry number and berry yield were reduced by rust infection; however, mean berry weights were similar among all canes. On 26 Aug. 2016, rust-infected plants had two fewer leaves and had ≈ 28 g less dry weight than uninfected plants, but results were not statistically significant.

When berry puree was evaluated, soluble solids and pH were similar among canes, but berry puree from rust-infected canes was 0.8 ˚Brix lower than that from uninfected plants. Titratable acidity of juice from rust-infected plants was lower than that of puree from uninfected plants.

A presentation entitled, "The Impact of Rust on Elderberry Plant Growth and Fruiting", was delivered to 125 elderberry growers and Extension Specialists at the Comprehensive Elderberry Workshop in Jefferson City, Mo on June 1, 2017. Another presentation, "Natural Elderberry Rust Infection of *Sambucus nigra* subsp. *canadensis* Plants was delivered to 250 research and extension workers at the American Society for Horticultural Science in Waikoloa, Hawaii on September 22, 2017. A newsletter article entitled, "Elderberry Rust Defoliating Plants was published on April 27, 2017 at: https://ipm.missouri.edu/MEG/2017/4/elderberryRust/ (1842 subscribers). An Extension guide on elderberry rust and its management was posted at: https://extension2.missouri.edu/ipm1036 in November 2017.

Goals and Outcomes Achieved

Before this study was conducted, little was known about the environmental conditions required for *P. bolleyana* infection of elderberry plants or the infection level that limits vegetative growth and fruiting American elderberry. Thus, this project generated new knowledge regarding the critical temperature range and duration of leaf wetness necessary for elderberry rust infection and the number of pustules

per plant whereby fruit yield and grower income is reduced. Most importantly, we found rust infection occurs at 9 to 18° C, ≥ 3 h leaf wetness, and ≥ 85% relative humidity on American elderberry plants. Also, a 31 % reduction in berry yield occurred when young 'Bob Gordon' elderberry plants have 6 or more rust pustules/plant during the growing season, which results in $440/ha estimated loss of income, using a typical plant spacing at 1.2 x 3.1 m (2,688 plants/ha). Even without rust re-infection, yield and plant growth was also reduced the subsequent growing season. For 'Wyldewood' plants with canes averaging 137 pustules/cane, yields were reduced by 47% and $2,295/ha loss of income due to rust infection. Based on these results, cultural, organic and chemical rust control measures recommendations were developed for producers when ≥ 6 rust pustules/plant occur on elderberry plants.

A presentation entitled, "The Impact of Rust on Elderberry Plant Growth and Fruiting", was delivered to 125 elderberry growers and Extension Specialists at the Comprehensive Elderberry Workshop in Jefferson City, Mo on June 1, 2017. Another presentation, "Natural Elderberry Rust Infection of *Sambucus nigra* subsp. *canadensis* Plants was delivered to 250 research and extension workers at the American Society for Horticultural Science in Waikoloa, Hawaii on September 22, 2017. A newsletter article entitled, "Elderberry Rust Defoliating Plants" was published on April 27, 2017 at: https://ipm.missouri.edu/MEG/2017/4/elderberryRust/ (1842 subscribers). An Extension guide on elderberry rust and its management was posted at: https://ipm.missouri.edu/MEG/2017/4/elderberryRust/ in November 2017.

Beneficiaries

The specialty crop groups and other stakeholders that benefit immediately from this study are members of the River Hills Elderberry Producers (150) and the Midwest Elderberry Association (100). Additionally, producers worldwide are beneficiaries of this work, including the 1842 subscribers to the University of Missouri Integrated Pest Management newsletter which has open internet access at: . https://ipm.missouri.edu/MEG/2017/4/elderberryRust/. As a result of this study, Extension specialists have access to an informational guide on elderberry rust, including a description of the disease cycle on host plants and recommendations for rust control at https://ipm.missouri.edu/pubs/ipm1036.pdf. Also, economic loss (≥ $440/ha) due to decreased fruit yield from elderberry rust infection can be reduced or eliminated, using disease control measures. Consumers of elderberry products will benefit from an increased and more regular supply of these products in the marketplace.

Lessons Learned

All goals of this project were achieved. However, a lesson learned during this study was to anticipate the unreliability of the use of a specific producer's planting due to a change in his rental agreement with the property owner. In spite of the unavailability of one producer's planting, another nearby planting was identified as a study site.

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Additional Information

Tables 1 - 8

Table 1. Continuous elderberry leaf wetness periods with corresponding mean maximum hourly temperatures and precipitation recorded at the Horticulture and Agroforestry Research Center near New Franklin, MO during spring 2016.

Date[Z]	Continuous leaf wetness (no. of hours)	Mean hourly temp. during wetness period (˚C)	Precipitation during leaf wetness period (mm)
3/12	3	12.5	3.1
3/12 to 3/13	18	13.2	5.6
3/13 to 3/14	13	10.9	0
3/14 to 3/15	13	11.4	0
3/31	7.5	13.1	5.1
4/6	3	13.3	0.5
4/10 to 4/11	13	11.9	17.5
4/16	5	10.8	0
4/16	10	10.8	0
4/17	11	12.3	0
4/18 to 4/19	16	16.2	58.7
4/19 to 4/20	11	15.0	35.1
4/20 to 4/21	13	9.7	0
4/22	9	8.9	0
4/23	11	11.4	0
4/25 to 4/26	10	16.2	0
4/26	3	15.4	0
4/27	3	15.8	1.9
4/27	4	12.4	0
4/29 to 4/30	15	14.2	34.5
5/1	8.5	12.0	0
5/6 to 5/7	9.5	12.2	0
5/7	3	17.8	0
5/8	7	14.3	0
5/8 to 5/9	16	17.1	0
5/9 to 5/10	11	16.0	6.9
5/10 to 5/11	14	16.1	1.0
5/12	5	14.4	0
5/15 to 5/16	10	11.2	17.3
5/16 to 5/17	22	10.4	81.8

[Z]Rust pustules (≈ 5) were first observed on elderberry plants on 5 Apr. By 29 Apr., a total of 304 pustules were observed on 59 plants and 350 total pustules were observed on 19 May on 63 plants.

Table 2. Mean number of *P. bolleyana* infected leaves, leaflets, and rust pustules on 'Bob Gordon' elderberry plants at three spacings from *Carex frankii* (Frank's sedge) plants on 29 Apr. 2016.[z]

Spacing from sedge (cm)	No. of infected leaves/p	No. of infected leaflets/p	No. of pustules/plant
10	3.3 a	5.8 a	7.6 a
20	1.7 b	2.5 b	3.5 b
30	2.8 ab	3.4 ab	3.9 b

[z]Means represent 24 replications of each spacing from sedge. Mean separation within columns by Fisher's protected LSD test ($P \leq 0.05$).

Table 3. Vegetative and fruiting characteristics of 'Bob Gordon' elderberry plants with or without *P. bolleyana* rust infection.[Z]

Treatment	Leaf no.[Y]	First flowering date[X]	First harvest date[X]	Last harvest date[X]	Berry no.	Berry yield (g)	Mean berry wt. (mg)	Leaf no.[W]	Shoot dry wt.[V] (g)
Rust-infected	37 a	181 a	225 a	236 a	761 a	84 a	116 a	77 a	48.6 a
Uninfected	31 b	183 a	221 a	238 a	930 a	121 a	127 b	73 a	31.4 b

[Z]Pooled data from rust-infected elderberry plants (n = 42) and non-infected plants (n = 12) were subjected to a t-test. Means followed by different letters are significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, or by a pooled test when variances were equal. Rust-infected plants averaged six pustules/plant.

[Y]Number of leaves/plant on 19 May 2016.

[X]Values represent Julian days.

[W]Number of leaves/plant on 19 Aug. 2016.

[V]Shoots harvested 10 cm above media surface on 10 Oct. 2016.

Table 4. Mean soluble solids, pH, and titratable acidity of berry puree from 'Bob Gordon' elderberry plants with or without *P. bolleyana* rust infection. [Z]

Treatment	Soluble solids (°Brix)	pH	Titratable acidity (g/100 mL as citric acid)
Rust-infected	10.6 a	5.0 a	0.68 a
Uninfected	11.2 a	5.1 a	0.48 a

[Z]Pooled data from rust-infected elderberry plants (n=42) and non-infected plants (n=12) were subjected to a t-test. Means followed by similar letters were not significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, or by a pooled test when variances were equal. Rust-infected plants averaged six pustules/plant.

Table 5. Vegetative and fruiting characteristics of 'Ozark' elderberry plants with or without *P. bolleyana* rust inoculation.[z]

Treatment	Leaf no.[y]	First flowering date[x]	First harvest date[x]	Last harvest date	Berry no.	Berry yield (g)	Mean berry wt. (mg)	Leaf no.[w]	Shoot dry wt. (g)[v]
Rust-inoculated	43 a	179 a	227 a	239 a	1129 a	109 a	165 a	61 a	36.3 a
Non-inoculated	44 a	188 b	235 a	252 a	621 a	70 a	117 a	80 a	38.8 a

[z]Pooled data from rust-infected elderberry plants (n = 12) and non-infected plants (n = 4) were subjected to a t-test. Means followed by different letters are significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, or by a pooled test when variances were equal. Rust-infected plants averaged 2.6 pustules/plant.
[y]Number of leaves/plant on 19 May 2016.
[x]Values represent Julian days.
[w]Number of leaves/plant on 19 Aug. 2016.
[v]Shoots harvested 10 cm above media surface on 10 Oct. 2016.

Table 6. Mean soluble solids, pH, and titratable acidity of berry puree from 'Ozark' elderberry plants with or without *P. bolleyana* rust inoculation.[z]

Treatment	Soluble solids (°Brix)	pH	Titratable acidity (g/100 mL as citric acid)
Rust-inoculated	10.9 a	4.6 a	0.70 a
Non-inoculated	11.8 a	4.6 a	0.72 a

[z]Pooled data from rust-infected elderberry plants (n = 12) and non-infected plants (n = 4) were subjected to a t-test. Means followed by similar letters are not significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, or with a pooled test when variances were equal. Rust-infected plants averaged 2.6 pustules/plant.

Table 7. Vegetative and fruiting characteristics of 'Wyldewood' canes with and without *P. bolleyana* rust infection.[z]

Treatment	Leaf no.[y]	First harvest date[x]	Last harvest date[x]	Berry no.	Berry yield (g)	Mean berry wt. (mg)	Leaf no.[w]	Shoot dry wt. (g)[v]
Rust-infected	56 a	217 a	225 a	1118 a	47 a	43.2 a	37 a	58.4 a
Uninfected	49 a	222 b	228 b	2105 b	88 b	40.8 a	39 a	86.3 a

[z]Pooled data from rust-infected elderberry canes (n = 33) and non-infected canes (n = 10) were subjected to a t-test. Means followed by different letters are significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, or with a pooled test when variances were equal. Rust-infected canes averaged 137 pustules/cane.
[y]Number of leaves/cane on 31 May 2016.
[x]Values represent Julian days.
[w]Number of leaves/canes on 26 Aug. 2016.
[v]Shoots harvested 10 cm above media surface on 13 Oct. 2016.

Table 8. Mean soluble solids, pH, and titratable acidity of berry puree from 'Wyldewood' elderberry canes with or without *P. bolleyana* rust infection.[z]

Treatment	Soluble solids (°Brix)	pH	Titratable acidity (g/100 mL as citric acid)
Rust-inoculated	10.9 a	4.5 a	0.68 a
Non-inoculated	11.7 a	4.4 a	0.78 b

[z]Pooled data from rust-infected elderberry canes (n = 33) and non-infected canes (n = 10) were subjected to a t-test. Means followed by different letters are significantly different ($P \leq 0.05$). Mean separation within columns by Satterthwaite test when variances were unequal, and pooled test when variances were equal. Rust-infected canes averaged 137 pustules/cane.

Project 8: Youth Gardening Education and Support

Kansas City Community Gardens
Kathy Jenkins Hart and Courtney Foy
Final Performance Report

Project Summary

In 2015, the Missouri Department of Agriculture made a first-time grant to Kansas City Community Gardens' Youth Gardening Education and Support (Schoolyard Gardens and Youth Gardens) project in the amount of $32,084.24. KCCG's Schoolyard Gardens program supports 135 Missouri preschools, elementary, middle, and high schools. During the grant cycle, Schoolyard Gardens increased the number of enrolled Missouri schools from 120 to 135, enhanced or amended soil at existing schools, added fruit trees and berry bushes, and helped plant and maintain Spring, Summer, and Fall gardens at each enrolled school.

KCCG's Youth Gardens initiative supports 23 Missouri youth gardens. With support from the Missouri Department of Agriculture, KCCG added 9 new sites and increased growing potential at existing gardens, including new raised garden beds, Missouri specialty crops like fruit trees, berry bushes, soil amendments, and maintenance supplies (straw, mulch, and tomato cages).

The purpose of this project is to introduce Kansas City's youth to new fruits and vegetables that are harvested fresh from their own gardens and develop lifelong habits of eating nutritious foods. Many of KCCG's beneficiaries come from low-income, food-insecure households that do not have easy access to fresh and nutritious fruits and vegetables. These programs provide a place for children to participate in the cultivation of their own nutritious food and learn how to prepare the fruits and vegetables they grow for healthy meals and snacks.

This project did not build on a previously funded project.

Project Approach

During the grant cycle, KCCG's Schoolyard Gardens program worked with 135 Missouri schools. KCCG expanded 31 existing schools' gardens by adding garden beds and amending garden soil. KCCG also enrolled 15 new Missouri schools into the Schoolyard Gardens program, including Smithville Primary School, Willow Woods Learning Center, Chapel Lakes Elementary, Scuola Vita Nuova, Butcher Greene Elementary, Grandview Middle School, Country Kids Early Learning Center, New Young Scholars Early Learning Center, Tiny Hearts Early Learning Center, Faith Academy, Northland Early Learning Center, Maplewood Elementary, Staley High School, Buckner Elementary, and Pembroke Hill School. Newly enrolled schools received Schoolyard Gardens support through site selection and evaluation, construction support, and garden training and technical assistance.
Fruit trees and berry buses were planted at 12 Missouri schools, including raspberry bushes, blackberry bushes, apple trees, and pear trees. Apple and pear trees were selected for schools, because their fruit-bearing season occurs during the school year. To create a more favorable growing environment, Schoolyard Gardens staff constructed 4' x 4' cedar boxes in which to plant the fruit trees. These boxes provide a barrier from lawnmowers and provide better soil conditions. Fruit bearing trees will produce fruit in 3-4 years.

KCCG's Schoolyard Gardens program works to ensure each school receives the individual technical and gardening support they need in order to successfully harvest from their gardens every year. Schoolyard Gardens staff work with each school to construct gardens that maximize harvest potential; select specialty crops that increase student interest in eating vegetables (i.e., sugar snap peas, broccoli, and rainbow carrots); provide gardening education to ensure proper care of plants and insects; coordinate harvesting sessions; and provide nutrition and food preparation education to teach students exciting and delicious ways to prepare their garden harvests for snacks and meals.

To ensure students and garden coordinators have a grasp on the necessary tasks needed to successfully grow vegetables and fruit, Schoolyard Gardens staff led a 9-week intensive gardening series. Grow in the Garden (Sprout in the Garden for preschools) was conducted at 18 Missouri schools and involved working with Schoolyard Gardens staff on a biweekly basis to learn basic planting techniques and care for a garden. Each session featured lessons on a different garden skill, including watering techniques, thinning and reseeding, insect identification, weed prevention, water conservation through mulching, and harvesting methods for the various types of Missouri specialty crops.

KCCG's Schoolyard Gardens program provided all enrolled schools ongoing educational support to garden coordinators/teachers through a number of workshops, printed materials, and online resources. In February 2016, Schoolyard Gardens co-hosted a garden curriculum training session for garden coordinators/teachers with KC Healthy Kids. This training session connected teachers to Missouri-aligned K-8 common core, standards-based lesson plans that incorporate their schools' gardens. In March 2016, KCCG held a Schoolyard Gardens Basic Gardening workshop for teachers. This session reviewed basic gardening practices needed for school gardens and educated teachers/garden coordinators on all of the technical assistance KCCG provides to them. The Preschool Gardens Assistant, created standalone garden lessons that combine gardening, nutrition, and physical activity to be used by preschool garden coordinators/teachers. Each lesson can be accessed on the Schoolyard Gardens page of the KCCG.org website and were updated to include more detailed information during the grant cycle.

Harvest parties are an important part of the Schoolyard Gardens program, conducted at the end of each growing season. These events celebrate the work the students did throughout their garden's season by introducing them to recipes using their own produce. Over 80 First-Graders at Three Trails Elementary in Independence, MO helped prepare kale in a variety of different ways, including kale chips and a kale salad. Students tasted the food at their fall celebration and shared the harvest with their principal.

Banneker Elementary 6th Graders in Kansas City, MO work in the garden each week, growing a variety of vegetables like Sweet Chelsea cherry tomatoes, Mokum carrots, Cherry Belle radishes, and jalapeno peppers. Garden volunteers were surprised by the students' love for jalapeno peppers. This fall, students harvested green tomatoes and made green tomato pickles in their classroom.

An art teacher at Hogan Middle School in Kansas City, MO, worked with students to grow beets, lettuce, carrots, and broccoli. The students prepared a "build your own" salad bar and shared with teachers and other students in the cafeteria. The excitement and interest of the garden has led to the planning of a fruit orchard and additional vegetable growing space for the coming season.

EPiC Elementary in Liberty, MO built their school garden in 2013. The garden's success and school-wide

interest encouraged the school to build 9 additional raised beds in 2016. The students also worked to create garden enhancements, including row cover frames and deer and rabbit deterrents. An Instructional Coach says the garden "provides a hands-on learning opportunity for the students and exposes them to fresh forms of the vegetables they eat."

KCCG enrolled 9 new Youth Gardens in 2016, including Hillcrest Community Center, Spofford House, Bridge Home for Children, Pemberton Park for Grandfamilies, Synergy Services, Barry-Platte Garden, Islamic Center of North America, Turn the Page KC, and Hilltop Family Court. Fruit trees were installed at Brush Creek Community Center, Hillcrest Community Center, Spofford House, Garrison Community Center, and East Hills Village. Berry bushes were also planted at 5 sites to add food-diversity.

KCCG's Youth Gardens' initiative supported 23 Missouri Youth Gardens during the grant cycle. Youth Gardens Coordinator constructed 18 raised beds and installed them at 7 different sites. To provide a healthier soil environment and protect against mower damage, KCCG constructed 10 fruit tree boxes. This is a new approach, and so far the solution has worked. Also installed were two 16"- tall raised vegetable beds that have been very popular with the residents at Pemberton Park for Grandfamilies, a housing complex for grandparents raising their grandchildren. With taller beds, elderly gardeners can work alongside their grandchildren without having to strain as they bend over to pick tomatoes or pull weeds.

The Kansas City Parks & Recreation Department has been a valuable partner as KCCG provides families in low-income neighborhoods exposure to gardening. Three of KCCG's newest Youth Garden sites are community centers operated by KCP&R, and the agency is incorporating the gardens into their summer classes. Brush Creek Community Center started their cucumber plants indoors and encouraged campers to try new foods, like radishes and kale fresh from the garden.

Spofford Home is a preventative and therapeutic treatment center for children suffering from abuse. KCCG built their garden with a Girl Scout, for her community service project. Along with cabbage, purple kale, collards, broccoli, and tomatoes, apple trees were recently added to the garden. Despite having gone through some very traumatic experiences, a nine year old boy who gardens at Spofford Home is hopeful and excited for the future through his garden participation. "I can't *wait* to make an apple pie," he says!

Goals and Outcomes Achieved

Our target during the project period was to: (1) Add eight new Missouri school gardens and eight new Missouri youth gardens (consisting of 1-4 4' x 12' raised beds); (2) Add fruit gardens consisting of fruit trees and/or berry bushes at ten new or existing Missouri school gardens and eight new or existing Missouri youth gardens; (3) Complete other garden improvements (adding raised beds or soil amendments) at five existing Missouri school gardens and five existing Missouri youth gardens, and (4) demonstrate an increase in the number of fruits and vegetables eaten by participating students.

Our achievements during the project period include: (1) The enrollment of 15 new Missouri schools into the Schoolyard Gardens program and 9 new Missouri sites into the Youth Gardens initiative; (2) The addition of fruit trees and berry bushes to 14 Missouri schools and 10 Missouri youth garden sites; (3) The completion of garden improvements at 31 Missouri schools and 7 Missouri youth garden sites, and (4) A 93% positive-response rate among garden coordinators/teachers that participation in the

garden increased their students' daily servings of fruits and vegetables.

Beneficiaries

During the grant period, KCCG's Schoolyard Gardens program served 135 Missouri schools with approximately 8,100 preschool-high school students participating. KCCG's Youth Gardens' initiative served 23 youth gardens with over 400 children and their families participating during spring, summer, and fall growing seasons. The youth involved in this project learned valuable lessons in gardening and nutrition that will help to develop lifelong appreciation for growing their own food. This can eventually result in a significant decrease in the cost of a family's groceries and medical costs associated with improper nutrition.

Lessons Learned

KCCG's Schoolyard Gardens program piloted row cover usage to extend growing seasons and, more importantly, to speed up the growing process during the spring planting season. Because of the nature of the school calendar, spring crops must be encouraged to grow as quickly as possible. By covering crops such as broccoli and cabbage as soon as they were planted in the spring, plant maturity increased by over one week and insect damage was minimized. In the fall of 2016, KCCG purchased supplies to create sturdy, movable frames for the row cover. Eight Missouri schools are using these frames to extend greens, like spinach and collards. Additionally, Schoolyard Gardens' staff encourages schools to plant tomato and pepper plants in late May, so maximum production happens in August when students are at school.

Because many schools are not in session during critical growing seasons, garden usage lessens from June through July. A number of schools do have summer programs or activities at the sites, and nearly 55% of Schoolyard Gardens' plant warm-season gardens. Schools with limited garden interaction are encouraged to plant sweet potatoes, peanuts, and sunflowers, which all take less regular maintenance and will mature after students return in the fall. For schools that do not plant warm-season gardens, KCCG staff has worked to lessen the opportunity for invasive weeds that threaten to overrun the garden. Schoolyard Gardens' staff lay landscaping fabric over the raised beds to serve as bed covers during their dormant summers. Because of the limited nature of many school budgets, KCCG provides tools on loan to enrolled Schoolyard Gardens' schools, including reliable tomato cages, hand tools, and hoses. Without this loan program, many of the schools would not have the ability to establish or maintain their gardens.

Throughout the course of the Youth Gardening initiative, our youth gardens coordinator often reported hearing from his program participants that they would like to grow sweet "fruits" in addition to the tomatoes and carrots more common in food gardens. This project was a great way to introduce brambles (blackberries and raspberries), strawberries, apples, Asian pears, and cherries to a new audience and provide them with lessons on how to grow their own. KCCG's Youth Gardens' initiative puts gardening into the daily activities of the youth we serve. Community centers with thousands of visitors each year now have demonstration gardens with vegetable and fruit crops at their entrances. These gardens act at catalysts for youth to develop a healthy, lifelong habit of gardening. A child visiting an enrolled community center to play basketball, for example, could take a tomato home to enjoy with family for dinner and then decide to participate in the community center's youth garden.

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Additional Information

Additional information can be viewed at:

http://kccg.org/schoolyard-gardens-kccg/

http://kccg.org/gardening-resources/

A glimpse of some school garden activities,

Building:

Planting:

Maintaining:

Harvest:

A sampling of cafeteria food provided from harvest:

Project 9: Continuous Evaluation of Seven Grape Varieties from the Cross of Norton and Cabernet

Missouri State University
Dr. Wenping Qiu
Final Performance Report

Project Summary

The project is a continuation of a previously funded project "Evaluation of Seven Grape Varieties from the Cross of Norton and Cabernet Sauvignon for Selecting New Wine Grapes for the MO Grape and Wine Industry" by the SCBGP. The specific issue and problem is that only a limited number of grape varieties are grown in Missouri and produce quality wines because of harsh climate and high disease pressure. New wine grape varieties are needed for the Missouri grape and wine industry, and will make the industry viable and sustainable. The motivation is that new varietal wines can boost marketing, increase competitiveness, and broaden spectrum of Missouri vintage wines. Breeding and selection of new grape varieties is just in time to fulfill the strategic goal for the industry in enhancing Missouri's wine reputation and expanding Missouri wine's market.

In this project, we recorded viticultural traits in 2016 and 2017, and new results complemented the previous records by verifying the viticultural relevant traits. The verified results help select NC6 as a potential new cultivar for the Midwest region and also a new wine was made from NC6 in 2017. The verified traits are crucial data for making decisions in the selection of the best grape varieties for future planting grapes and making wines. A decision has been made on which new grape varieties shall be selected for the phase II of the project after the multiple years' evaluation. Graduate student Kaylie Austin and two summer interns were trained in this project. We have achieved the project's goal and accomplished major proposed objectives.

Project Approach

The goal of this project is to continue the assessment of the seven new grape varieties for their viticultural characteristics in 2016 and 2017.

We performed the evaluation of viticultural important traits of the seven varieties and two parents "Norton" and "Cabernet Sauvignon" in the project. We recorded dates of bud break, bloom, and harvest dates in 2016 and 2017 (Table 1 and 2). We performed assays of Brix, TA and pH in 2016 (Table 1). The traits of the seven new grape varieties and two parents that have been recorded were summarized in Tables 1 to 4.

Project Investigator Dr. Qiu has supervised overall project progress and administrated the project budget. He worked closely with Susanne Howard to implement the proposed objectives, ensure the recording of traits in the vineyards and the implementation of experiments in the laboratory. Dr. Qiu supervised the evaluation of disease resistance. Susanne Howard has managed the vineyard and greenhouses. She recorded dates of bud break, bloom, veraison, and harvest. Graduate student Kaylie Austin and two summer interns assisted collecting samples, evaluating disease resistance, measuring pruning weight, berry weight, and yield. Kaylie assisted Susanne in measuring pH, TA, and Brix. Kaylie and Susanne analyzed and compiled the data. Dr. Qiu and Susanne Howard wrote the

report.

Goals and Outcomes Achieved

The following are four specific tasks we proposed in the project, we summarized our achievements in bold context.

1. We will assess disease resistance against powdery mildew and downy mildew under controlled conditions by artificial inoculation. This will allow us to collect data under laboratory conditions. We will start evaluating of berry's resistance to gray mold caused by *Botrytis cinerea*.
   Resistance of berries to Botrytis grey mold was evaluated (Table 3). Powdery mildew and downy mildew was not evaluated in the field due to the application of fungicides to those vines as part of standard vineyard practices.
2. We will record the parameters of berry chemistry.
   Berry chemistry of the seven selections was measured (Table 1 and 2).
3. We will start record date of harvest, number of cluster/vine and pruning weight.
   Harvest dates and harvest parameters were measured (Table 1 and 2).
4. We will record cluster weight, berry weight and yield/vine.
   Yield per vine and berry weights are reported in Tables 1 and 2.

Significant recommendations: Based on the data collected in the last two years, we do not recommend selection NC43. We recommend selections NC6, NC17 and NC65 for further evaluation (Table 4). One of the most significant accomplishments is that wine has been made from the selection NC6 by Dr. Karl Wilker in the experimental winery at the Missouri State Fruit Experiment Station. We will continue evaluating NC6, NC17 and NC65 in the Missouri State Fruit Experiment State in the future and plan to grow in other locations for further evaluation. Graduate and undergraduate students have been trained and become skillful laborers.

Cabernet Sauvignon were planted so that traits of new varieties can be compared. The results from the evaluation in previous years reinforced the conclusion that Cabernet Sauvignon is not suitable for wine production in Missouri and emphasized the importance of breeding new cultivars for the industry.

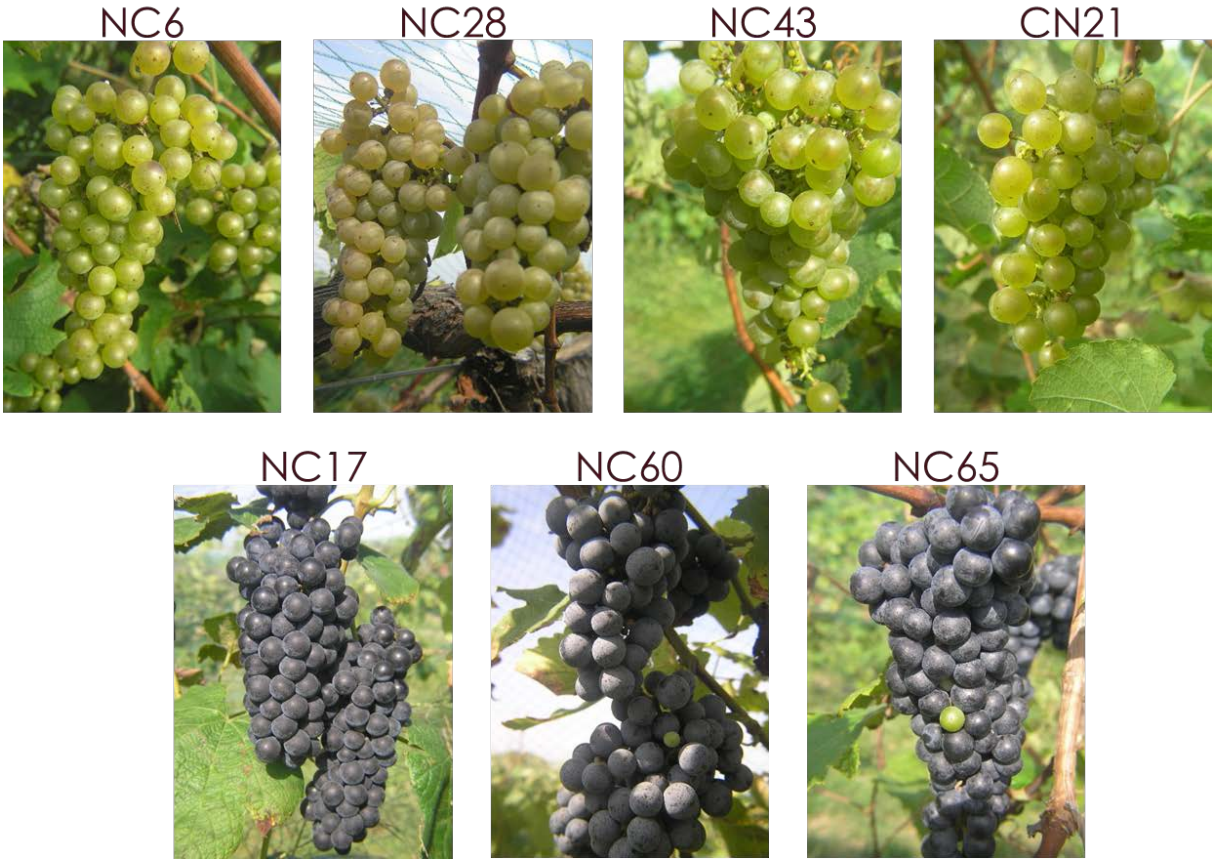

Figure 1: Clusters of the seven selections that were evaluated in this project

Table 1: Traits evaluated for the seven selections and two parents "Norton" and "Cabernet Sauvignon"-2016

New Variety	Botrytis Index (wounded)	Botrytis Index (unwounded)	Pruning Weight (lbs)	Bud Break	Bloom	Harvest Date	Yield/ Vine (lbs)	berry weight (g)	Brix	TA	pH
NC6	2.03	0.76	1.64	4/11/2016	6/6/2016	9/21/2016	12.77	1.28	21.70	0.59	3.21
NC28	1.7	0.33	1.17	4/8/2016	5/29/2016	9/27/2016	5.83	1.32	23.90	0.57	3.30
NC43	1.3	0.83	1.51	4/11/2016	6/2/2016	10/18/2016	5.11	1.58	21.00	0.65	3.19
CN21	2.7	0.47	1.68	4/12/2016	6/3/2016	9/27/2016	8.1	1.09	24.40	0.67	3.21
NC17	1.2	0.77	0.56	4/11/2016	6/4/2016	10/4/2016	4.17	1.29	23.80	0.75	3.39
NC60	1.76	0.53	0.82	4/9/2016	6/2/2016	10/11/2016	1.71	1.34	22.50	0.73	3.35
NC65	1.97	0.833	0.81	4/13/2016	6/3/2016	10/11/2016	N/A	1.20	20.20	0.99	3.25
Parent 'Norton'	0.57	0.47	1.19	4/13/2016	6/3/2016	10/4/2016	14.09	1.23	24.10	0.64	3.37
Parent 'Cab'	3.06	1.37	0.70	4/14/2016	6/4/2016	10/4/2016	N/A	0.81	19.40	0.76	3.15

Table 2: **Traits evaluated for the seven selections and two parents "Norton" and "Cabernet Sauvignon"-January to May 31, 2017**

New Variety	Pruning Weight (lbs)	Bud Break	Bloom	Harvest	Yield/ Vine (lbs)	berry weight (g)	Brix	TA	pH
NC6	2.42	4/11/2017	5/29/2017						
NC28	2.18	4/7/2017	5/28/2017						
NC43	2.23	4/10/2017	5/29/2017						
CN21	1.98	4/13/2017	6/1/2017						
NC17	1.11	4/9/2017	5/31/2017						
NC60	1.26	4/7/2017	5/31/2017						
NC65	1.57	4/12/2017	5/30/2017						
Parent 'Norton'	1.82	4/13/2017	5/30/2017						
Parent 'Cab'	0.26	4/13/2017	5/30/2017						

Table 3: **Evaluation of Botrytis resistance of the seven selections and two parents "Norton" and "Cabernet Sauvignon"**

Variety	Rating	Classification
NC6	2.03	Tolerant
NC28	1.70	Moderately Resistant
NC43	1.30	Moderately Resistant
CN21	2.70	Tolerant
NC17	1.20	Moderately Resistant
NC60	1.77	Moderately Resistant
NC65	1.97	Moderately Resistant
Cabernet Sauvignon	3.07	Moderately Susceptible
Norton	0.57	Resistant

Table 4: **Summary of favorable traits (+) of the seven selections and two parents "Norton" and "Cabernet Sauvignon". The three selections NC6, NC17 and NC65 that have promising traits for further evaluation are in bold.**

Variety	Botrytis Incidence	Botrytis Severity	Downy Mildew Severity	pH	Total Titratable Acidity	Brix
NC6	-	+	+	+	+	+
NC65	+	+	+	+	+	+
NC17	+	+	+	+	+	+
NC28	+	+	-	+	+	+
NC43	-	+	+	+	+	-
CN21	+	-	-	+	+	+
NC60	+	+	-	+	+	+
Cabernet Sauvignon	-	-	-	+	+	-
Norton	+	+	+	+	+	+

The seven new hybrids were initially selected from the 95 progenies of the 2005 Norton and Cabernet Sauvignon cross. Norton-Cabernet Sauvignon hybrids have not been bred and assessed in Missouri. Evaluation of the hybrids of the two prominent grapes will generate new knowledge and insights on viticultural important traits.

Beneficiaries

Economic impact of the Missouri grape and wine industry was estimated as $1.6 billion annually according to a 2010 report prepared for the Missouri Wine and Grape Board (Stonebridge Research Group LLC 2010). Up to 2009, Missouri has 97 operating wineries of producing 925,000 gallons of wines and 393 vineyards with a total of 1,600 acres of fruit-bearing vines and harvesting 4,400 tons of grapes. It is predicted that the impact will continue to grow. With the steady growth of the Industry, new grape varieties and wine varietals are crucial to the sustainable future of the Missouri grape and wine industry. The main beneficiary of the project is Missouri Grape and Wine Industry. Additional beneficiary is the Missouri State Fruit Experiment Station whose mission is to conduct research and outreach projects for the advancement and improvement of the Missouri fruit crop industry. This project has supported the State Fruit Experiment Station's research, outreach and education programs. The hybrids have been assessed for traits that are suitable for Missouri growing conditions. Three selections shall be evaluated for multiple years and made into wines for evaluation of enological traits.

Breeding and selection of new grape varieties has fundamental and significant impact on the strategic planning and sustainable economic viability of the Missouri grape and wine industry. Selection and growing of new Norton-based grape varieties will benefit the Missouri grape and wine industry in the long term. If wines are made of the selected grapes, they will add freshness to the marketing and recognition of Missouri wines and increase Missouri wines' competitiveness in an increasingly competitive global markets**.**

Lessons Learned

One of the original goals of cross breeding Norton with Cabernet Sauvignon was to identify offspring with disease resistance as high as Norton. Scoring disease incidence and severity after fungicide applications would have distorted the results, so initially the hybrids plants were not sprayed at all. While this gave good initial results, eventually it leads to a buildup of high amounts of inoculum in the vineyard. It took several years to reduce the inoculum again to levels comparable to neighboring vineyards. The block of vines for this secondary evaluation was established inside the vineyard while the inoculum levels where still high. This resulted in a longer establishment phase to bring these vines to a mature and fruit bearing status than average, and impacted the type of data available in the first year.

While a complete no-spray situation may give a clear picture of disease resistance, this should only be used as a short term practice and if possible separated widely from other vineyards. We also found that spray applications of OxiDate combined with a "soft" insecticide for spotted wing drosophila can provide partial control of pre harvest berry rot complex.

Disease resistance against powdery mildew was not evaluated in the vineyard. Any assessment of disease incidence or severity would have been skewed by fungicide applications that are required to produce useable fruit for assessing yield and measuring berry chemistry. Resistance to powdery mildew shall be evaluated under the laboratory settings in the future.

We did not attend annual the ASEV-Annual Meeting at Monterey, CA from June 27 to July 1, 2016 as proposed. We did not realize that we can't collect two year's data by the time we would write an abstract for attending the annual meeting. After we collected data for two years, we planned to attend the annual ASEV-Eastern Section meeting, we found that the dates of meeting were after the end of the project. The travel expenses would not be reimbursed after the budget was finalized at the end of May 31. But we were able to present the results in a regional "2017 Show Me Grape and Wine Conference and Symposium" that was held at Columbia, Missouri, March 8-10, 2017.

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Additional Information

Presentations:

Kaylie Austin, Susanne Howard and Wenping Qiu
Assessment of seven new varieties from the cross of Norton and Cabernet Sauvignon
2017 Show Me Grape and Wine Conference and Symposium, March 8-10, 2017. Columbia, Missouri, US.

Thesis

Kaylie Austin**, An assessment of seven new grape varieties and a study of *grapevine vein-clearing virus* in native Vitaceae plants,** May, 2017, Graduate College, Missouri State University

Project 10: Genetic Study of Rooting Ability in *Vitis aestivalis*-derived "Norton" Grape

Missouri State University - Darr College of Agriculture
Chin-Feng Hwang, Ph.D.
Final Performance Report

Project Summary

Why do hardwood cuttings from some grape cultivars root readily, whereas cuttings from others do not? This question is commercially significant, since vegetative propagation by dormant cuttings is the preferred method to produce large quantities of plant material in the grape and wine industry. The *Vitis aestivalis*-derived 'Norton' is a premium wine grape cultivar grown in the Midwest. A significant limiting factor of Norton propagation is how recalcitrant this cultivar is to rooting by dormant hardwood cuttings, which results in limited stock available to meet demand. In view of this, a mapping population of 184 F_1 individuals was constructed from a cross between Norton and Cabernet Sauvignon to study the genetic variation in rooting ability of dormant cuttings and their subsequent growth. For genotyping, 43,000 single nucleotide polymorphism (SNP) markers have been obtained from this population. The construction of a linkage map using SNP markers is completed, and a high-resolution map using both simple-sequence repeats (SSR) and SNP markers has been integrated. A quantitative trait loci (QTL) analysis indicated a rooting ability locus on chromosome 1 of Cabernet Sauvignon. DNA markers closely linked with the trait have been identified and can be further used for the vegetative propagation capacity and rooting ability of Norton grape as well as to determine whether it can be improved in the F_1 hybrid population.

Project Approach

Vitis aestivalis-derived 'Norton', the official grape of the State of Missouri, is grown in many regions of U.S. where *V. vinifera* production requires extensive pesticide use for fungal disease and pest management. Norton (a.k.a. Cynthiana) grape was discovered in a location near Alexandria (formerly Potomac), Virginia, circa 1828 and is a dominant red grape variety used for winemaking in the Eastern and Midwestern U.S. Outstanding traits of Norton are its high level of resistance against a broad-spectrum of foliar and berry diseases and an abundance of anthocyanins and organic acids. Norton is highly resistant to powdery mildew, downy mildew, and harvest rot complex, the latter including black rot, bitter rot and bunch rot. Norton wine is praised for its intense flavor, rich color and full body. It represents a premium wine that is made from an American grape. The unique characteristics of Norton in disease resistance and cold hardiness have heightened its attractiveness to grape growers due to increasing concerns regarding environmental protection and pesticide avoidance. However, propagation of Norton through traditional hardwood cutting has been a major hindrance in providing enough plants to meet commercial demand. Thus, planting stock is limited and costly. Research in the genetics of Norton rooting ability has not yet been explored or understood. Genetic mapping of Norton x *V. vinifera* populations will increase our knowledge of the genetic determinants of this complex agronomical trait. Overall, we seek 1) knowledge of any factor that promotes or constrains rooting ability; and 2) guidelines that allow the incorporation of rooting ability as a selection criterion in strategic or operational breeding plans. We believe that the results generate from this research will provide new insights into the fundamentals of root biology.

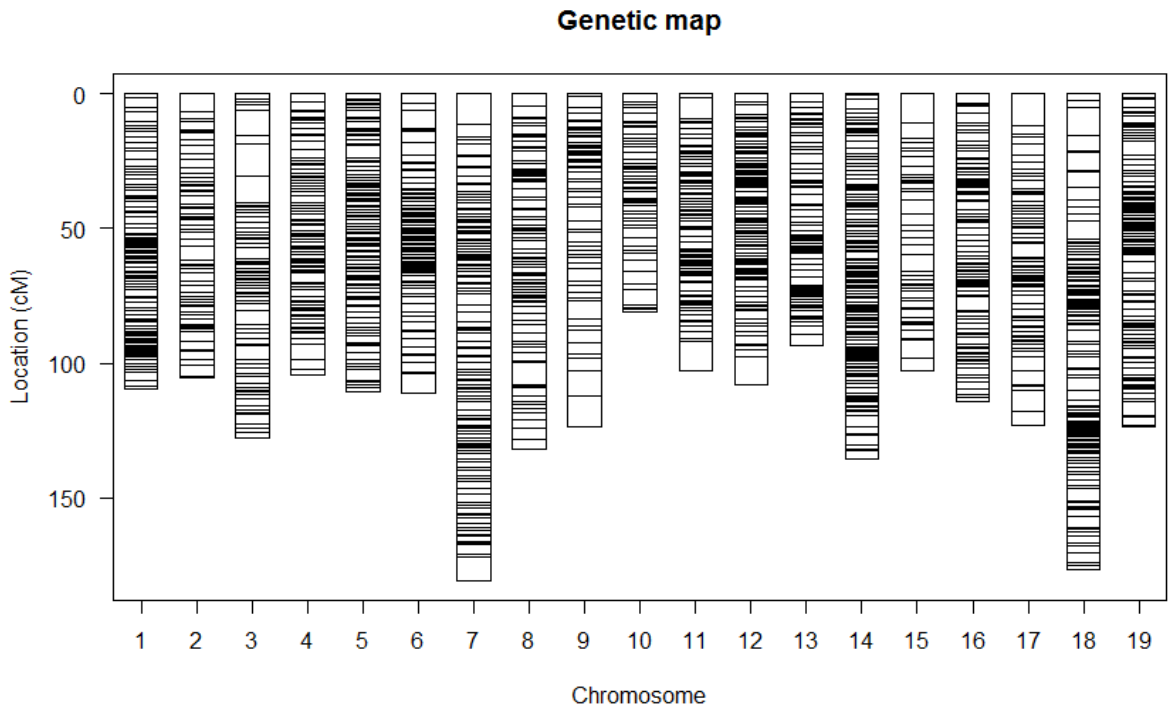
Specific Objectives:

1. Integrate a Norton and Cabernet Sauvignon linkage map using both SSR and SNP markers
2. Conduct segregation analysis of the population for rooting ability for additional two years
3. Identify genetic markers associated with the rooting for future marker-assisted selection

1. Integrate a Norton and Cabernet Sauvignon linkage map using both SSR and SNP markers

An ideal mapping population size for establishing a framework genetic map is approximately 200 progenies. We have established a mapping population of 261 F_1 progeny from crosses between *Vitis aestivalis*-derived 'Norton' and *V. vinifera* 'Cabernet Sauvignon'. This F_1 population was maintained at the Missouri State Fruit Experiment Station (MSFES) in Mountain Grove, Missouri. The first microsatellite/SSR-based linkage map for *V. aestivalis* was constructed using 183 progeny from the crosses of *V. aestivalis*-derived 'Norton' and *V. vinifera* 'Cabernet Sauvignon'. A total of 1,157 simple sequence repeat markers (SSR) were tested, 859 were amplified via PCR and 413 were polymorphic for at least one parent. The map for Norton consisted of 376 markers and covered 1,496.6 cM on 19 chromosomes. We also have assembled 279 polymorphic markers from Cabernet Sauvignon. The consensus map consisted of 411 markers on 19 linkage groups with a total distance of 1,678.6 cM (Hammers et al, 2017). Genotyping-by-sequencing (GBS) has been completed for the parents and 182 progeny of the Norton x Cabernet Sauvignon population. A total of 43,971 polymorphic SNPs were identified and saved as a Variant Call Format (VCF) file. This file was uploaded into TASSEL 5.0 and filtered to 40,724 SNPs to create an hapmap file. These markers with >10% of the missing genotypes and loci with >96% similitude were excluded, rendering 3,825 SNP markers. Combining these 3,825 SNP markers with 411 previously genotyped SSR markers yielded a total of 4,236 markers. Distorted markers ($P < 0.05$) were seen on every linkage group. These markers were included in the final genetic linkage map unless they hindered linkage map construction. A linkage map was constructed using R/QTL with 2,072 markers (407 SSRs and 1,665 SNPs) spanning a genetic distance of 2,203.5 cM (Figure 1).

Figure 1. SNPs and SSRs distribution across 19 linkage groups of grapevines derived by crossing *V.*



aestivalis-derived 'Norton' with *V. vinifera '*Cabernet Sauvignon'. Distances are in cM. Linkage groups were obtained by R/QTL software using a 4-way cross format for composite interval mapping (CIM).

2. Conduct segregation analysis of the population for rooting ability for additional two years

The preliminary data from the winter of 2015 indicated that the parents, Norton and Cabernet Sauvignon, showed significant difference in rooting behavior when propagated through dormant cuttings (Figure 2). Norton cuttings did not root at all. However, all of the Cabernet Sauvignon cuttings rooted very well with a maximum root length of 15 cm, 30 primary roots and 23 lateral roots in the longest root within the same period of time. Three-node dormant cuttings of uniform size were taken from 172 hybrids of *V. aestivalis*-derived 'Norton' x *V. vinifera* 'Cabernet Sauvignon' by Jacob Schneider, a graduate student, in December, 2016 and 2017 from the MSFES vineyard. Five cuttings were selected from each F_1 individual along with parents and standardized to a mass of 14-16 grams. The cuttings were treated with a low concentration (0.1%) of Indole-3 butyric acid (IBA), bundled in groups of 5 cuttings from the same vine and stuck in the rooting bed supplied with bottom heat set at 80 °F to promote root development before bud break. The rooting bed was filled with commercial growing media (Fafard growing mix, Agawam, MA) composed of 50-55% composted pine bark, Canadian Sphagnum peat moss, perlite, vermiculite and dolomitic limestone. It located in an unheated room (around 40 °F) to keep the upper portion of cuttings cool in order to avoid early bud break. The WinRHIZO software, an image analysis system, is specifically designed for root measurement in different forms including morphology (length, area and volume), architecture and color analyses. It is made of a computer program and image acquisition components that can be combined to meet different needs. Cuttings containing roots of > 1mm were considered as rooted. Root length and total number of primary and lateral roots were scored (Figure 2). A segregation analysis for rooting ability was performed with both parents and 172 F_1 progenies, resulting in 88 with more than 6 roots (3 &4 in

Figure 2) and 84 less than 3 roots (1&2 in Figure 2), fitting the expected ratio of 1:1. The data suggests that there is a major QTL for root ability in Cabernet Sauvignon.

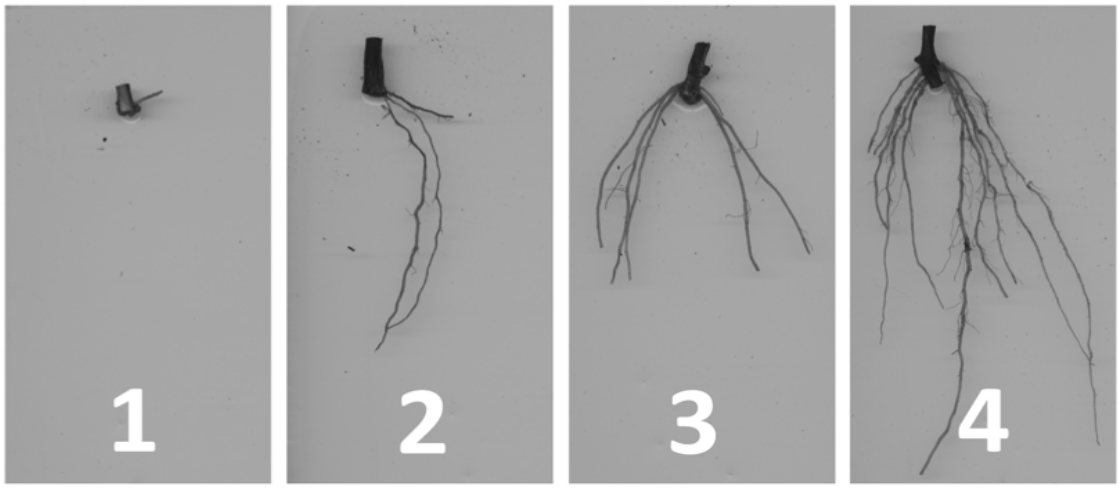


Figure 2. Confirmed F_1 hybrid progeny showing segregation in dormant rooting ability, 1 being low rooting potential (Norton) and 4 being high rooting potential (Cabernet Sauvignon).

3. Identify genetic markers associated with the rooting for future marker-assisted selection

Both parents and the 172 F_1 progenies showed various degrees of rooting ability with this population indicating that this trait is inherited genetically. The 2-year phenotyping data was integrated with the consensus linkage map with both SSR and SNP markers to discover potential quantitative trait loci (QTL) for dormant rooting. Mixed linear model (MLM) analysis shows linkage group 1 to have the best marker-trait association with a value of 4.7 (Figure 3). R/QTL analysis of average root number (ARN) reveals that linkage group 1 may contain a QTL with a logarithm of odds (LOD) of 6.13 (Figure 4).

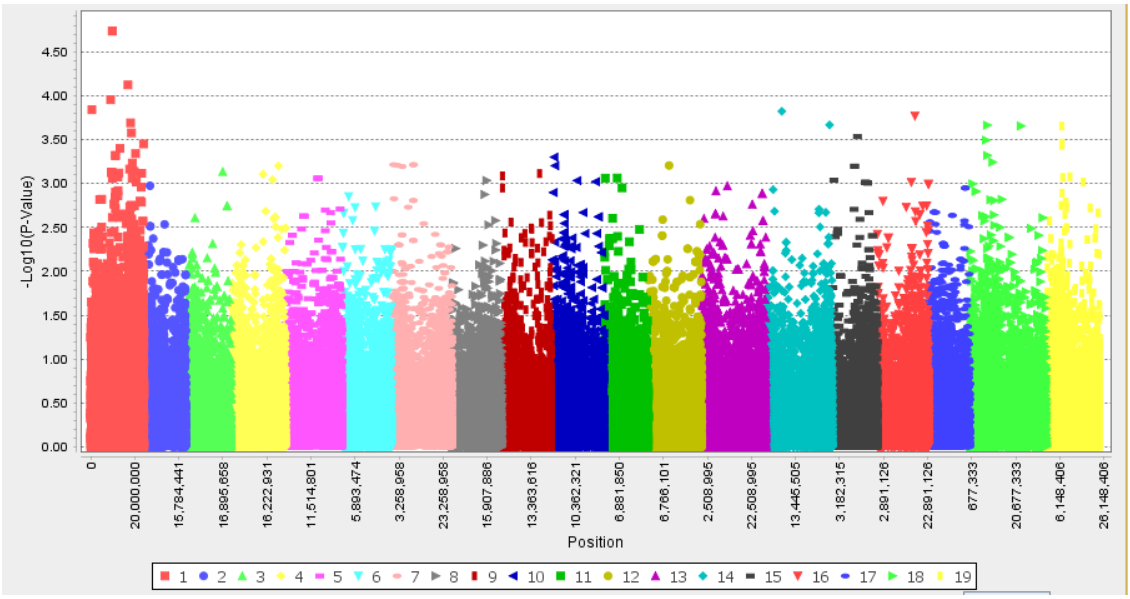


Figure 3. Manhattan plot using MLM in TASSEL5.0. A potential QTL was detected on linkage group 1 (first red bar). Each colored bar represents a chromosome. Each point represents a marker on the respective linkage group.

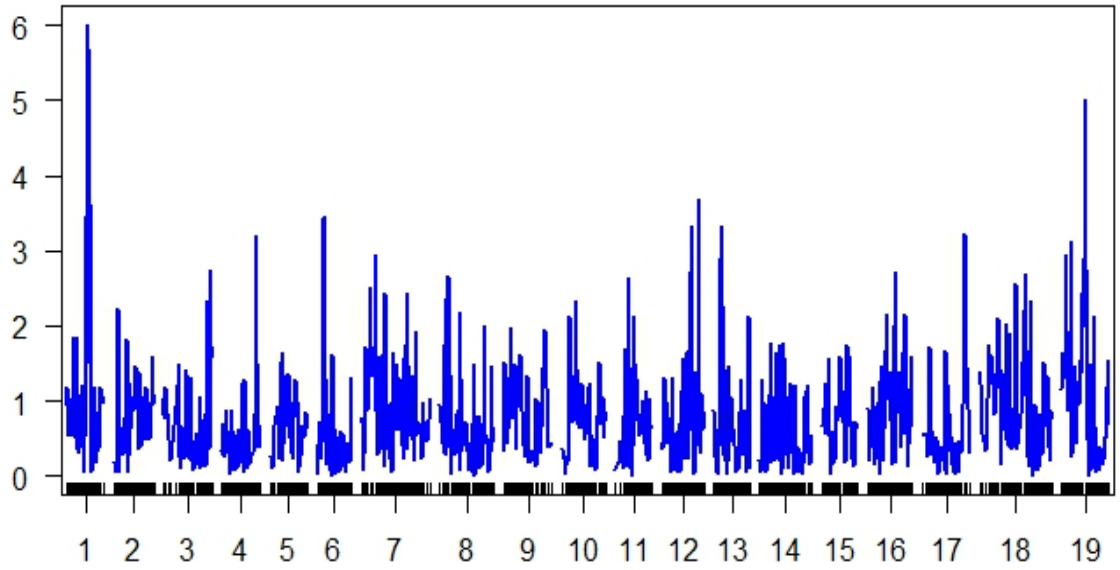


Figure 4. R/QTL analysis, using SSR & SNP markers, of average root number per genotype.

Goals and Outcomes Achieved

1. Using 6 universal SSR markers for the screen of F_1 population to eliminate the off-types (not interspecific hybrids) and construct a mapping population with 261 genotypes

2. Tested 1,157 SSR markers for potential polymorphism on a small set of DNA including parents and 6 F_1 genotypes and 413 of which have been identified as polymorphic markers for Norton. A 19-chromosome Norton genetic linkage map with 411 SSR markers using JoinMap 4.1 software (Hammers et al, 2017) was constructed. Two hundred and seventy-nine polymorphic markers were also assembled from Cabernet Sauvignon.

3. GBS has been completed for the parents and 182 progeny of this population. The 3,825 polymorphic SNP markers have been identified in this population. Of these, 1,665 SNP and 407 SSR markers were clustered into 19 linkage groups for a total of 2,072 markers to construct a Norton-based high-resolution linkage map (Figure 1).

4. Protocol using dormant hardwood cuttings has been established for the evaluation of rooting ability. Segregation analyses of the parent and 172 F_1 progeny on rooting potentials have been conducted and quantified the phenotyping data using statistic software in four categories (Figure 2).

5. A major QTL for rooting ability has been discovered on linkage group 1 by MLM analysis of the genotype and phenotype data and corroborated by R/QTL (Figure 3 & 4).

6. The location of this work at the Missouri State Fruit Experiment Station at Mountain Grove, Missouri is situated in a rural region of Southern Missouri and serves Northwest Arkansas. The project has provided access for science education and training of biotechnology for high school students and teachers to strengthen their Science, Technology, Engineering and Mathematics (STEM) curriculum. Summer internships also provided to work on grape molecular breeding.

A comparison of actual accomplishments with the goals established for the project.

Proposed Activities	Accomplishments
Identification of polymorphic markers using parents and 6 F_1 genotypes (techniques include DNA isolation, polymerase chain reaction (PCR), gel electrophoresis and DNA fragment analysis via capillary electrophoresis	Additional crosses were done in the vineyard to increase the number of genotypes in the F_1 population. Using SSR markers, interspecific hybrids have been identified, and the mapping population has been expanded from 92 to 261 genotypes. More than 1,000 SSR markers were tested and 413 of which were identified as polymorphic markers.
Construction of the Norton genetic linkage map using SSR markers	A 19-chromosome Norton genetic linkage map with 411 SSR markers with a total distance of 1,678.6 cM. was constructed using JoinMap 4.1 software (Hammers et al, 2017).
Construction of a high-resolution Norton linkage map based using both SSR and SNP markers	Using GBS, 3,825 single nucleotide polymorphism (SNP) markers were generated. Of these, 1,665 SNP and 407 SSR markers were clustered into 19 linkage groups in 159 genotypes for a total of 2,072 markers spanning a genetic distance of 2,203.5 cM (Figure 1).
Phenotyping rooting ability index include root length, root number and lateral root number	A segregation analysis on rooting potential was completed; root length and total number of primary and lateral roots were scored (Figure 2)
Map and localize the major QTL for rooting ability	Combining a 2-year phenotyping data with the linkage map, a significant QTL was identified on linkage group 1 (Figure 3 & 4). This information will be used for future marker-assisted selection.

A comparison of baseline or benchmark data with quantifiable targets

Proposed Measurable Outcomes	Achieved Outcomes
Develop a mapping population between Norton and Cabernet Sauvignon. An ideal mapping population size for establishing a genetic map is about 200 progeny.	A mapping population has been established with 261 genotypes and maintained by the professional field crew at Missouri State Fruit Experiment Station (MSFES), Mountain Grove, MO

Construct a SSR Norton linkage map and identify SNP markers via GBS to lay a foundation for future grape breeding	A high-resolution linkage map was constructed using JoinMap 4.1 with 2,072 markers (407 SSRs and 1,665 SNPs). This is the first high-density genetic map of 'Norton' by combining both SSR and SNP markers
Phenotype the entire mapping population for dormant cutting rooting ability	A segregation analysis using 192 F_1 progeny on rooting potential was completed (Figure 2). Using the newly developed Norton linkage map, a major QTL was identified on chromosome 1 (Figure 3 & 4). New protocol for rooting ability developed and tested on the parents and F_1 progenies (Figure 2).
Provide summer internships to work on grape molecular breeding program	Six summer interns in 2016 and 2017 stayed at MSFES for 3 months to learn via hands-on experience in the laboratory and vineyard
Disseminate/publish research data at various conferences, in peer-reviewed journals and students with MS and Ph.D. degrees	Daniel Adams graduated with a MS degree, May 2017. Surya Sapkota graduated with a Ph.D. Degree, December 2017. Please see "Additional Information" for details regarding conference attendance.

If outcome measures are long-term, summarize the progress that has been made towards achievement and describe future activities that will be conducted after the project's completion to help lead to the fulfillment of the outcomes.

To identify the QTLs, a mapping population of 182 individuals was constructed from a cross between *V. aestivalis*-derived 'Norton' and *V. vinifera* 'Cabernet Sauvignon'. A consensus genetic map has been constructed with 411 polymorphic SSR markers clustered in 19 linkage groups (Hammers et al, 2017). In collaboration with VitisGen (www.vitisgen.org), a high-density linkage map was constructed using JoinMap 4.1 with 407 SSR and 1665 SNPs (total of 2,072 markers). A major QTL for dormant cutting rooting potential on linkage group 1 has been identified and will be used for future marker-assisted selection. Careful genetic mapping of this population provides the foundation and tools to associate molecular markers with rooting ability of Norton for future new cultivar release. The new knowledge produced from this proposed project also will be disseminated to the adult learner through the VESTA program.

<u>Beneficiaries</u>

How many benefited from the project?

The Project Director, Dr. Chin-Feng Hwang, has been invited to the following conferences to present the research results from this project: American Society of Enology and Viticulture (ASEV)-Eastern Section, North American Grape Breeders Conference (NAGBC), VitisGen II Annual Meeting Missouri Grape and Wine Research Symposium (MGWRS), Show Me State Grape & Wine Conference (SMSGWC) and Missouri Grape and Wine Research Board Meeting (MWGRBM). A manuscript on the construction of Norton linkage map using 411 SSR markers has been published (Hammers et al, 2017); it has been distributed to the grape breeding and genetics community worldwide. In addition to the professional conferences, the results also being presented at grower meetings such as Field Days and Outreach

Workshop in conjunction with viticulture/enology advisors to better educate growers on the benefits of new Norton/*Vitis vinifera* hybrids with improved pathogen resistance, rooting ability and fruit quality. The extension/outreach effort has provided information on traits that are being incorporated into new varieties, explain new advances in technology that accelerate the development of new and improved grape cultivars and the importance of these new traits with regard to farming practices and sustainability. Missouri State University (MSU) leads the Viticulture and Enology Science and Technology Alliance (VESTA) program, a partnership of institutions in 17 states, funded as a National Center of Excellence from the National Science Foundation's (NSF) Advanced Technology Education program. This program is focused on the development of on-line educational materials and training workshops for secondary students, teachers, farm advisors, grape growers and enologists. The new knowledge produced from this proposed project also has been disseminated to the adult learner through the VESTA program. Based on the data in Table 1, there are approximately four thousand people worldwide affected by the distribution of this new knowledge.

Table 1. The number of people affected by the distribution of this new knowledge

Dissemination Sources	ASVE-ES (July 19-20, 2016 & July 10-12, 2017)	VitisGen II Annual Meeting (Jan 11-12, 2018)	NAGBC (Aug 24-25, 2017)	MGWRS & MWGRB (2016, 2017 & 2018)	SMSGWC (March 8-9, 2017)
Number of people participated	**1,200**	**150**	**300**	**500**	**1,100**

How did they benefit from the project?

Using the *V. aestivalis*-derived 'Norton' as a perennial woody model plant, the work presented in this proposal provides an exceptional opportunity in both research and education. It includes interdisciplinary training opportunities for students in plant breeding, genetics and genomics with a specific focus on viticulture. The grape and wine industry will be aided by new grape cultivars. The education program has included hands-on experience both in the laboratory and vineyard and produce highly trained professionals that will address the need for a knowledgeable and skilled workforce for the American grape and wine industry. We have recruited two graduate student and three summer interns to work on this project. These focal areas target one of the most commercially significant traits in the industry, since vegetative propagation by dormant cuttings is the preferred method to produce large quantities of plant material.

Lessons Learned

The original proposed project was designed based on our infrastructure and capacity. We completed the proposed work in a timely manner with goals and outcome measures achieved.

There is always a risk of vine loss due to cold injury during winter. To manage this risk, a total of 162 genotypes with at least six 18-inch cuttings per seedling (plus parents) were shipped to E.J. Gallo Winery, Modesto, CA to establish a backup population. We shipped the rest of the mapping population by July 2017. This backup planting is an important resource for us to reduce the possibility of loss of important genotypes. It could also provide additional phenotyping material.

Grape breeding programs require long-term investments and continuity because the time required from initial crossing to variety release usually take decades. In addition, growing grapes is an expensive and

labor-intensive endeavor. However, the budget has been carefully planed in order to achieve projected results with minimum spend. Plant materials for this project are grown and maintained by a professional crew at MSFES; they are employed at MSU and provide work paid by institutional funds. MSU also will provide housing at MSFES for the graduate students without charge.

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Additional Information

Publications

Mia Hammers, Surya Sapkota, Li-Ling Chen and **Chin-Feng Hwang** (2017). Constructing a Genetic Linkage Map of *Vitis aestivalis*-derived 'Norton' and Its Use in Comparing Norton and Cynthiana. Molecular Breeding **37**: 64.

Surya Sapkota, Ph.D.; Thesis: High Density Mapping and Quantitative Trait Loci Analysis for Fungal Disease in *Vitis aestivalis*-Derived 'Norton' (December 2017)

Daniel Adams, MS; Thesis Title: Genetic Analysis of Cold Hardiness in a Population of Norton (*Vitis aestivalis*) and Cabernet Sauvignon (*Vitis vinifera*) Hybrids (May 2017)

Conferences

Dr. Chin-Feng Hwang and three students; Surya Sapkota, an MSU/University of Missouri collaborative Ph.D. student; Daniel Adams and Jacob Schneider, both Plant Science Master's students, attended the 41th American Society for Enology and Viticulture (ASEV)-Eastern Section Conference July 19-20, 2016 in St. Louis, Missouri. Dr. Hwang was invited to present a seminar entitled "Molecular Genetic Approaches to Norton Grape Improvement".

Dr. Chin-Feng Hwang was invited to present a seminar entitled "Optimizing *Vitis aestivalis*-derived 'Norton' Grape Breeding using Molecular Genetic and Genomic Approaches" on September 20, 2016 in the Department of Viticulture and Enology, University of California, Davis. *The USDA-SCBGP funds were not used for this trip; however, the results from this project were presented in this conference as an opportunity to promote the USDA-SCBGP.*

Dr. Chin-Feng Hwang was invited to attend the Research Committee meeting of the Missouri Wine and Grape Board and reported the progress of this project to the Committee on October 26, 2016.

Dr. Hwang gave a seminar entitled "Optimizing Marker-Assisted Selection for Norton Grape Breeding", Show Me State Grape & Wine Conference, Columbia, Missouri, March 08, 2017.

Graduate students, Surya Sapkota, presented a talk entitled "Construction of a high-density linkage map of *Vitis aestivalis*-derived 'Norton' using both SSR and SNP markers and identification of quantitative

trait loci (QTLs) associated with downy mildew resistance" in the 6th Missouri Grape and Wine Symposium on March 09, 2017.

Dr. Hwang, Li-Ling Chen (Research Specialist) and three students (Surya Sapkota, Will Knuckles and Jacob Schneider) attended the 42nd American Society for Enology and Viticulture (ASEV) Eastern Section Conference on July 10-12 in Charlottesville, Virginia. Surya Sapkota was invited to give a seminar entitled "Fine Mapping and Detection of Downy Mildew Resistance Locus in Norton-based Population". Will Knuckles and Jacob Schneider, presented posters on their research and participated in the 'Flash Talk' where students gave timed, three-minute presentations on their research.
Knuckles presented a poster entitled "The Identification of Interspecific Hybrids, Jaeger 70 x Vignoles Grapes Using SSR Markers"
Schneider presented a poster entitled "Genetic Study of Dormant Rooting Ability in Grapes"

Dr. Hwang gave a seminar entitled "Grape Breeding Progress Report from Missouri State University", North American Grape Breeders Conference, University of California, Davis, California, August 25, 2017.

Dr. Chin-Feng Hwang was invited to attend the Research Committee meeting of the Missouri Wine and Grape Board and reported the progress of this project to the Committee on June 6 and October 17, 2017.

Dr. Chin-Feng Hwang and Li-Ling Chen, research specialist, were invited to attend the first annual meeting of the Cornell University-based VitisGen II program January 11-12, 2018. The RNAseq workshop was provided for us to learn how to identify the gene of interests using transcriptomic data.

In general, the College of Agriculture at Missouri State University offers about 10 summer internships every year. The two graduate summer assistantships provided from this funding were awarded to two MS graduate students, Daniel Adams and Jacob Schneider. Working together with Li-Ling Chen (Research Specialist), the graduate students and undergraduate summer interns were able to gain teaching experience by direction the summer interns in the laboratory to 1) isolate DNA from grape leaves, 2) determine the concentration of isolated DNA using a spectrophotometer, 3) visualize DNA via electrophoresis, 4) perform polymerase-chain reaction (PCR) and 5) run DNA fragment analysis via capillary electrophoresis. The purpose of these procedures was to verify the true hybrids at the seedling state by using DNA markers. In the vineyards, they were also able to provide the hands-on experience with traditional breeding techniques including parental selection, flower emasculation and pollination.

Project 11: High Tunnel Production/Rotation of Primocane Bearing Raspberries in Grow Bags

Missouri State University – Darr School of Agriculture
Marilyn Odneal
Final Performance Report

Project Summary

The United States is the third largest raspberry producer in the world. Even so, the domestic demand exceeds supply. The perishability of raspberry fruit limits postharvest storage and makes local production attractive.

Although field grown primocane bearing raspberries have not performed well in Missouri, high tunnel production has been successful. High tunnels are used for protection from the elements, environmental modification, and/or season extension in late winter/spring and in fall.

Growing primocane fruiting raspberries in high tunnels show several advantages compared to field grown including increased yield and berry size, extension of the growing season and improved fruit quality. Successful high tunnel primocane raspberry research and demonstration plantings have been reported by the University of Arkansas (Rom et. al., 2008) and by Missouri State University (Odneal and Wilker, 2015).

The problem with a perennial plant, like raspberries, planted in-ground in a tunnel is that the space is tied up all year round and other annual crops cannot be rotated in and out of the space, limiting overall productivity and profitability. Putting the raspberries in a container, such as a grow bag, would allow for the plant to be rotated in and out of the tunnel to allow for the production of other crops when the raspberries are not producing. Unfortunately, there is little information available on cultivar performance in containerized culture in high tunnels (Heidernreich et. al. 2012).

This trial investigated the high tunnel production of primocane bearing raspberries in grow bags for an additional two years. This method opens the space in the tunnel to be utilized by other crops when the raspberries are removed. The present project (a continuation of the initially funded 2-year project) determined which varieties are suitable for this system in this region and that the system is sustainable for at least 4 years.

The results from the trial will allow growers the ability to easily test and possibly add a profitable crop to their mix, ultimately leading to greater economic farm sustainability.

This project has NOT submitted to or funded by another federal or state program.

Literature

Heidernreich, C., M. Pritts, K. Demchak, E. Hanson, C. Weber and M. J. Kelly. 2012 (revised). High Tunnel Raspberries and Blackberries. Dept. of Horticulture Publication No. 47, Cornell University.

Odneal, M. B. and K. Wilker. 2015. Raspberry Demonstration and Distillation at the Missouri State University Fruit Experiment Station. Poster presented at the 2015 North American Raspberry and Blackberry Conference, February 24-27, Fayetteville, AR.

Rom, C., M. E. Garcia, D. Johnson, J. Popp, B. Morgan, J. Bachmann, and H. Friedrich. 2008. Off-season

organic blackberry and raspberry production to expand markets and sustain farm profitability. Research Report.

Many growers have recently constructed high tunnels due in part to the NRCS federal high tunnel grant program and information is needed to help them decide which crops and rotation schemes will be most profitable in their situation. The problem with perennial raspberries in-ground in a high tunnel is that annual crops cannot be rotated into this high value covered space. This trial provides growers with information on adding raspberries to their product mix without dedicating the space in the high tunnel to a single crop year round.

Raspberries have been successfully containerized and grown in greenhouses and high tunnels in New York, although information on varieties that perform well in containerized high tunnel production is lacking (Heidernreich et. al, 2012). The results of this trial will make a significant contribution to growers and researchers as to which cultivars are adapted to containerized high tunnel production.

Heidernreich, C., M. Pritts, K. Demchak, E. Hanson, C. Weber and M. J. Kelly. 2012 (revised). High Tunnel Raspberries and Blackberries. Dept. of Horticulture Publication No. 47, Cornell University.

This current project is a continuation of the previously funded project USDA SCBGP Award Agreement # 12-25-B-1680. This project afforded the chance to look at raspberry production in a high tunnel in bag culture for an additional two years to see if the plants would remain productive and whether or not the grow bags would continue to function or need to be replaced.

Project Approach

The experimental design is a randomized complete block with 5 treatments (cultivars) and 4 blocks by location in the tunnel. Each replication consisted of 5 plants in grow bags or 5 linear feet of row (See planting plan in section 8 – Additional Information).

Five primocane producing raspberry cultivars were originally planted in the grow bags in 2014. From 2014 - 2017, early season vegetable crops were planted and harvested before the bagged raspberry plants were rotated into the high tunnel space and trellised. Shoots were thinned to 4 - 6 per bag. The raspberries were irrigated/fertigated and moisture and air temperature were monitored. Harvest data were recorded and the raspberries were rotated out of the high tunnel after pruning to overwinter outdoors with straw mulch for cold injury protection. Pesticides were applied weekly during harvest to manage Spotted Wing Drosophila (SWD) until the end of September when SWD were no longer detected. Harvest continued through late November and in some cases, early December.

In the framework of the current grant (2016 – 2017), information dissemination included general tours and individual consultations at the Missouri State Fruit Experiment Station (MSFES), posts on the MSFES Blog, conferences attended, Greenhouse and High Tunnel Workshops held at Mountain Grove in 2016 and 2017, and the Darr Center Garlic Field Day.

Results continue to show that the raspberry cultivars in grow bags rotated into the tunnel in May and out of the tunnel in December to overwinter outdoors bear a commercially acceptable and potentially profitable crop. The grow bags continue to be sound and function. We did realize that we needed to add soilless media to the grow bags in 2017 to replace media lost in the previous years of production.

University Extension offered several opportunities to present the information on this project including the Great Plains Growers Conference and the Midwest Winter Vegetable Conference.

The Ozarks Farmers' Agricultural Cooperative (affiliated with the West Plains Small Business Incubator) invited the PI to deliver a fruit production presentation at their first conference "Bring Back the American Small Farm" January 28 and 29, 2016. The raspberry project was mentioned in the general presentation.

Goals and Outcomes Achieved

Raspberries were harvested in 2016 and 2017 and data on marketable yield and average berry weight was recorded and statistically analyzed.

The project was featured on all general Missouri State Fruit Experiment Station Tours as well as one-on-one grower advisement.

The project was featured and presented at the Greenhouse and High Tunnel Workshops at Mountain Grove in 2016 and 2017.

Four years of data have been collected and analyzed at this point (2 in the previous grant period and 2 in this current grant period). Four years of data also strengthen the possibility of publication in a professional refereed journal.

Goal – The goal to provide information on containerized raspberry production in high tunnels for an additional two years was achieved. Five primocane bearing varieties of raspberries were successfully grown, harvested and overwintered in the rotation between field and high tunnel in the third and fourth growing season.

Performance measure – High tunnel production of fruit from the five cultivars tested were comparable to the standard cultivar, Josephine, from which base line data had been recorded in an earlier in-ground high tunnel demonstration planting at Mountain Grove (Table 1. Average annual yield and weighted average berry weight of raspberry cultivars in grow bags in a high tunnel 2014 – 2017.).

Benchmark – The results of this project has been disseminated through various channels (see Table 4. Quantitative data concerning beneficiaries of the project) thus adding to the information available concerning containerized high tunnel raspberry production systems.

Target – Information on five raspberry varieties was made available for growers, researchers and outreach and extension personnel through various channels – blog, conferences, workshops and open houses held on site, and one on one and small group tours.

Josephine was chosen as the reference cultivar in this trial due to its performance in an earlier demonstration trial at the Missouri State Fruit Experiment Station. Joan J average (2014 – 2017) annual yield was significantly higher than the average annual yield of Josephine. All other cultivars' average annual yield was not statistically different from Josephine. Crimson Giant average (2014 – 2017) annual berry weight was significantly higher than all other cultivars in the trial and Himbo Top average annual berry weight was significantly lower than Josephine (Table 1

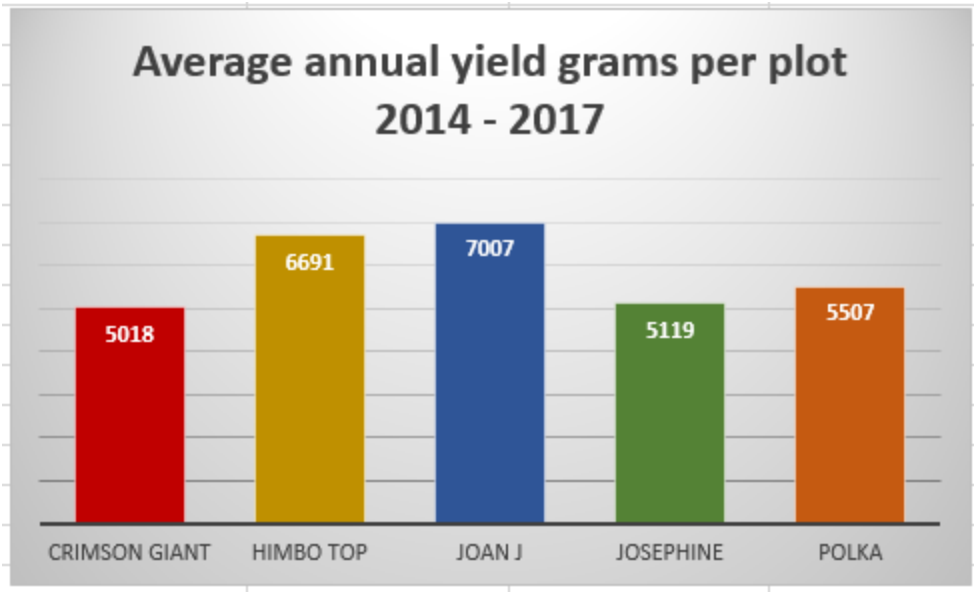
Average annual yield and weighted average berry weight of raspberry cultivars in grow bags in a high tunnel 2014 – 2017).

All cultivars to date have performed well compared to our reference cultivar. Joan J. yields the earliest with the majority of fruit produced in July and August. Polka produced the most of its fruit in July, August, and September, whereas Himbo Top and Josephine produced the most fruit in September. Crimson Giant produced the most fruit late in the season in October and November, even into December. The differences in percent yield through time will offer growers several options in fitting the raspberries into their high tunnel production systems, keeping in mind that late season production may command a higher price for fruit.

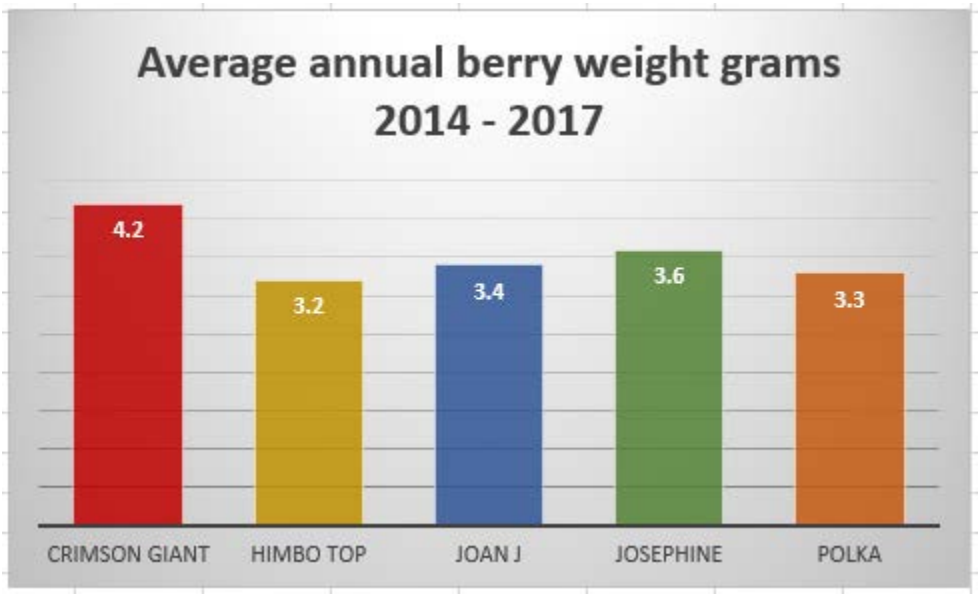
Table 1. Average annual yield and weighted average berry weight of raspberry cultivars in grow bags in a high tunnel 2014 – 2017.

Treatment	Avg. Annual Yield grams per plot (5 grow bags or 5 foot of row)*	Avg. Annual. Yield lbs./5 foot of row	Average Annual Berry Weight Grams*
Crimson Giant	5018 c	11.1	4.2 a
Himbo Top	6691 ab	14.7	3.2 c
Joan J	7007 a	15.4	3.4 bc
Josephine	5119 bc	11.3	3.6 b
Polka	5507 bc	12.1	3.3 bc

*Experiment is a randomized complete block with 5 treatments (cultivars) and 4 replications.
Statistics – ANOVA 1 way, means separated by Tukey-Kramer Multiple Comparison Test at the 0.05 level of significance.



Plot size is 5-1 foot diameter grow bags or 5 feet of row.



Beneficiaries

The specialty crop beneficiaries of this project are growers who are presently using or considering high tunnels for production in their farming operations. Outreach advisors and extension personnel will also benefit with the information concerning raspberry variety performance in high tunnels in bag culture. The larger research community will also benefit from this research. As stated in the recently revised "High Tunnel Raspberries and Blackberries "Currently, little information is available on variety performance for containerized high tunnel brambles (raspberries and blackberries)." (Heidernreich et. al 2012).This project will provide new information in the area of containerized raspberry production in high tunnels that is presently lacking.

This project was used as the thesis project in training a plant science graduate student, Jennifer Morganthaler. She graduated in Summer 2016 and was hired as a clinical instructor with Missouri State University in August, 2016.

Heidernreich, C., M. Pritts, K. Demchak, E. Hanson, C. Weber and M. J. Kelly. 2012 (revised). High Tunnel Raspberries and Blackberries. Dept. of Horticulture Publication No. 47, Cornell University.

Table 3. Quantitative data concerning beneficiaries of the project.

Dissemination source	**Presentation**	**Number of persons**
Masters student Jennifer Morganthaler	Presented project information in Agricultural Research Models in Spring semester, 2016.	30 students and faculty
SFES Blog What's Happening in the Field	23 blog posts detailed project happenings (see 8. Additional Information).	Estimated 5 – 6,000 visitors annually
Great Plains Growers Conference St. Joseph Missouri, January 9, 2016 Presentation is posted on website http://www.greatplainsgrowersconference.org/saturday-presentations.html	**High Tunnel Raspberry Production in Grow Bags** Jennifer Morganthaler and Marilyn Odneal Oral presentation	Approx 400 – 500 participants (concurrent sessions)
Midwest Winter Vegetable Conference, Webb City, Missouri, January 22, 2016 Presentation is posted on website http://www.webbcityfarmersmarket.com/winter-production-conference.html	**High Tunnel Raspberry Production in Grow Bags** Jennifer Morganthaler and Marilyn Odneal Oral presentation	Over 100 participants.
North American Raspberry and Blackberry Conference 2016 Williamsburg, Virginia, March 3 - 4 Presentation is posted on website http://www.raspberryblackberry.com/wp-content/uploads/Progress-Report-High-Tunnel-Raspberry-Production-in-Grow-Bags.pdf	**Progress Report – High Tunnel Raspberry Production in Grow Bags** – Jennifer Morganthaler and Marilyn Odneal Poster presentation	Over 200 participants. 240 members.
Greenhouse High Tunnel Workshop 2016 August 3 - 4 Presentations posted on website https://ag.missouristate.edu/mtngrv/high-tunnel-workshop-2016.htm	• Project was featured in **Overview of High Tunnel Fruit Production** by Marilyn Odneal, Missouri State and on the high tunnel tour.	Over 75 participants

	Jennifer Morganthaler and Marilyn Odneal	
2. **Garlic Field Day** at the Darr Agriculture Center, Missouri State University April 21, 2017.	Display and oral presentation on the project. Jennifer Morganthaler and Marilyn Odneal	10 participants
Greenhouse and High Tunnel Workshop 2017 October 12 - 13 Presentations posted on website https://ag.missouristate.edu/mtngrv/Workshop2017.htm	Project was featured on high tunnel tour. Jennifer Morganthaler and Marilyn Odneal	Over 30 participants

Lessons Learned

Spotted Wing Drosophila was discovered in Missouri in 2013, therefore, pesticide applications needed to be made on a weekly basis during harvest. Pesticides are applied at night in order to avoid contacting pollinators. We realized the importance of additional canopy management in order to be more effective in applying pesticides. Now, we initially thin the plants in grow bags to approximately 4 shoots per bag when the straw is initially removed from the overwintering grow bags. The bags are left outdoors to grow. Excess shoots will grow during this period of time, so when the bags are going to be rotated into the high tunnel, these excess shoots are removed. In addition, during the growing season, excess shoots and low lying lateral branches are removed at intervals in order to manage the canopy density and allow for more efficient harvest and pesticide application.

We purchased a larger size 50% shade cloth with and observed that after it was put over the high tunnel during hot weather. When the weather turned cool and humid after shade cloth installation, botrytis blossom blight in 2016 and 2017. The shade cloth is installed over the outside of the tunnel and is difficult to easily remove during cool, humid weather and recover when weather turns hot again. We would like to engineer a system in the future that would allow us to easily pull the shade cloth over the plants inside the tunnel as well as easily remove it when cool, cloudy and humid weather occurs.

We were surprised in a grower perception of bag culture vs. hydroponics. In our last Greenhouse and High Tunnel Workshop, several participants in the evaluation mentioned that hydroponics seemed “unnatural” since soil was not a component. This does not appear to be the perception for container or bag culture even though the media used is soilless.

For the most part, our goals were achieved.

Our temperature and moisture monitoring system was not convenient and was difficult to manage since we needed to physically download the data and often did not have time in the summer to do this. We researched the best system upgrade during 2016 – 2017.

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Additional Information

Blog posts at http://blogs.missouristate.edu/fruitexperimentstation/?s=raspberry&x=0&y=0

1. Raspberries moved out of the high tunnel for overwintering
   http://blogs.missouristate.edu/fruitexperimentstation/2015/12/16/raspberries-moved-out-of-the-high-tunnel-for-overwintering/

2. Weighing raspberry canes after pruning
   http://blogs.missouristate.edu/fruitexperimentstation/2016/01/06/weighing-raspberry-canes-after-pruning/

3. MSU Grad Student presents research at Great Plains Growers Conference in St. Joseph
   http://blogs.missouristate.edu/fruitexperimentstation/2016/01/10/msu-grad-student-presents-research-at-great-plains-growers-conference-in-st-joseph/

4. Shoring up the high tunnel for late winter vegetables
   http://blogs.missouristate.edu/fruitexperimentstation/2016/01/25/shoring-up-the-high-tunnel-for-late-winter-vegetables/

5. Veggies planted in the high tunnel today
   http://blogs.missouristate.edu/fruitexperimentstation/2016/03/01/veggies-planted-in-the-high-tunnel-today-2/

6. MSU raspberry research presented at the North American Raspberry and Blackberry Conference in Williamsburg VA
   http://blogs.missouristate.edu/fruitexperimentstation/2016/03/07/raspberry-research-presented-at-the-north-american-raspberry-and-blackberry-conference-in-williamsburg-va/

7. Raspberries rotated into the high tunnel today
   http://blogs.missouristate.edu/fruitexperimentstation/2016/05/26/raspberries-rotated-into-

the-high-tunnel-today/

8. Blossom blight symptom in raspberries
http://blogs.missouristate.edu/fruitexperimentstation/2016/07/15/blossom-blight-symptom-in-raspberries/

9. Botrytis it is
http://blogs.missouristate.edu/fruitexperimentstation/2016/07/19/botrytis-it-is/

10. Brown Marmorated Stink Bug Found in High Tunnel (by Jennifer Morganthaler)
http://blogs.missouristate.edu/fruitexperimentstation/2016/10/20/brown-marmorated-stink-bug-found-in-high-tunnel/

11. Raspberry harvest discontinued in high tunnel due to cold temperatures December 12, 2016
http://blogs.missouristate.edu/fruitexperimentstation/2016/12/12/raspberry-harvest-discontinued-in-high-tunnel-due-to-cold-temperatures

12. Raspberries moved out of the high tunnel today December 16, 2016
http://blogs.missouristate.edu/fruitexperimentstation/2016/12/16/raspberries-moved-out-of-the-high-tunnel-today/

13. Plastic removed from the high tunnel today December 21, 2016
http://blogs.missouristate.edu/fruitexperimentstation/2016/12/21/plastic-removed-from-the-high-tunnel-today/

14. Plastic replaced on high tunnel February 9, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/02/09/plastic-replaced-on-high-tunnel/

15. Hail damage to high tunnel and greenhouses March 1, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/03/01/hail-damage-to-high-tunnel-and-greenhouses/

16. Bagged raspberries thinned and fertilized April 10, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/04/10/bagged-raspberries-

thinned-and-fertilized/

17. Garlic Field Day at Darr April 21, 2017
http://blogs.missouristate.edu/ag/2017/04/24/garlic-research-field-day-at-darr/?utm_source=feed&utm_medium=feed&utm_campaign=feed

18. Raspberries rotated in high tunnel May 1, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/05/02/raspberries-rotated-into-high-tunnel-may-1/

19. Plastic replaced (again) on high tunnel today May 10, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/05/10/plastic-replaced-on-high-tunnel-today/

20. Canopy management in raspberries July 15, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/07/17/canopy-management-in-raspberries/

21. Shade cloth was put on the high tunnel July 18, 2017
http://blogs.missouristate.edu/fruitexperimentstation/2017/07/21/shade-cloth-was-put-on-the-high-tunnel-july-18/

22. Botrytis in Raspberries August, 2017
https://blogs.missouristate.edu/fruitexperimentstation/2017/08/11/botrytis-in-raspberries/

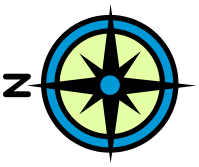
23. 2017 Greenhouse and High Tunnel Workshop held October 12 and 13, 2017
https://blogs.missouristate.edu/fruitexperimentstation/2017/10/16/2017-greenhouse-and-high-tunnel-workshop-held-october-12-and-13/

24. Raspberries in grow bags were pruned and rotated out of the high tunnel today December 14, 2017
https://blogs.missouristate.edu/fruitexperimentstation/2017/12/14/raspberries-in-grow-bags-were-pruned-and-rotated-out-of-the-high-tunnel-today/?utm_source=feed&utm_medium=feed&utm_campaign=feed

High Tunnel Raspberry in Grow Bags Project Map

Experimental design is randomized complete block with 5 treatments (cultivar) and 4 replications (blocks). Five plants in bags are used for each replication (5 feet of row).

Cultivars of primocane bearing raspberry under test include Crimson Giant, Himbo Top, Joan J, Josephine, and Polka



KEY:

Block A –north-west location in tunnel.

Block B –south-east location in tunnel.

Block C –north-east location in tunnel.

Block D –south-west location in tunnel.

East end of high tunnel		
Polka		Polka
Himbo Top		Himbo Top
Joan J		Josephine
Crimson Giant		Crimson Giant
Josephine		Joan J
BLOCK C		BLOCK B
Polka		Crimson Giant
Himbo Top		Joan J
Josephine		Himbo Top
Joan J		Josephine
Crimson Giant		Polka
BLOCK A		BLOCK D
West end of high tunnel (by door)		

Project 12: Increasing the Decision Making of Scaling-Up Production for Specialty Crops

The Curators of the University of Missouri
Debi Kelly
Final Performance Report

Project Summary

With the increasing demand today for local food in particular by institutions, grocery stores and wholesalers, producers must determine if they would like to scale up their production to meet these demands. The concept of growing specialty crops in square feet rows vs growing by the acre can be daunting. Many decisions must be made for scaling up can be achieved successfully such as land access, labor, equipment, infrastructure, finances and more. The goal of this project was to provide education to Missouri farmers and producers to increase their decision-making of scaling up production for specialty crops. Outputs for the project included the creation of curricula, PowerPoint presentations and handout materials for 10 workshops across the state over a 3-year period with one cancelled workshop from lack of participants. Two webinars were held with a third being cancelled due to lack of registrants. Two hundred twenty eight (228) individuals attended the workshops and webinars. Short-term outcomes indicated that 100% of the participants increased their knowledge in the decisions needed to scale up production and "who, what, when, where, and why" to understand the expectations of the Specialty Crop Block Grant Program grant proposals. Mid-term outcomes include 26% of the participants will decide to increase their specialty crop acreage with 46% of the participants claiming they would begin writing a Specialty Crop Block Grant. This does not build on a previously funded project.

2016 – 33% of the awarded grants were indirect result of attending an educational event.
2017 – 33% of the awarded grants were indirect results of attending an education event.
2018 – Awarded grants have not been announced as of the submission of this report.

Project Approach

The project approach created curriculum of PowerPoints and handouts. Education primarily occurred as face-to-face workshops at different locations across the state and at annual agricultural conferences. Webinars were also scheduled.

Ten workshops and one webinar were held across the state. Results from these educational activities are documented below in the Goals and Outcomes Achieved. Thirteen workshops were originally planned however only ten occurred. Three locations declined hosting a workshop in their area. Partners for this project were MU Extension offices and farmers' markets participating as host location. Results were disseminated at the Missouri Farmers' Market Association Annual Conference, the Missouri Organic Association Annual Conference and the Great Plains Growers Conference. Information about the project was also disseminated on Facebook.

Specific quantitative outcomes of the project are cited in the Project Summary above. Qualitative terms included many.

"I wanted to drop a quick line to let you know the workshop in St. Roberts was much appreciated and

time well spent. I left with some great information not only the upcoming available specialty crop grant opportunity but a wealth of information on all sorts of resources and ideas and confirmation for our updated business model."

"I wanted to let you know that I wrote a letter of support this week for a project by a farmer who was directly inspired to submit a specialty crop application after attending one of your workshops."

"Thank you for the detailed presentation! I have a much better foundation to start from when I pursue specifically crop expansion in the future.

Goals and Outcomes Achieved

The project projected 390 participants for 13 workshops. However only 10 workshops occurred for 228 participants. Three webinars were to occur but only two did with one cancellation due to lack of registrants. It was anticipated that 75 individuals would attend the 3 webinars but in reality only a total of 12 participated.

The highlight of the project is that 100% of the participants understood the 10 Keys to Scaling Up Production as well as how to utilize the Specialty Crop Block Grant to assist in the process.

Beneficiaries

Specialty crop producers, particularly vegetable and fruit producers were the main beneficiary of this project. Two hundred twenty eight (228) specialty crop producers benefited from this project by learning how scaling up production and grant writing. These producers benefited by understanding how difficult it can be to scale down the total number of vegetable or fruit types and varieties in order to successfully increase production. Increasing production means more mainstream production practices as well as more mainstream marketing. An economic impact of the project was not included as part of the project.

Lessons Learned

Thirteen workshops were projected but only 10 were completed. One cancelled due to lack of registrants. Several locations identified to host a workshop decided against hosting due to the lack of interest from their farmers. Also noted that farmers still would prefer face-to-face education to learning through technology still since registration was low for two of the webinars and the third cancelled.

Lessons learned include consistently planning for how to evaluate and to remember to follow through at the time of the event itself. This saves much time in having to make continued efforts to get follow-up information from participants.

Contact Person

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Additional Information

Promotional Flyer:

Specialty Crop Block Grant Writing to Enhance Scaling Up of Production Workshops

Learn about 10 keys to scaling up production and gain firsthand knowledge about how to write a specialty crop block grant to potentially fund your project.

Jan 18 – Farmington
Jan 19 – St. Roberts (snow date Jan 31)
Jan 26 – MOA Conference
Feb 8 - Webinar
Feb 16 – Webb City

For more information email kellyd@missouri.edu. To register see information on reverse side.

MISSOURI Agriculture

UNIVERSITY OF MISSOURI Extension

Locations

Jan 18 – Farmington Public Library, 101 North A Street, Farmington, MO, 6-9 pm. To register, call 573-883-3548, $10 for lunch.

Jan 19 – St. Roberts Hampton Inn Meeting Room, 103 St. Robert Plaza Dr., St. Robert, MO, 10 am – 2:30 pm. To register, call 573-774-6177 (snow date Jan 31), $10 for lunch.

Jan 26 – Midwest Organic Association Conference, Kansas City, MO. http://www.moaconference.org/

Feb 8 – Webinar, 6-8 pm. To register, email kellyd@missouri.edu or call 636-797-5391, free.

Feb 16 – Central Methodist Church, 6 Pennsylvania, Webb City, MO, 10 am-4 pm. To register call 417-478-8139, $10 for lunch.

MISSOURI Agriculture

UNIVERSITY OF MISSOURI Extension

Project 13: Building on Success – Expanding Training to Specialty Crop Farmers Statewide
Webb City Farmers Market

Eileen Nichols
Final Performance Report

Project Summary

The purpose of this project was to organize and present The Missouri Tomato School, a comprehensive educational program targeting commercial tomato producers with the goal of increasing knowledge of best practices, profitability of small farmers and availability of local tomatoes for customers. On June 28 and 29, 2018, in Jackson, Missouri, national and regional subject matter experts shared information on all aspects of tomato production over a 1.5-day program of presentations, panel discussions, and farm tours. Presenters included experienced and innovative farmers, tomato extension and research specialists, and those who market and process tomatoes.

The tomato is among the most widely grown commercial vegetables in Missouri. Farmers who intend to produce this crop profitably must remain current on tomato cultural practices, cultivar developments, pest management, and marketing strategies.

This project built on the success of the 2017 Missouri Tomato School held in Webb City and supported by SCBGP funding. The School was well received by Southwest Missouri tomato farmers.

Project Approach

The 2018 Tomato School, which covered only tomatoes, a specialty crop, was a collaborative project involving members of University of Missouri Extension and Lincoln University Cooperative Extension who worked with the market to recruit presenters, establish topic and design the program and do all the tasks outlines in the work plan required for a successful School.

This was a very short-term project, with a start date of June 15, 2018 and an end date of July 10, 2018. Much of the planning took place prior to the start date such as tentatively securing presenters and location and issuing tentative save the dates. Just completing the project successfully in that time period was a significant accomplishment. Because the market had hosted a similar school in 2017, we already had a program model that worked well, as well as contacts with our main presenters. Responses from attendees (in next section) demonstrate the quality of the School presentations. This was, however, the first time our team organized a project taking place outside of Southwest Missouri, relying on a local host and it provided valuable lessons and cemented important relationships with our presenters which are detailed in "Lessons Learned".

Goals and Outcomes Achieved

Objective 1: This project proposed to train approximately 50 farmers who would gain knowledge in best tomato production practices.

We did not meet this objective as only 26 farmers attended the conference. We believe this was due to our being uncomfortable with widely publicizing the event until funding was in place and because

this was funding being released by other grantees, publicity was significantly delayed. We had also anticipated that our local host partner would handle local publicity and it turned out that the host had little experience in media relations.

Objective 2: This project proposed to train approximately 10 extension specialists/educators who would gain knowledge in best tomato production practices and share that knowledge with many tomato growers in Missouri.

We exceeded Objective 2 as 11 extension specialists/educators attended the School. This was in part because SARE agreed to provide scholarships which enabled the educators to attend at little expense and because the School qualified for In-Service Education.

The post School evaluation showed that of the attendees who responded: The overall knowledge game was .900; average knowledge level improved from 2.380 to 3.280 on a 1-4 Likert Scale.

- 81% responded that they would change a production practice on their farm as a result of attending.
- 89% reported that they would follow-up on available resources.
- 89% reported that they would attend additional trainings.
- 71% reported that they would keep in touch with a grower they met at the School.
- 89% reported that the overall program fully met or exceeded their expectations.

The comments of attendees will be used to improve Missouri Tomato Schools planned for 2019 and 2020.

Beneficiaries

Twenty-six small and medium specialty crop producers, including both new and experienced, benefited directly by attending the school, the majority of whom stated that they would change tomato production practices because of the knowledge gained.

Many more tomato farmers will benefit through the expertise of the 11 extension specialists/educators trained at the School.

The topics covered at the School included:

- Successful tomato production with plasticulture
- Keeping a healthy environment in the greenhouse
- Top tomato diseases and how to manage them
- How to build a caterpillar tunnel
- Humidity control in a tomato greenhouse
- Issues with heaters in a tomato greenhouse

- Dicamba on specialty crops
- Optimizing shelf life for tomatoes
- Presentations by local successful tomato farmers

Lessons Learned

This project provided valuable lessons, made more valuable by the fact that the market will be undertaking with its collaborators two more Tomato Schools to be held in Jefferson City and one other Missouri location in 2019 and 2020 respectfully. These lessons include:

1. Secure a strong local partner with proven organizational skills and the ability to connect with a large number of prospective attendees.
2. Establish a MOU with the local partner outlining responsibilities, both organizational and fiscal, and establishing expectations. (For example, the host organization at the 2018 School handled the farm tours. The farms, it turned out, did not have the substantial tomato production that our team had expected, and thus provided limited opportunities for instruction.)
3. Provide enough lead time to send out a Save the Date at least 3 months prior to the School.
4. Finalize the program at least two months prior to the School to allow for a strong publicity campaign.
5. Have a member of the Southwest Missouri team supervise on-site registration.

On the positive side, we secured a team of presenters for the 2018 School (Joe Kimble and Rick Snyder) that exceeded our expectations and who have agreed to present at our 2019 and 2020 Schools.

Contact Person

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Additional Information

Missouri Tomato Conference

Thursday & Friday, June 28 & 29, 2018
Jackson, Missouri

Tomatoes are Missouri's biggest selling specialty crop but they can be a challenging crop to grow successfully. Whether you grow in the field or under cover, you won't want to miss this conference featuring nationally known experts, as well as regional experts and local successful tomato farmers.

For additional brochures and registration forms go to:
https://www.facebook.com/MOStrikeForce/

Sponsors of the Conference:

MISSOURI AGRICULTURE

The Missouri Department of Agriculture has funded a portion of this project, through a Specialty Crops grant.

UNIVERSITY OF MISSOURI Extension

LINCOLN UNIVERSITY MISSOURI COOPERATIVE EXTENSION

The Webb City Farmers Market
Eat local – Eat fresh

MO Strike Force Project

Missouri Tomato Conference

Thursday & Friday, June 28 & 29, 2018*
At the Cape Girardeau County Extension Center
684 Jackson Trail, Jackson, MO

Thursday, June 28

Registration – 8 to 8:45 am

8:45—**Welcome**

9:00 am - **10:00 - Successful Tomato Production with Plasticulture** – Joe Kemble

10:00 - 11:00 - **Keeping a Healthy Environment in the Greenhouse** – Rick Snyder

11 - Noon - **Top Tomato Diseases and Management** – Joe Kemble

Noon - 1:00 pm - Lunch - **Eat with an Expert** - Join one of the presenters for a discussion during lunch

1:00 - 3:00 pm **- Concurrent Sessions**

Track 1: Field Tomatoes -

Farmer presentation - Rick Bollinger of Lukey Pickin's Farm

Tips on managing irrigation—David Middleton

How to Build a Caterpillar Tunnel—Shon Bishop

Track 2: Greenhouse and High Tunnel tomatoes

Farmer presentation – Rennie Phillips of Sandhill's Farm

Humidity Control – Rick Snyder

Issues with heaters in a greenhouse—Rick Snyder

3:30 - 4:30 - **Dicamba on specialty crops –** Sarah Denkler

4:30 - 5:30 - **Keeping 'Em Fresh—Optimizing Shelf Life for Your Tomatoes —** Joe Kemble

Friday, June 29

8:30 am - 12:30 - **Farm tours and on-farm demonstrations led by our presenters & other experts at two area farms with field & protected tomato crops**

- *All presentations subject to change.*

Presenters

Dr. Rick Snyder, Mississippi State University – DDr. Snyder is Extension/Research Professor at the Truck Crops Experiment Station inCrystal Springs, MS.

His educational background includes a B.S. from the University of Connecticut, an M.S. from Ohio State University, and Ph.D. from Cornell University, all in horticulture. His areas of specialty include commercial production of greenhouse tomatoes and other vegetables, as well field vegetables. He coordinates the very popular annual Fall Flower & Garden Fest at the experiment station, which draws 5,000 visitors each fall. Dr. Snyder hosts the well-known Mississippi Greenhouse Tomato Short Course, now in its 28th year, and is a highly sought speaker on all aspects of greenhouse tomato production.

Dr. Joe Kemble, Auburn University - Dr. Kemble is Extension Vegetable Specialist & Professor at Auburn University, AL. He is the senior editor of the annual Vegetable Crop

Handbook for the Southeastern US, and works extensively with all aspects of tomato production. His educational background includes degrees from University of Delaware and North Carolina State University. Dr. Kemble's research program focuses on use of cover crops and reduced tillage for vegetable production, nutrient manage ment, double cropping using plasticulture. His extension appointment includes work with farms of all sizes in solving production problems, developing irrigation and fertigation schedules, improving cultural practices, designing irrigation systems, and encouraging vegetable growers to try new or different ideas and alternative vegetable crops through on-farm research and demonstrations.

Patrick Byers (far right) is Regional Horticulture Specialist with the Webster County office of University of Missouri Extension with extensive experience in field and protected tomato production.

Shon Bishop (near right) is a Small Farm Specialist for the Innovative Small Farmers Outreach Program (ISFOP) with extensive experience in high tunnel

installation. Shon is the lead extension specialist for the Year-Round Education Center.

Robert Balek (left) is a horticulture specialist with the Jasper County office of University of Missouri Extension and works with tomato growers in Southwest Missouri.

David Middleton (below left) grew up on a diversified grain and livestock farm near Laddonia, Missouri. He graduated from the University of Missouri with a B.S. and M.S. in Animal Science. David joined Lincoln University Cooperative Extension (LUCE) in 2014 as the Farm Outreach Worker (FOW) for Lawrence and Greene Counties.

Sarah Denkler (right) is a horticulture specialist with University of Missouri Extension in Southeast Missouri based out of Butler County. She works with commercial specialty growers in the region, I ncluding those that grow tomatoes.

The Jesup Wagon 2.0 is a modern take on George Washington Carver's innovative Jesup Wagon which rolled out of Tuskegee Institute in 1906 (right—Carver's drawing for the first wagon). Like the first Jesup Wagon, the 2.0 version is also a "moveable school" bringing the latest technology to farmers, this time in Missouri.

When completed, the Wagon will include kits on:

- Irrigation
- Hand tools for high tunnels and other small areas
- Pesticide safety kit and backpack sprayer calibration kit
- BSC tractor attachments
- Low tunnel/caterpillar tunnel kit
- Technology kit containing a DJI Phantom 4 Pro Drone and accessories, a tensiometer, a soil compaction tester and a ph, moisture, light and temperature meter

The kits are managed for the Webb City Farmers Market by a team of Southwest Missouri MU Extension and LU Co-operative Extension colleagues. The project is funded by the Missouri Department of Agriculture using specialty crops funds. Special thanks to our teammates at Lincoln who secured funding for the Jesup Wagon 2.0 trailer shown above.

StrikeForce Evaluation: Tomato Workshop – Jackson, MO – 28 June 2018

Program Impact Report

1. **How well were your expectations met in this program?**

Category	*n=*	*percent*
I have unmet expectations	0	0%
Below my expectations	0	0%
Somewhat met my expectations	3	11%
Fully met my expectations	16	59%
Exceeded my expectations	8	30%

Explain _____

- speakers were fabulous
- very informed
- Lots of topics covered!

2. **Overall, after completing this workshop, to what level has your knowledge increased:**

Category	*n=*	*percent*
Not at all	0	0%
I have learned information I did not know	5	19%
I am confident I can implement practices introduced in this workshop	17	63%
I have gained a mastery of topics covered	1	4%
I now feel I could teach this to someone else	4	15%

Comments below ……..

- Excellent
- very good program, great detail

3. **Listed below are the topics presented during this workshop. On the left, circle your knowledge of each topic BEFORE the workshop. On the right, circle your knowledge of each topic AFTER the workshop.**

How confident you are in using these practices or researching information after the workshop:

	Question:	*Non-existent*	*Minimal*	*Moderate*	*Considerable*
		%	%	%	%
1	Tomato production practices	0	0	55.6	44.4
2	Tomato irrigation	0	0	59.3	40.7
3	Tomato diseases	0	3.8	53.8	42.3
4	Plasticulture tomato production	0	11.1	59.3	29.6
5	Greenhouse/Tunnel tomato production	0	3.7	66.7	29.6

Please complete side 2