

**Missouri Department of Agriculture  
Susan Bennett, SCBGP Program Coordinator  
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Final Performance Report  
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## **Project 1: Growing Missouri's Chestnut Industry-Harvesting, Marketing and Financial Decision-Making**

### **University of Missouri**

Dr. Michael Gold

Final Performance Report

### **Project Summary**

The goal of this project was to support growers' efforts to mechanize chestnut harvests. Rapid and efficient chestnut harvesting is essential for growers to expand their acreage up to a commercial scale, minimize labor costs and maintain a top quality product for the marketplace.

The current project built upon a previously funded project with the SCBGP (12-25-G-0611) entitled **Exploring Rural Development with Local Youth through Specialty Crops: Chestnuts**. The primary project purpose of that SCBGP was to help create a chestnut industry in Missouri through the establishment of working orchards linked to extensive grower training for new producers, MU Extension Specialists and FFA students. In 2008, 2009 and 2010 four hands-on chestnut production workshops were offered to a total of 60 current and potential chestnut producers during strategically selected phases of the growing season to optimize demonstration and learning opportunities. In addition, large chestnut roast festivals were conducted annually at the MU HARC Farm.

In addition to the research and demonstration orchards developed and maintained by MU at the Horticulture and Agroforestry Research Center in New Franklin, MO, a very successful commercial demonstration orchard was established near Napton, MO (now 15 acres in size) that has subsequently begun to serve as a key site for conferences and workshops in orchard establishment and maintenance for existing and prospective new growers.

The above named project provided a spark to help grow the now increasing interest in Missouri's commercial chestnut production. One measure of Missouri's chestnut industry growth can be found in the fact the Forrest Keeling Nursery (which sells chestnut seedlings and grafted cultivars) has experienced a 600% increase in its chestnut sales over the past 5 years. Forrest Keeling Nursery also established its' own annual "Great River Road Chestnut Roast" in 2011.

Building upon the previous SCBGP (mentioned above), the factors that motivated this SCBG proposal were as follows:

- 1) In the Eastern USA, a domestic edible chestnut industry has been growing rapidly for the past decade. In 2007, the USDA National Agriculture Statistics Service conducted its' first ever survey of chestnut production nationwide. The 2012 census showed a 13.5% growth in acres in production compared with 2007. Missouri acreage doubled in size. Over the past 20 years the University of Missouri Center for Agroforestry (UMCA) has become a national leader in providing baseline research results in support of the young industry. UMCA is the recognized chestnut authority in Missouri and adjacent states.
- 2) The project PI (Gold) served as President of the Chestnut Growers of America (CGA) from 2007-2013. CGA is the only national organization representing chestnut producers in the USA. As President, it was clearly evident that there was an immediate need for a user friendly tool for existing and especially potential new producers to use to evaluate the potential for entering into the chestnut production business. In addition, if chestnut

production acreage was to grow in size beyond a “hand pick or u-pick” size of ~10 acres, then mechanized harvest equipment needed to be demonstrated.

Mechanization will increase the competitiveness of locally grown chestnuts and enable domestic growers to produce the tonnage required to replace imports.

The MU Center for Agroforestry (UMCA) has the nation’s leading chestnut research program, laying the foundation for a new chestnut industry in Missouri and surrounding states. To strengthen growth of Missouri’s developing chestnut industry, rapid and efficient mechanized chestnut harvesting is essential for chestnut growers to deliver only top quality chestnut products into the fresh market for consumer satisfaction and to offset imports.

The project objectives were to: Support growers’ efforts to mechanize the chestnut harvest through harvest demonstration workshops; Conduct a “time-and-motion” study to quantify the labor saving benefits of a commercial harvester; Create, demonstrate and release a Chestnut Financial Decision Support Tool to help chestnut growers and other decision makers make financially sound management and investment decisions; and Provide advanced financial and market information to enable growers to profitably sell their chestnut crop.

## **Project Approach**

Activities performed in 2014 to accomplish the project objectives:

1. Three invited chestnut talks were/will be presented (by Michael Gold) in 2014:
  - a) “Chestnuts: Building a Perennial Specialty Crop Industry From Scratch” was presented at the Great Plains Growers Conference, January 11, 2014, St. Joseph, MO. Attendance: 120 landowners.
  - b) “Chestnuts: Building a Perennial Specialty Crop Industry From Scratch” was presented at the Permaculture Voices Conference, March 16, 2014, Temecula, CA. Attendance: 150 landowners.
  - c) “A to Z of Successful Chestnut Production” will be presented at the National Young Farmers Conference, Stone Barns Center for Food and Agriculture, December 4, 2014, Tarrytown, NY. Attendance: 120 farmers expected.
2. Participated in the Chestnut Growers of America annual meeting, June 21-22, 2014, Gibsonville, NC. Attendance: 60 chestnut growers.
3. A tractor-pulled mechanical chestnut harvester was purchased. The FACMA model C300T was delivered on September 4, 2014. Harvester was acquired through a Michigan-based distributor.
4. A fall field day was organized at the MU Horticulture and Agroforestry Research Center on October 4, 2014, New Franklin, MO. The event included a field demonstration and discussion of the FACMA harvester. Attendance: 75 individuals, including current Missouri chestnut growers.
5. The Center for Agroforestry participated in the 4<sup>th</sup> Annual Great River Road Chestnut Roast, October 18, 2014, Elsberry, MO. Information on chestnut production in Missouri

was shared with roast attendees. This event is sponsored by Forrest Keeling Nursery. Attendance: ~1,000 individuals.

6. In 2014, an online Excel-based Chestnut Financial Decision Support Tool was created. The tool will be released in early 2015 to help chestnut growers and other decision makers (e.g., cooperatives, agricultural lenders) make financially sound management and investment decisions.

Activities performed in 2015 to accomplish the project objectives:

1. Presentations presented (by PI Michael Gold) in 2015:
  - a) "Profits with Specialty Crops" was presented at the Beginning Veteran Farmers: Opportunities and Resources for Veterans Interested in Agriculture, April 27, 2015, Rolla, MO. Attendance: 60 military veterans currently farming or interested in becoming farmers.
  - b) "Agroforestry" was presented at the Veterans to Farmers Program, Falcon Ridge Farm, May 16, 2015, Competition, MO
  - c) "Chestnut Cultivar Evaluation in Missouri, USA" was presented at the 14<sup>th</sup> North American Agroforestry Conference, June 1-3, 2015, Ames, Iowa. Attendance: 175 farmers, extension agents, non-profit staff, undergraduate and graduate students and faculty.
  - d) "Chestnut Growers of America Market Survey" was presented at the Chestnut Growers of America Annual Meeting, June 10-12, 2015, Stockton, CA. Attendance: 75 commercial chestnut growers.
  - e) "Chestnut Financial Decision Support Tool" was presented at the Chestnut Growers of America Annual Meeting, June 10-12, 2015, Stockton, CA. Attendance: 75 commercial chestnut growers.
  - f) "Marketing for Agroforestry" was presented at the 3<sup>rd</sup> Annual Agroforestry Academy, July 20-24, 2015, Columbia, MO. Attendance: 40 including landowners, military veterans, extension agents, trainers.
  - g) "Specialty Crop Development -- The Example of Chinese Chestnut" was presented at the 106<sup>th</sup> Annual Meeting of the Northern Nut Growers Association, July 26-29, 2015, La Crosse, Wisconsin. Attendance: 225 amateur and commercial nut growers.
  - h) Alley Cropping in Nut Orchards was also presented at the 106<sup>th</sup> Annual Meeting of the Northern Nut Growers Association, July 26-29, 2015, La Crosse, Wisconsin. Attendance: 225 amateur and commercial nut growers.
  - i) "A to Z of Successful Chestnut Production" was presented at 9<sup>th</sup> Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) on October 17,

2015, New Franklin, MO. Attendance: 150 landowners, amateur and commercial nut growers, undergraduate and graduate students.

2. Tours of the chestnut orchards at the MU Horticulture and Agroforestry Research Center (HARC) on October 17, 2015, New Franklin, MO:
  - a) Tour for two scientists from INBio, a non-profit Costa Rican NGO dedicated to the preservation of tropical biodiversity, March 5, 2015.
  - b) Borlaug Fellows from Senegal and Cochrane Fellowship participants from Turkmenistan and Tajikistan, June 20, 2015. Attendance: 25
  - c) Missouri Department of Conservation, June 30, 2015. Attendance: 35
  - d) Annual Agroforestry Academy, July 20-24, 2015, Columbia, MO. Attendance: 40
  - e) Tour for Dr. Gokhan Yazici and Dr. Arun Chattopadhyay, Etimine USA, Inc. August 5, 2015.
  - f) Tour for Dr. Anne Tittor, Center for InterAmerican Studies, University of Bielefeld, Germany, August 26, 2015.
  - g) Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) on October 17, 2015, New Franklin, MO. Attendance: 150 (five tour groups, 30 per group).
  - h) Tour for Dr. Sarah Taylor Lovell and graduate/undergraduate students from the University of Illinois, October 19, 2015. Attendance: 7
3. Center for Agroforestry faculty and staff collected cultivar performance data (yield and nut size) on a replicated chestnut cultivar trial (established in 1999) for the first time since 2011. The 2015 yield data will be used to refine the Chestnut Financial Decision Support Tool to increase the accuracy of the growth and yield equations.
4. The Center for Agroforestry hosted the 9<sup>th</sup> Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) on October 17, 2015, New Franklin, MO. **There were 1,500 people in attendance** over a 6 hour period. The event included HARC farm tours to showcase chestnut orchards along with a field demonstration and discussion of the FACMA mechanical harvester. In addition, a chef prepared a series dishes featuring chestnuts, free roasted chestnuts were provided along with supporting literature (recipes, how to grow chestnuts), fresh chestnuts were sold by private vendors, and chestnut trees were sold by Forrest Keeling Nursery.
5. Participated in the 5<sup>th</sup> Annual Great River Road Chestnut Roast, October 24, 2015, Elsberry, MO. Information on chestnut production, recipes and nutrition information was shared with roast attendees. This event is sponsored by Forrest Keeling Nursery. Attendance: ~850 individuals.
6. In 2015, an online Excel-based Chestnut Financial Decision Support Tool was released to assist chestnut growers and other decision makers (e.g., cooperatives, agricultural lenders) make financially sound management and investment decisions. (<http://www.centerforagroforestry.org/profit/#specialty>) The Financial Decision Support Tool was presented at the 2015 annual meeting of the Chestnut Growers of America (see above) and also shared with participants at the

Northern Nutgrowers and North American Agroforestry Conferences in addition to attendees at the Missouri Chestnut Roast.

Activities performed in 2016 to accomplish the project objectives:

1. Presentations presented (by PI Michael Gold) in 2016:
  - a) “Agroforestry Opportunities for Small Farms” was presented at the Agroforestry and Woodland Management Workshop, May 25-26, 2016, Jefferson City, MO. Attendance: 80 landowners currently farming or interested in becoming farmers, plus MU and Lincoln U extension educators and state (MDC) and federal agency (NRCS) staff.
  - b) “Chestnut Growers of America Annual Market Survey 2015-2016” was presented at the Chestnut Growers of America Annual Meeting, June 10-12, 2016, Columbia, MO. Attendance: 70 commercial chestnut growers.
  - c) “Marketing Agroforestry Products” was presented at the 4th Annual Agroforestry Academy, July 25-29, 2016, Columbia, MO. Attendance: 42 including landowners, military veterans, extension agents, trainers.
  - d) “Opportunities for Chestnut Production in the Midwest” was presented at the Southwest Center Field Day on Sept. 23, 2016, Mt. Vernon, MO. Attendance: 75 landowners.
  - e) “Today’s Chestnut Market” was presented at 10th Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) on October 8, 2016, New Franklin, MO. Attendance: 90 landowners, amateur and commercial nut growers, undergraduate and graduate students.
2. Tours of the chestnut orchards at the MU Horticulture and Agroforestry Research Center (HARC), 2016, New Franklin, MO:
  - a) Tour for four visiting faculty from Moscow State University, Russia, April 19, 2016.
  - b) Tour for five scientists from Hunan Agricultural University, China, May 1, 2016.
  - c) Tour for Russell Diez-Canseco, President and CEO, Vital Farms, May 7, 2016.
  - d) Chestnut Growers of America tour of the MU Horticulture and Agroforestry Research Center (HARC), June 11, 2016, New Franklin, MO. Attendance: 70
  - e) Tour for fifteen Missouri High School Agriculture Science educators as part of Agroforestry Summer Institute training, June 21, 2016.
  - f) Tour for Dr. Lloyd Sumner and five graduate students, July 7, 2016.
  - g) 4th Annual Agroforestry Academy, July 25-29, 2016, Columbia, MO. Attendance: 42
  - h) Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) in New Franklin, MO. Attendance: 150 (five tour groups, 30 per group).
  - i) Tour for 10 Mizzou undergraduate students enrolled in Natural Resources themed Freshman Interest Group (FIG) program.
3. Center for Agroforestry faculty and staff collected cultivar performance data (yield and nut size) on a replicated chestnut cultivar trial (established in 1999) for the second time since

2011. The 2015 and 2016 yield data will be used to refine the Chestnut Financial Decision Support Tool to increase the accuracy of the growth and yield equations.

4. The Annual Chestnut Growers of America conference was held from June 10-12, 2016 at the University of Missouri, Columbia, MO. Comprehensive harvest, marketing and financial decision-making information were presented during the conference.
5. The Center for Agroforestry hosted the 10th Missouri Chestnut Roast at the MU Horticulture and Agroforestry Research Center (HARC) in New Franklin, MO. **There were 3,000 people in attendance** over a 6 hour period. The event included HARC farm tours to showcase chestnut orchards along with a field demonstration and discussion of the FACMA mechanical harvester. In addition free roasted chestnuts were provided along with supporting literature (recipes, how to grow chestnuts), fresh chestnuts were sold by private vendors, and chestnut trees were sold by Forrest Keeling Nursery.
6. A follow up survey of 2016 Missouri Chestnut Roast participants was conducted (**for results, see attached**). It is clear that our ongoing “market pull” strategy via the Chestnut Roast is continuing to draw more consumers to be familiar with and to purchase chestnuts.
7. Participated in the 6th Annual Great River Road Chestnut Roast in Elsberry, MO. Information on chestnut production, recipes and nutrition information was shared with roast attendees. This event is sponsored by Forrest Keeling Nursery. Attendance: ~950 individuals.

### **Goals and Outcomes Achieved**

#### Excerpts from 1680 Project 1 State Plan

**Outcome #1:** Goal: Expand acreage of chestnut orchards in Missouri and surrounding states.

**Performance measure:** Number of additional acres planted.

**Benchmark:** current acreage - 55 acres.

**Target:** Quintuple current chestnut orchard acreage from 55 to 255 planted acres by 2015.

Performance will be determined through follow-up surveys to all individuals who attended workshops in 2014 and 2015. The surveys will include questions on acres planted as a result of the training, what information was gained from the trainings, what knowledge was shared and with who to increase awareness about chestnuts and modern harvesting practices, plus documentation of success stories and ongoing challenges.

**Based on annual surveys of CGA membership, the identified growth in chestnut production over the 3 year duration of this grant totals 346.5 acres in newly established**

**chestnut orchards.** This surpasses the projected target of 255 new acres. This should also be reflected in the results of the 2017 Census of Agriculture – results forthcoming in 2018.

#### 2014 Explanation of chestnut orchard acreage for Goal # 1

In 2007, chestnuts were included for the very first time within the USDA Census of Agriculture (Table 32 – Fruits and Nuts).

In 2012, chestnuts were again included in the USDA Census of Agriculture (Table 32 – Fruits and Nuts).

- ✓ Specifically for Missouri, the 2007 USDA Census of Agriculture reported 95 acres of chestnut orchards in Missouri, 40 acres “nonbearing” and 55 acres “bearing”.
- ✓ In 2012 USDA Census of Agriculture reported 200 acres of chestnut orchards in Missouri, 76 acres “nonbearing” and 124 acres “bearing”.

This dramatic increase in Missouri chestnut acreage, both “bearing” and “nonbearing” is directly connected to the ongoing efforts of the Center. With funding from a previous Missouri SCBG “**Exploring Rural Development with Local Youth through Specialty Crops: Chestnuts**”, our Center conducted chestnut workshop series (4 trainings per year), in 2009 and 2010. A total of 59 individuals attended the workshops. In addition to the trainings, the Center held its annual Chestnut Festival in both 2009 and 2010 providing additional exposure to chestnut production through farm tours and informal contacts with Center staff and chestnut vendors. An additional annual Great River Road Chestnut Roast was established by Forrest Keeling Nursery (Elsberry, MO) in 2011 and has been continued in 2012, 2013 and 2014. The Center has been directly involved in providing educational materials to all participants (no formal pre or post surveys were involved) at each Great River Road Chestnut Roast. Since 2009, Forrest Keeling Nursery has been providing the Center’s recommended cultivars through its commercial sales.

The combination of ongoing Center research/outreach/training activities and ongoing Forrest Keeling Nursery outreach and sales activities has resulted in the rapid growth of chestnut acreage in Missouri (and in surrounding Midwest states).

**Outcome #3:** Goal: Increase depth and breadth of market knowledge for 50 current and potential growers.

**Performance measure:** Number of workshop participants; documented increase in knowledge.

**Benchmark:** Pre-workshop knowledge.

**Target:** Provide advanced training to 50 current and potential growers. Pre- and post-workshop surveys will be conducted with all participants to quantify gains in knowledge.

**In June of 2016, UMCA hosted the annual CGA conference in Columbia, MO. Seventy individuals attended the annual CGA Conference. A post-conference survey was conducted following that meeting to determine the benefits of trainings to chestnut producers. Relevant survey results follow.**

#### Impacts of conferences, trainings or outreach events:

Prompt the establishment of chestnut orchards: Approximately 67% of our respondents indicated that conferences, trainings or outreach events promoted them to establish chestnut orchards. There are 42% of the respondents indicated information from Northern Nut Growers Association (NNGA) prompted them to establish their chestnut orchards. Chestnut trainings at

UMCA, Annual CGA Meeting/membership in CGA, Missouri Chestnut Roast also contributes to chestnut orchards establishment (Fig. 2). Respondents also indicated other sources of information that helps to establish their orchards, including: UMCA bulletin growing Chinese chestnuts, articles published in MO conservation magazine, Horticulture and Agroforestry Research Center activities, Northwest Michigan Chestnut Conference 1990-1991, and Chestnut alliance in later 1990s.

Prompt the plant of additional acres of chestnut: There are 10 respondents who indicated they have planted additional acres of chestnut between 2013 and 2015. Approximately, 6 respondents (60%) reported that conferences, trainings or outreach events promoted them to plant additional acres of chestnuts. Chestnut trainings at UMCA, NNGA, Annual CGA Meeting/membership in CGA, Missouri Chestnut Roast were all found to prompt respondents' decisions on planting additional acres of chestnut (Fig. 2). Respondents also mentioned that economic benefits encouraged them to plant additional acres of chestnut.

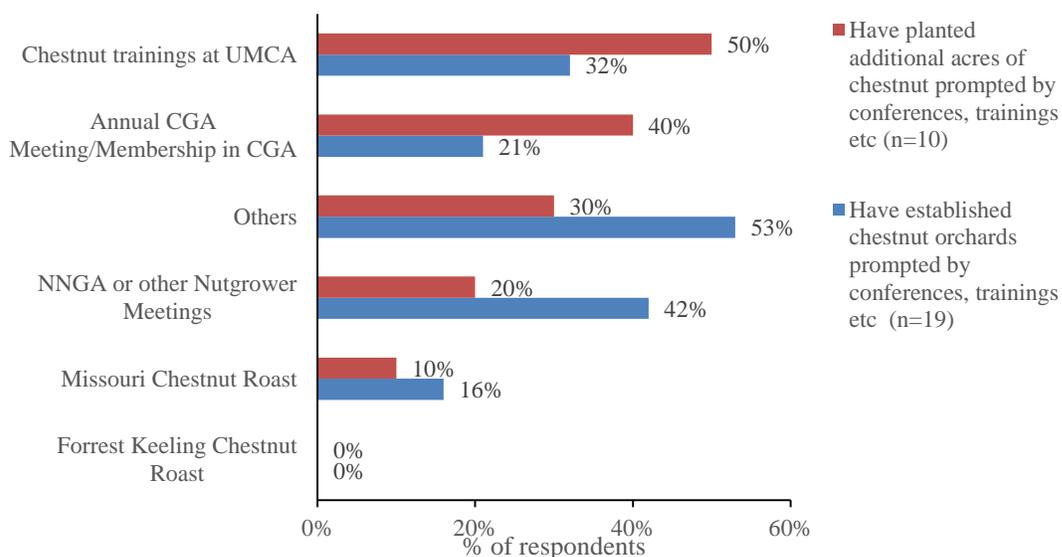


Fig. 2. Percentage of respondents who have established/planted additional acres of chestnuts prompted by conferences, trainings, outreach events and others.

*Number of acres of chestnut planted:* Survey results showed that, in 2016, an average of 52 acres of chestnuts per respondent were planted. Between 2012 and 2015, an additional 44 acres of chestnut were planted by our respondents, of which 34 acres (77%) were indicated as prompted by conferences, trainings or outreach events.

*Key information gained from the conferences or trainings that led to planting chestnuts:* Sixteen respondents answered this question. All of these respondents indicated that production

information gained from the conferences or trainings led to planting chestnuts (Fig. 3). Information on harvest, marketing, pollination provided in the conferences or trainings are also indicated by at least half of the respondents regarding their positive role in planting chestnuts. Two respondents explicitly mentioned that the information on value added products and cultivar quality, provided by the conferences and other activities, encourages them to plant chestnuts.

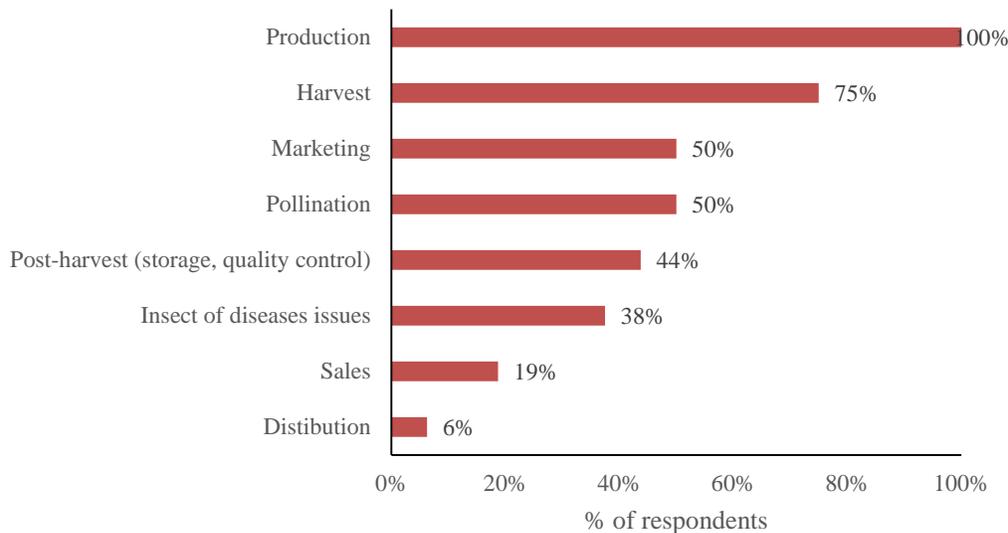


Fig 3. Key information gained from the conferences or trainings that led to planting chestnuts ( $n=16$ ).

Explanation of information on the pre- and post-workshop surveys conducted with participants (Goal #3).

As mentioned previously when this annual report was submitted, the Center lost two key full time staff positions in 2012 (economist) and 2013 (marketing and evaluation specialist). The Center had no resources to fill either of those positions until recently (2015). As a result, we did not hold a formal chestnut training workshop in the fall of 2014; rather we held a field day. We did not conduct pre and post surveys of the individuals who attended the field day in 2014.

In 2015, the Center filled the Agroforestry position that focused on both economics and marketing.

**2015**

**Outcome #1:** Goal: Expand acreage of chestnut orchards in Missouri and surrounding states.

**Performance measure:** Number of additional acres planted.

**Benchmark:** current acreage - 55 acres.

**Target:** Quintuple current chestnut orchard acreage from 55 to 255 planted acres by 2015.

Performance will be determined through follow-up surveys to all individuals who attended workshops in 2014 and 2015. The surveys will include questions on acres planted as a result of the training, what information was gained from the trainings, what knowledge was shared and

with who to increase awareness about chestnuts and modern harvesting practices, plus documentation of success stories and ongoing challenges.

**Outcome #1:** Expand acreage of chestnut orchards in Missouri and surrounding states  
**Plans are to survey Missouri/Midwest chestnut growers who attend 2016 Chestnut Growers of America annual meeting** hosted by the SCBGP project PI (Gold) and Center for Agroforestry, Summer 2016. We will obtain information on acres planted as a result of the training, what information was gained from the trainings, what knowledge was shared and with who to increase awareness about chestnuts and modern harvesting practices, plus documentation of success stories and ongoing challenges.

**Outcome #2:** Goal: Reduce overall harvest costs for chestnuts.

**Performance measure:** Time of harvest, labor costs.

**Benchmark :** Match up with harvest costs incurred by chestnut producers on the U.S. West Coast.

**Target:** Cut harvest costs in half. Performance will be monitored by a “time-and-motion” study on commercially producing acres at MU HARC farm comparing time and labor for manual vs. mechanical harvesting and processing.

**Outcome #2:** Goal: Reduce overall harvest costs for chestnuts. Data will be forthcoming in the final report.

As explained below in the “corrective actions” section of the final report, the planned time-and-motion study was not performed as outlined in the original proposal. Lacking the data from the time-and-motion study, it is not possible to provide accurate harvest cost reduction information in this final report.

### **Beneficiaries**

Chestnut growers and other decision makers, i.e. Missouri Nutgrowers Association (MNGA), the Chestnut Growers in America (CGA), the Midwest Nut Producers Council (MNPC) and the Northern Nutgrowers Association (NNGA) are beneficiaries of the project.

The number of beneficiaries directly affected by the project’s accomplishments includes the entire membership of the CGA (110 active chestnut growers located from coast to coast) who benefit directly from the annual chestnut market surveys conducted by UMCA. Results of this market survey are presented annually at the national CGA members’ conference to provide

producers with an indication of the market growth, annual sales and sales categories, wholesale and retail prices, future projections for new acreage and future market demand trends.

MNGA has 120 active members and NNGA has 700 members.

The potential economic impact of the project is demonstrated in the continued growth of the US chestnut industry illustrated by UMCA annual market surveys of CGA membership.

- ✓ The 2013-2014 Annual Market Survey revealed that members planned to establish 5,065 new trees on 91 acres.
- ✓ The 2014-2015 Annual Market Survey revealed that 25% of CGA members planned to expand their orchards in the coming year, specifically establishing 8,000 new trees on 88.5 new acres.
- ✓ The 2015-2016 Annual Market Survey revealed that 43% of CGA members planned to expand their orchards in the coming year, specifically establishing 8,127 new trees on 167 new acres.

According to the National Agriculture Census of 2007 there were a total of 3,335 acres in chestnut production throughout the USA. By the 2012 census, 3,784 total acres were reported. The identified growth in chestnut production over the 3 year duration of this grant totals 346.5 acres in newly established chestnut orchards. These surveys include only the individuals who belong to the CGA. This represents an approximate 10% additional reported growth in planned US chestnut acreage from CGA members alone.

It is clear that members of CGA (the group who best represent active US chestnut producers), who receive benefit from the results of UMCA's annual market surveys and results from our field production trials, are confident in the future growth and expansion of future chestnut sales. In addition to CGA members, MNGA and NNGA members also benefitted from similar UMCA presentations on the status of the US/Midwest/Missouri chestnut industry which were offered during the life of this SCBGP project.

## **Lessons Learned**

### **2014**

The planned Sept./Oct. 2014 time-and-motion study to quantify the labor saving benefits of the C300T commercial harvester was not conducted for two primary reasons. First, the Michigan distributor of the FACMA 300T delivered the harvester in early September, 2014, a full month beyond the requested delivery date. This did not allow enough time for the research team to become thoroughly familiar with the operation of the harvester to permit the conduct of an accurate time and motion study in the fall of 2014. Second, due to employee turnover, the Center for Agroforestry was without its economist and its marketing specialist in 2014.

Due to loss of Center for Agroforestry economist and the Center for Agroforestry marketing specialist, the comprehensive harvest, marketing and financial decision-making workshop

scheduled for the Horticulture and Agroforestry Research Center in October of 2014 was not held.

Corrective actions:

- 1) Experience gained through use of the FACMA harvester in the fall of 2014 will permit a much more accurate time-and-motion study to be carried out in the fall of 2015; and
- 2) The Center for Agroforestry will hire a new economist (with market research skill) in 2015 and this individual will be responsible for conducting the time-and-motion study in the fall of 2015 and participating in the comprehensive harvest, marketing and financial decision-making workshop scheduled for October, 2015.

With the corrective actions described above, measurable outcomes are still realistic and will be attained by the end of the grant in 2015.

## **2015**

1. The planned Sept/Oct. 2015 time-and-motion study to quantify the labor saving benefits of the C300T commercial harvester was not conducted for the following reason: We had intermittent mechanical problems with the FACMA 300T harvester during the 2015 harvest season. The timing of mechanical breakdowns interfered with our ability to realize our planned Time and Motion Study during the 2015 harvest season. The Time and Motion Study is designed to be run both early in the harvest season during light nut drop and also during the height of the harvest season with intense nut drop. This is required to gain a true comparison of hand harvesting vs mechanical harvesting. By the time the intermittent mechanical issues were finally resolved, it was too late in the harvest season to conduct an accurate Time and Motion Study.
2. In lieu of a separate harvest, marketing and financial decision-making workshop, this activity was rolled into the 9<sup>th</sup> Annual Missouri Chestnut Roast which was held for the first time since 2010. The presentation "A to Z of Successful Chestnut Production" covered the topics including harvest, marketing and financial decision making.
3. A survey of the 9<sup>th</sup> Annual Missouri Chestnut Roast attendees was conducted, including a conjoint consumer preference analysis, and the results of that survey are included.

## **2016**

1. The planned time-and-motion study to quantify the labor saving benefits of the C300T commercial harvester was not conducted for the following reason: The Time and Motion Study is designed to be run both early in the harvest season during light nut drop and also during the height of the harvest season with intense nut drop. This is required to gain a true

comparison of hand harvesting vs mechanical harvesting. A shortage of technical support staff left us unable to perform the Time and Motion Study during the 2016 season.

### **Contact Person**

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### **Additional Information**

#### **2015 Missouri Chestnut Roast Festival - Survey Report**

The 9th Missouri Chestnut Roast Festival (MCRF) was held on October 17, 2015 at MU's Center for Agroforestry Research Center in New Franklin, MO. The first MCRF was organized in 2003 and continued annually until 2010. With renewed Center funding, this festival was re-established in 2015. The main objective of the festival is to increase Missouri residents' awareness of chestnuts through providing sample of roasted chestnuts and cooking demonstrations.

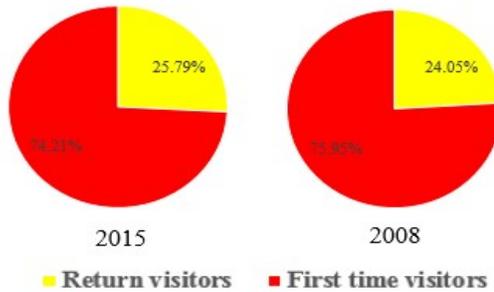
Market research was conducted during the festival to examine Missouri residents' familiarity with chestnuts, festival attendance objectives, and preferences for chestnuts. Onsite surveys using the same questionnaires were administered in 2008 and again in 2015 to compare Missouri residents' chestnuts knowledge and changes in preference during that period. Survey questions were divided into five sections: 1) Contained questions regarding respondents' past attendance to MCRF, chestnuts consumption frequency, chestnut purchase experience, and level of familiarity with cooking chestnuts. 2) Asked about respondents' motivations for attending the festival. Twelve motivations were listed in the questionnaire including: taste chestnuts and other Missouri specialty products, buy chestnuts, buy other Missouri specialty products, learn about chestnuts, learn about other Missouri specialty products, learn about agroforestry, visit the Hickman House, the uniqueness of the Missouri Chestnut Roast festival, to enjoy a day out, the activities for children, the variety of entertainment and activities offered, and I like to attend festivals. Respondents were asked to indicate the level of importance for each reason using five Likert scales. 3) Inquired into respondents' travel and stay information at the chestnut roast festival. 4) Contained questions about attendee demographics. 5) To explore respondents' preferences to chestnuts price, production process and origin, a conjoint analysis was included in the survey.

### **Results**

Number of responses: The 2015 MCRF had approximately 1,500 visitors compared to 4,500 visitors in 2008. A total of 194 responses were collected in 2015 compared to 524 responses in

2008. The ratio between number of respondents and total festival participants in 2015 (~ 13%) was very similar to the ratio in 2008 (~ 12%).

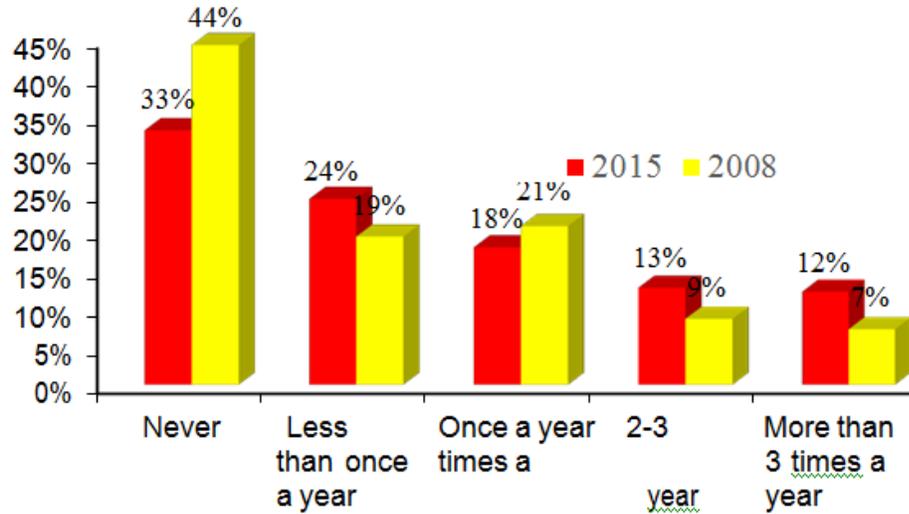
Have you attended the event before? Return visitors accounted for approximately 25% of total respondents in both years.



**Fig. 1** Previous attendance at the Missouri Chestnut Roast Festival

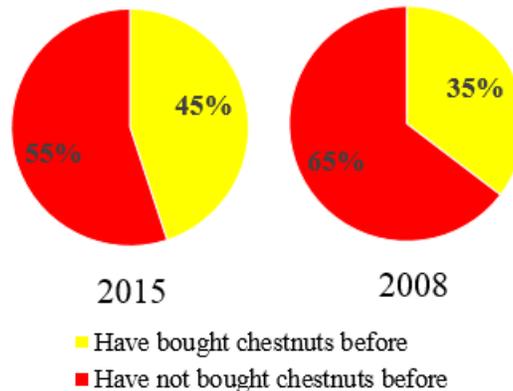
How often do you consume chestnuts? Results suggest that on average, festival participants' consumption frequency of chestnuts has increased since 2008. A higher percentage of respondents in 2015 indicated they had previously consumed chestnuts compared to respondents from 2008. Approximately 25% of the respondents in 2015 indicated they had consumed chestnuts at least 2 times a year compared to 16% in 2008. This demonstrates that

the “market pull” of consumer exposure to chestnuts via festivals and other events is drawing additional consumers into the marketplace.



**Fig. 2** MCRF participants' chestnuts consumption frequency

Past purchase: Survey results indicate that there is an increase in festival participants' chestnut purchasing behavior. A higher percentage of respondents in 2015 had previously purchased chestnuts compared to 2008 respondents.

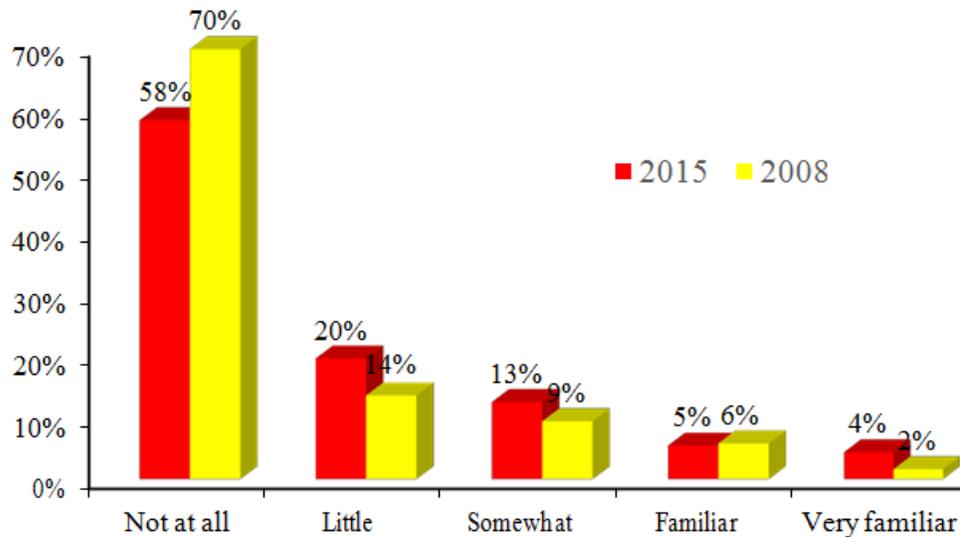


**Fig. 3** MCRF participants' past chestnuts purchasing behavior

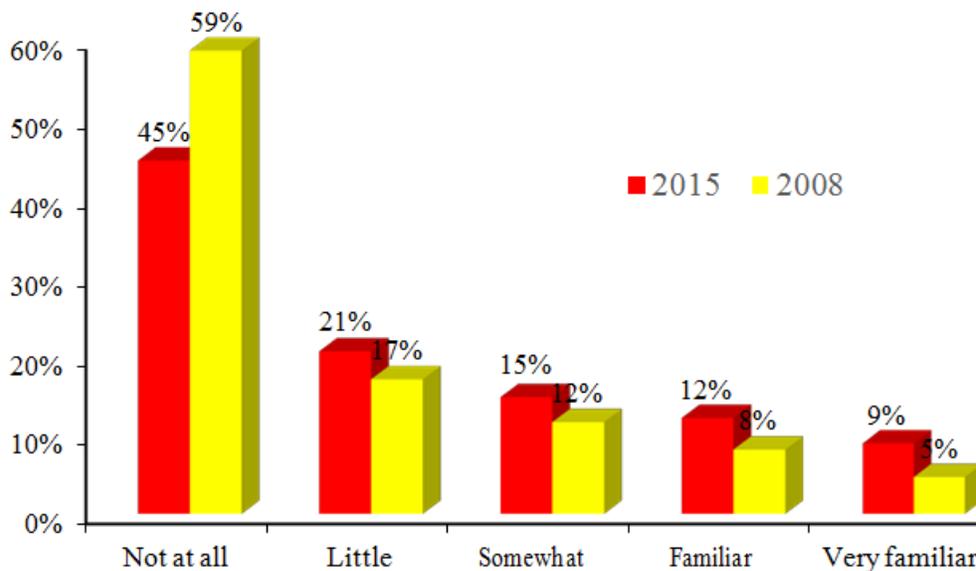
Familiarity with cooking chestnuts: There is an increase in festival participants' familiarity with cooking chestnuts. Their familiarity with roasting chestnuts and preparing chestnuts with recipes

had both increased. Approximately 36% of the respondents indicated they were at least somewhat familiar with roasting chestnuts in 2015 compared to 25% in 2008. Similarly, a higher

percentage of 2015 respondents (42%) indicated at least some degree of familiarity with preparing chestnuts from recipes as compared to respondents in 2008 (30%).



**Fig. 5** MCRF participants' familiarity with preparing chestnuts with recipes



**Fig. 4** MCRF participants' familiarity with roasting chestnuts

Motivations of attending MCRF: A higher percentage of festival participants came to the festival to learn about agroforestry in 2015 (56%) compared to festival participants in 2008 (44%). Also, a greater proportion of participants in 2015 attended MCRF to buy chestnuts (40%) that was the

case in 2008 (34%). Roughly 70% (67%) of the respondents came to the festival to taste chestnuts and other Missouri specialty products. More than 80% of the respondents indicated

that “agri-tourism” (enjoying a day out in the Missouri River Hills) as the important motivation to attend the festival.

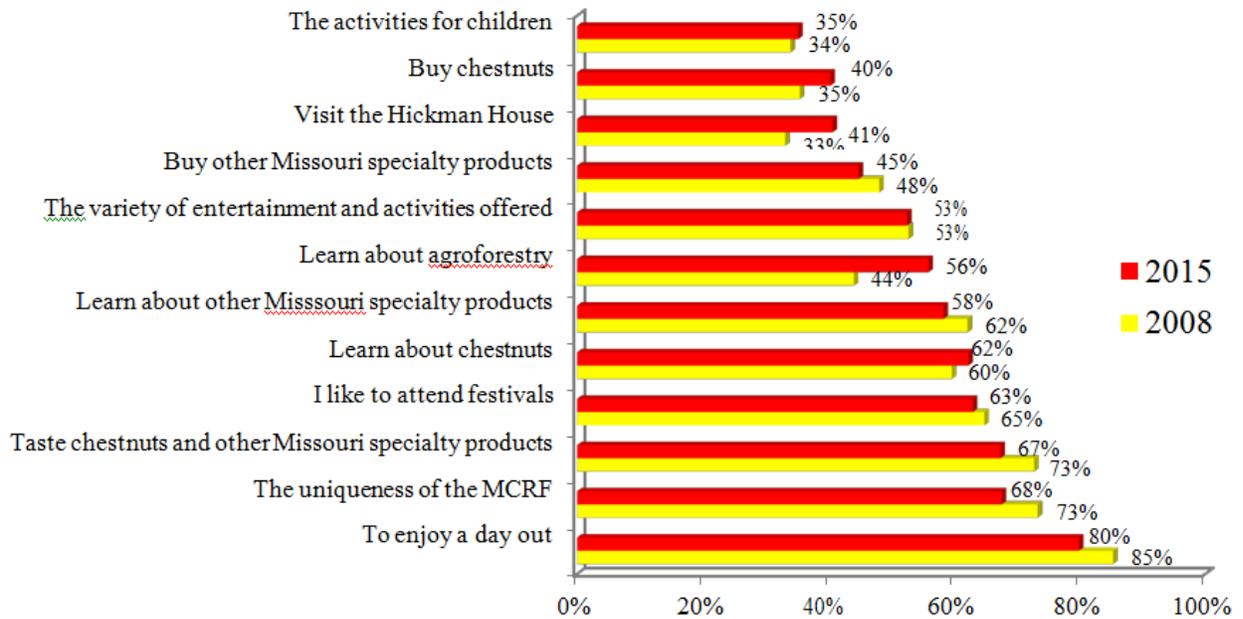


Fig. 6 MCRF participants' motivations of attending MCRF

Distance to the MCRF: In both 2008 and 2015, the majority of festival participants were located nearby (less than 30 miles) the festival. The nearest larger-sized city, Columbia, MO (pop. ~110,000) is ~30 miles from the MCRF.

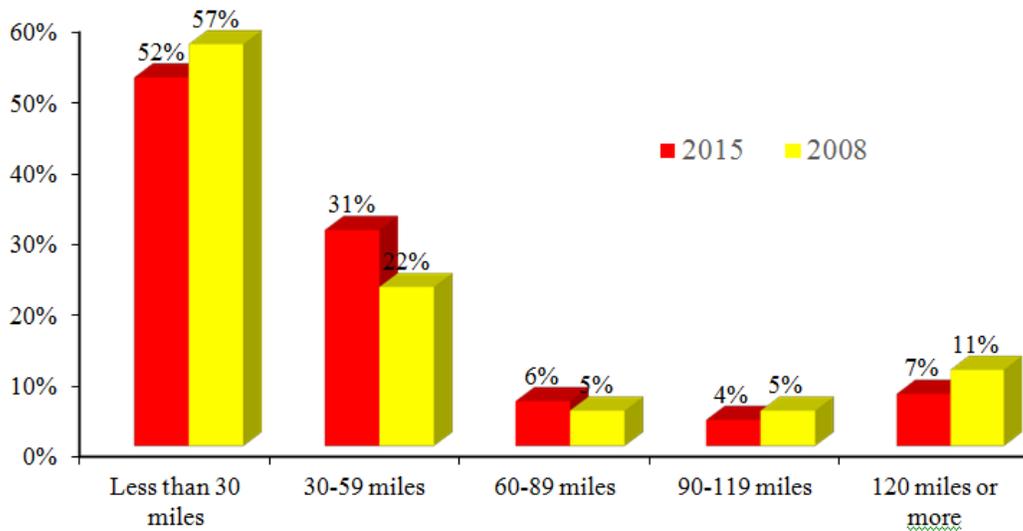
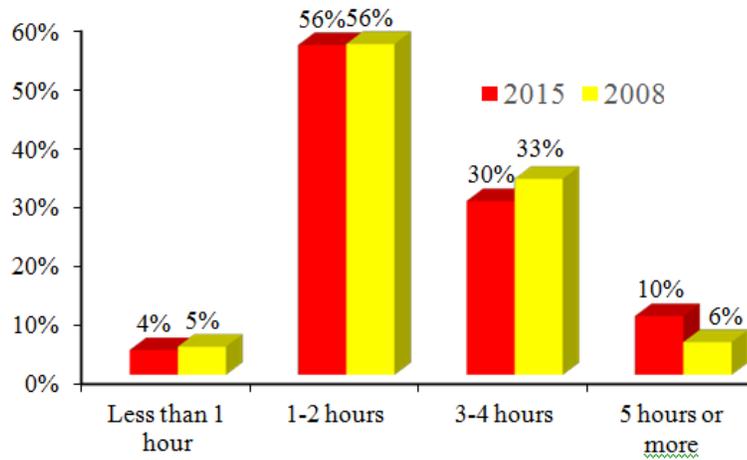


Fig. 7 MCRF participants' traveling distances to the festival

How long did you stay or plan to stay at the festival? In 2008 and 2015, the majority of festival participants stayed or planned to stay at the festival for 1-2 hours.



**Fig. 8** MCRF participants' number of hours stayed/planned to stay at the festival

Demographics: Table 1 provides descriptive statistics on respondents' demographic information. Distributions of age, annual household income and marriage status were quite similar in both years, with the majority of respondents married and at least 46 years old. Annual household incomes were almost evenly divided, 50.3% having incomes over \$50,000, 49.7% with incomes below \$50,000. Given the proximity to the University of Missouri, the vast majority of respondents (78.6%) had at least an undergraduate college degree. Almost half of the

respondents in 2008 were from an urbanized area, which is 5% higher than respondents in 2015.

**Table 1.** Descriptive statistics of respondents' demographic characteristics from 2015 and 2008 surveys

<b>Variable</b>	<b>2015</b>	<b>2008</b>
<b>Age</b>		
25 or less	15.79%	10.38%
26-35	16.32%	18.66%
36-45	13.68%	15.00%
46-55	17.37%	20.58%
56-65	20.53%	19.80%
Over 65	16.32%	15.58%
<b>Annual household income</b>		
Less than \$25,000	19.16%	16.56%
\$25,000-\$34,999	13.77%	8.93%
\$35,000-\$49,999	16.77%	17.65%
\$50,000-\$74,999	19.16%	25.49%
\$75,000-\$99,999	9.58%	12.85%
\$100,000 or more	21.56%	18.52%
<b>Gender</b>		
Female	55.97%	59.53%
Male	44.03%	40.47%
<b>Education</b>		
High School	15.93%	15.75%
Technical School	2.75%	4.13%
College Degree	32.97%	36.81%
Graduate Degree	45.60%	37.21%
Other	2.75%	6.10%
<b>Marriage status</b>		
Unmarried	32.97%	31.45%
Married	67.04%	68.55%
<b>Distance from an urbanized area of at least 50,000</b>		
We are located in an urbanized area	44.97%	50.78%
Less than 5 miles	5.82%	9.53%
5-9 miles	4.23%	4.47%
10-29 miles	17.99%	16.93%
30-59 miles	19.05%	12.26%
60 miles or more	7.94%	6.03%

Preferences on different chestnut attributes: Table 2 illustrates respondents' purchasing preferences to chestnut price, origin and production processes. Based on odds ratios from model results, the most outstanding stated preference was for "buy local" compared to chestnuts that are imported. While the buy local odds ratio was much lower in 2015 compared with 2008, the

preference for local is still the most important consumer preference. The preference rankings remained the same between 2015 and 2008: local>US>imports; organic slightly greater than pesticide free and both preferred over conventional forms of production using pesticides.

Model results also suggest that respondents in 2015 were more slightly more sensitive to chestnuts price changes compared to 2008 respondents. Interestingly, at least in this survey, there is an observable trend that over time, the higher preferences to locally grown and U.S. produced chestnuts compared to imports have decreased. The similar trend can also be observed on respondents' preferences to organic certified and pesticide free chestnuts compared to conventionally produced chestnuts.

**Table 2.** Respondents' chestnuts preferences – results from conditional logit models

	2015				2008*			
	Coefficient	p-value	Std. Error	Odds ratio	Coefficient	p-value	Std. Error	Odds ratio
Produced in Missouri	1.739	<0.001	0.127	5.692	3.032	<0.001	0.083	20.731
Produced in the U.S.	1.363	<0.001	0.115	3.908	1.449	<0.001	0.073	4.257
Organic certified	1.199	<0.001	0.105	3.317	1.454	<0.001	0.089	4.280
Pesticide free	1.157	<0.001	0.114	3.180	1.358	<0.001	0.062	3.888
Price	-0.204	<0.001	0.031	0.815	-0.307	<0.001	0.020	0.736

\*The 2008 results were adapted from Aguilar et al. (2010)

### **Conclusion:**

This report compared MCRF participant survey results from 2015 to those received back in 2008. Survey results indicate that MCRF participants' chestnut consumption frequency has increased since 2008. The 2015 participants were more familiar with both roasting chestnuts and preparing chestnuts using recipes. In addition, compared to 2008 participants, a higher percentage of 2015 festival participants came to the festival to buy chestnuts and become educated about agroforestry.

Festival participants' chestnuts preferences were affected by price, production process and region of origin. Higher chestnuts prices lead to lower purchasing preferences. Festival participants preferred locally produced chestnuts and U.S. produced chestnuts over imports.

Higher preferences were also given to organic and pesticide free chestnuts compared to conventionally produced chestnuts.

Reference:

Aguilar, F. X., Cernusca, M. M., Gold, M. A., & Barbieri, C. E. (2010); Frequency of consumption, familiarity and preferences for chestnuts in Missouri. *Agroforestry systems*, 79(1), 19-29.

## Chestnut Roast Survey 2015

Please check the appropriate boxes. Your participation is entirely voluntary, and all information provided is anonymous.

<b>A. HAVE YOU ATTENDED THIS EVENT BEFORE?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <b>IF YES, IN WHICH YEAR</b> (Check all that apply)							
<input type="checkbox"/> 2003	<input type="checkbox"/> 2004	<input type="checkbox"/> 2005	<input type="checkbox"/> 2006	<input type="checkbox"/> 2007	<input type="checkbox"/> 2008	<input type="checkbox"/> 2009	<input type="checkbox"/> 2010

<b>B. HOW OFTEN DO YOU CONSUME CHESTNUTS?</b>				
<input type="checkbox"/> Never	<input type="checkbox"/> Less than once a year	<input type="checkbox"/> Once a year	<input type="checkbox"/> 2-3 times a year	<input type="checkbox"/> More than 3 times a year

<b>C. HAVE YOU EVER BOUGHT CHESTNUTS?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No
--

<b>D. HOW FAMILIAR ARE YOU WITH COOKING CHESTNUTS?</b>	Not at all	Little	Somewhat	Familiar	Very familiar
1. Roasting chestnuts	<input type="checkbox"/>				
2. Preparing chestnuts using recipes	<input type="checkbox"/>				

<b>E. HOW IMPORTANT ARE THE FOLLOWING REASONS FOR ATTENDING THE CHESTNUT ROAST?</b>	Not important (1)	(2)	(3)	(4)	Very important (5)
Taste chestnuts and other Missouri specialty products	<input type="checkbox"/>				
Buy chestnuts	<input type="checkbox"/>				
Buy other Missouri specialty products	<input type="checkbox"/>				
Learn about chestnuts	<input type="checkbox"/>				
Learn about other Missouri specialty products	<input type="checkbox"/>				
Learn about agroforestry	<input type="checkbox"/>				
Visit the Hickman House	<input type="checkbox"/>				
The uniqueness of the Missouri Chestnut Roast festival	<input type="checkbox"/>				
To enjoy a day out	<input type="checkbox"/>				
The activities for children	<input type="checkbox"/>				
The variety of entertainment and activities offered	<input type="checkbox"/>				
I like to attend festivals	<input type="checkbox"/>				

<b>F. YOUR TRAVEL AND STAY AT THE CHESTNUT ROAST FESTIVAL</b>	
1. Was the Chestnut Roast the primary purpose of your visit in the region?	<input type="checkbox"/> Yes <input type="checkbox"/> No
2. How far did you travel to attend the festival?	<input type="checkbox"/> Less than 30 miles <input type="checkbox"/> 30-59 miles <input type="checkbox"/> 60-89 miles <input type="checkbox"/> 90-119 miles <input type="checkbox"/> 120 miles or more
3. How long did you stay or plan to stay at the festival?	<input type="checkbox"/> Less than 1 hour <input type="checkbox"/> 1-2 hours <input type="checkbox"/> 3-4 hours <input type="checkbox"/> 5 hours or more
4. With whom did you come to the festival? (Check all that apply)	5. With how many people? Total # of people: _____
<input type="checkbox"/> I came alone <input type="checkbox"/> With my spouse/partner <input type="checkbox"/> With my family <input type="checkbox"/> With friends	

<b>G. DEMOGRAPHICS</b>	
1. Your age:	4. Your gender: <input type="checkbox"/> Female <input type="checkbox"/> Male
<input type="checkbox"/> 25 or less <input type="checkbox"/> 26-35 <input type="checkbox"/> 36-45 <input type="checkbox"/> 46-55 <input type="checkbox"/> 56-65 <input type="checkbox"/> Over 65	5. Your level of education:
2. With whom do you live at home? (Check all that apply)	<input type="checkbox"/> High School <input type="checkbox"/> Technical School <input type="checkbox"/> College Degree <input type="checkbox"/> Graduate degree <input type="checkbox"/> Other (specify) _____
<input type="checkbox"/> I live alone <input type="checkbox"/> With my spouse, significant other or partner <input type="checkbox"/> With child(ren) 6 years old or younger <input type="checkbox"/> With child(ren) 7-12 years old <input type="checkbox"/> With child(ren) 13-17 years old <input type="checkbox"/> With others (parents, friends, adult children...)	6. Your marital status:
3. Your total household income:	<input type="checkbox"/> Never married <input type="checkbox"/> Widowed <input type="checkbox"/> Divorced or separated <input type="checkbox"/> Married or living with partner
<input type="checkbox"/> Less than \$25,000 <input type="checkbox"/> \$25,000 - \$34,999 <input type="checkbox"/> \$35,000 - \$49,999 <input type="checkbox"/> \$50,000 - \$74,999 <input type="checkbox"/> \$75,000 - \$99,999 <input type="checkbox"/> \$100,000 or more	7. How far do you live from an urbanized area of at least 50,000 people?
	<input type="checkbox"/> We are located in an urbanized area <input type="checkbox"/> Less than 5 miles <input type="checkbox"/> 5 - 9 miles <input type="checkbox"/> 10 - 29 miles <input type="checkbox"/> 30 - 59 miles <input type="checkbox"/> 60 miles or more

H. Please review the following 9 boxes which represent 9 pairs of hypothetical chestnut products you may purchase and for each box select the ONE product (either A or B) that you would be most likely to purchase. If you definitely don't prefer any of them you can select "Neither".

The choices differ in terms of 1) Price (\$3, \$5 and \$7), 2) Production process (Conventional, Pesticide free and Organic certified) and 3) Origin label (produced in Missouri, Produced in the USA, and Imported). All products meet a standard of quality that guarantees freshness, good flavor and nuts free of fungal or bacteria-caused damages.

Box 1.	A	B	
Price per pound	\$3	\$3	
Production process	Conventional	Conventional	
Origin label	Missouri	U.S.A.	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 2.	A	B	
Price per pound	\$5	\$3	
Production process	Conventional	Pesticide free	
Origin label	U.S.A.	Imported	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 3.	A	B	
Price per pound	\$7	\$5	
Production process	Conventional	Conventional	
Origin label	Imported	Missouri	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 4.	A	B	
Price per pound	\$5	\$5	
Production process	Organic Cert.	Organic Cert.	
Origin label	Missouri	U.S.A.	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 5.	A	B	
Price per pound	\$7	\$5	
Production process	Organic Cert.	Pesticide free	
Origin label	U.S.A.	Imported	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 6.	A	B	
Price per pound	\$3	\$7	
Production process	Organic Cert.	Organic Cert.	
Origin label	Imported	Missouri	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 7.	A	B	
Price per pound	\$7	\$3	
Production process	Pesticide free	Conventional	
Origin label	Missouri	Missouri	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 8.	A	B	
Price per pound	\$3	\$5	
Production process	Pesticide free	Organic Cert.	
Origin label	U.S.A.	Imported	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

Box 9.	A	B	
Price per pound	\$5	\$7	
Production process	Pesticide free	Pesticide free	
Origin label	Imported	U.S.A.	
Please check your preferred choice →	<input type="checkbox"/> A	<input type="checkbox"/> B	<input type="checkbox"/> Neither

## **Missouri Chestnut Roast Festival Survey Report – 2016**

On October 8th, 2016, the 10th annual Missouri Chestnut Roast Festival (MCRF) was held by MU's Center for Agroforestry (UMCA) at Horticulture and Agroforestry Research Center (HARC), New Franklin, MO. The MCRF is held to increase the general public's awareness of fresh chestnuts and chestnut value-added products by providing free chestnuts samples, chestnut cooking demonstrations and giving presentations on relevant topics.

This year's festival drew an increased number of visitors compared to 2015 (3,000 visitors in 2016, 1,500 in 2015).

Following the MCRF, a consumer market survey was conducted online to assess the attendee's familiarity with chestnuts and determine their interests in obtaining more information about chestnuts. The survey questionnaire was designed based on the chestnut survey initially developed by UMCA in 2009. Survey questions are designed to capture respondents' familiarity with chestnuts along with their past purchase and consumption patterns. The survey also captures participants' feedback on the festival and how the festival impacts their future consumptions of chestnuts and other specialty crops.

Data were collected using an online survey administered through Qualtrics after the 2016 Missouri Chestnut Roast Festival. Email addresses of festival participants were collected during the festival and a survey link was sent via email to potential survey respondents after the festival. Reminder emails were sent one week later to increase response rate. In total, 74 responses collected. Return visitors accounted for approximately 60% of total respondents in 2016.

### **Results and discussion**

Respondents expressed great interest in attending the festival with more than half of the respondents indicating that they drove over 60 miles one-way to attend the 2016 chestnut roast. Furthermore, 75% of respondents indicated that the chestnut roast was their primary purpose of their visit to the region. More than half of the respondents stayed at the festival for over 3 hours.

In terms of expenses at the festival (e.g. chestnuts and other specialty crops purchase), respondents reported that an average of \$59 was spent at the festival.

### Chestnuts: Past Purchase and Consumption

Results of the survey indicate that there is an increase in festival participants' chestnuts purchasing behavior. A higher percentage of respondents in 2016 has previously purchased chestnuts compared to 2015 respondents (Figure 1).

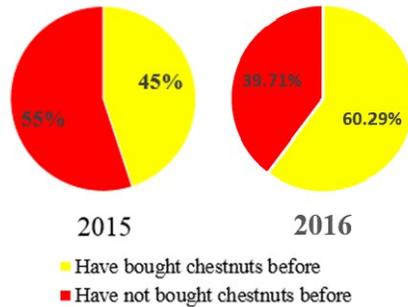


Fig. 1 MCRF participants' past chestnut purchasing behavior

Chestnut consumption increased compared to 2015. Compared to 2015 respondents, a higher percentage of respondents in 2016 indicated they had previously consumed chestnuts. Approximately 37% of the respondents in 2016 indicated they had consumed chestnuts at least

2 times a year compared to 25% in 2015. Almost 70% of the respondents indicated they had purchased chestnuts in places other than chestnut festival.

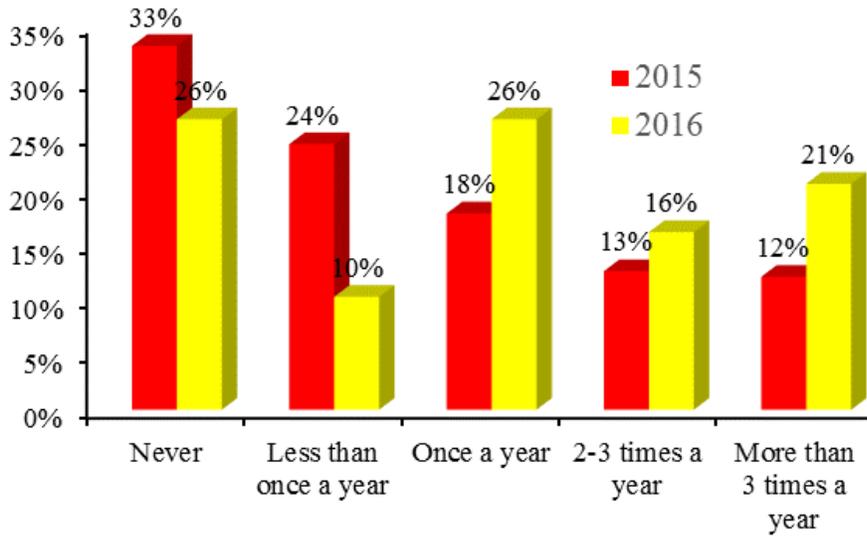


Fig. 2 MCRF participants' chestnuts consumption frequency

Familiarity with cooking chestnuts: There is an increase in festival participants' familiarity with cooking chestnuts. Their familiarity with roasting chestnuts and preparing chestnuts with recipes increased. Approximately 46% of the respondents indicated they were at least somewhat familiar with roasting chestnuts in 2016 compared to 36% in 2015. In terms of their familiarity

with preparing chestnuts with recipes, 16% of respondents indicated they are familiar with preparing chestnuts with recipes in 2016 compared to 9% of the respondents in 2015.

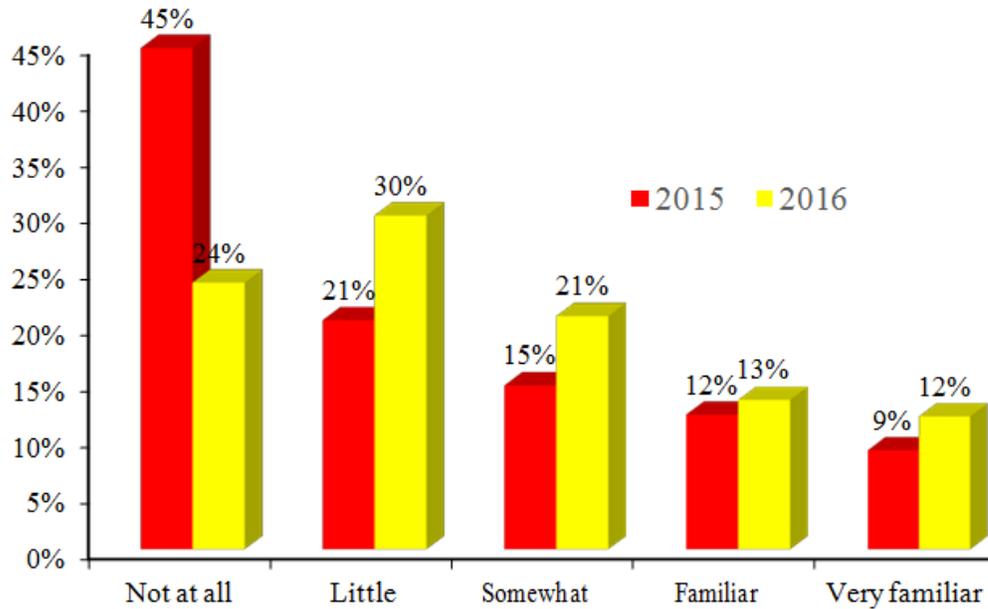


Fig. 3 MCRF participants' familiarity with roasting chestnuts

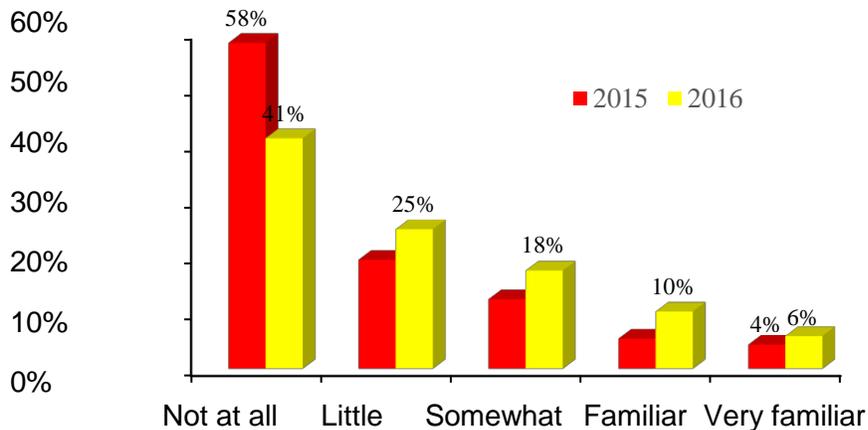


Fig. 4 MCRF participants' familiarity with preparing chestnuts with recipes

Festival Experience: The overall participants' experience with the festival was rated very high, with almost 95% of the respondents indicated their experience at the festival was either "Good"

or “Excellent”. The majority of respondents agreed that the MCRF provided not only good learning opportunities but also good entertainment. More than 97% of the respondents indicated they would recommend the Chestnut Roast to others.

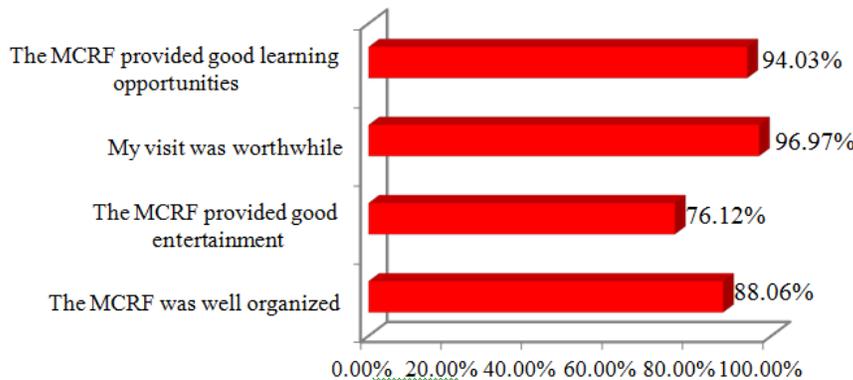


Fig. 5 MCRF participants’ experience with the festival

In terms of participants’ preferences for the diverse 2016 Chestnut Roast offerings, a very high percentage of respondents liked samples of roasted chestnuts (92%) and the chestnut cooking demonstration (95%). Compared with the agroforestry project bus tours (71%), respondents (84%) preferred the walking tours of the agroforestry projects at the Horticulture and Agroforestry Research Center. It has to be stated that October 8, 2016 turned out to be a “picture perfect” sunny and pleasant day to be out on the HARC farm.

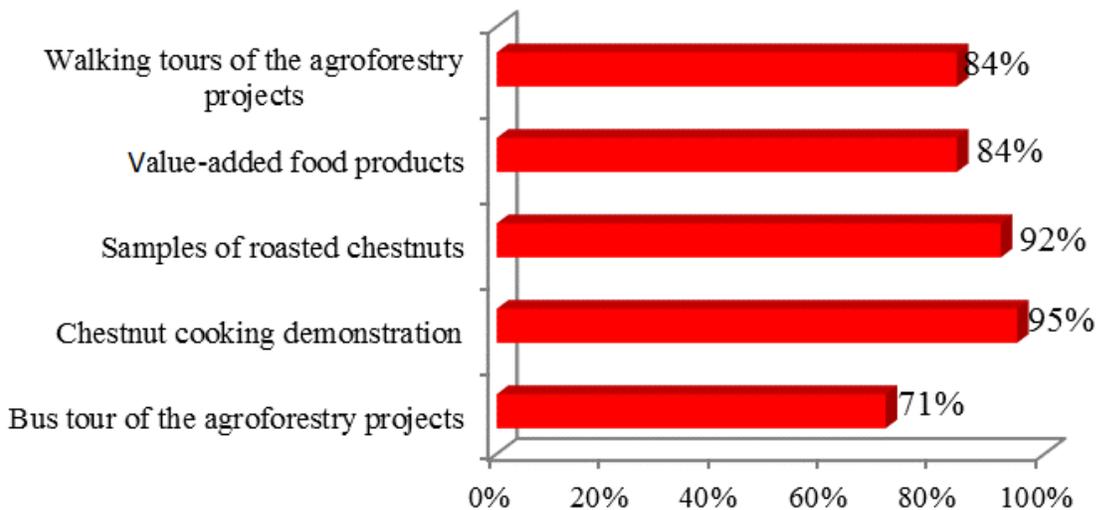


Fig. 6 MCRF participants’ preferences to 2016 Chestnut Roast Offerings

Festival Impacts: The festival impacts on participants’ knowledge about chestnuts and other specialty crops, agroforestry practices, and their future planned purchase were also estimated. The festival not only increased participants’ knowledge on the health values of nuts but also increase their interests in Missouri specialty products, as indicated by 72% of the respondents. More than 75% of the respondents indicated that they learned about the economic and

environmental benefits of agroforestry. The knowledge and experience from the festival also increased participants' future planned purchase of chestnuts, black walnuts, pecans, and other Missouri specialty products.

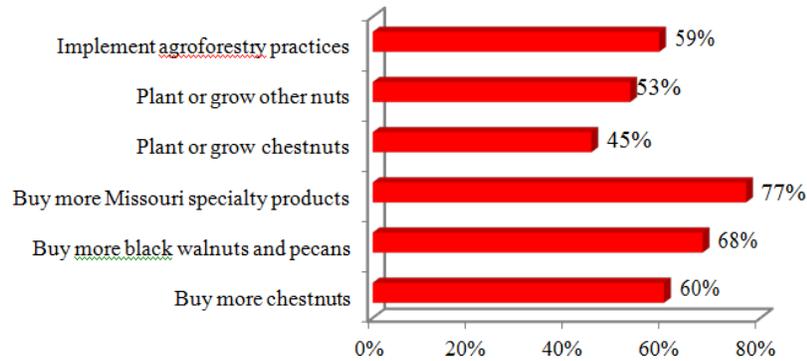


Fig. 7 MCRF participants' future planned purchase/grow chestnuts and other specialty crops, and planned implementation of agroforestry practices

Demographics: Table 1 provides descriptive statistics on respondents' demographic information. The majority of our respondents are married, have at least a college degree, at least 46 years old and had an annual household income of at least \$50,000. More than half of the respondents live in/close to an urbanized area.

Table 1. Descriptive statistics of respondents' demographic characteristics

Variable	(%)
Age	
25 or less	6.25%
26-35	7.81%
36-45	10.94%
46-55	20.31%
56-65	31.25%
Over 65	23.44%
Annual household income	
Less than \$25,000	10.91%
\$25,000-\$34,999	9.09%
\$35,000-\$49,999	12.73%
\$50,000-\$74,999	21.82%
\$75,000-\$99,999	23.64%
\$100,000 or more	21.82%
Gender	
Female	58.73%
Male	41.27%
Education	
High School	7.69%
<u>Technical School</u>	<u>3.08%</u>
Some College, no degree	12.31%
College Degree	33.85%
Graduate Degree	43.08%
Marriage status	
Unmarried	15.38%
Married	84.62%
Distance from an urbanized area of at least 50,000 people	
We are located in an	
urbanized area	32.81%
Less than 5 miles	3.13%
5-9 miles	6.25%
10-29 miles	32.81%
30-59 miles	9.38%
<u>60 miles or more</u>	<u>15.63%</u>

Conclusion:

This report reviewed survey results based on MCRF participants' familiarity with, past purchases and consumption of chestnuts, along with festival impacts on their future consumptions of chestnuts and other specialty crops. Survey results suggested that MCRF participants' chestnuts consumption has increased, and their familiarity with roasting chestnuts

has also increased. However, familiarity with preparing chestnuts using recipes still needs to be improved.

The MCRFs has been held by UMCA for 10 years. It is an event where participants can not only enjoy themselves but also gain knowledge on chestnuts and other Missouri specialty crops. As reported by the respondents, the 2016 MCRF provided a great visitor experience, and helped them to better understand chestnuts and other Missouri specialty crops. The festival also provided great opportunity to better understand Agroforestry practices. Two brief comments from survey respondents will close out this report.

- “Great festival. Love that I can taste free chestnuts and buy trees... Love everything about the Festival”.
- “Keep up the good work”.

## **Project 2: Development of a Combined Black Walnut Harvester-Huller that will Transform Harvest Efficiency and Producer Profitability**

### **Hammons Products Company**

Kim Mesenbrink

Final Performance Report

### **Project Summary**

Missouri is the world’s largest producer, processor, and marketer of American Black Walnuts (*Juglans nigra*). Presently, Black Walnuts produced in Missouri are hand-harvested from wild trees, yielding only 6 to 7% edible kernel. The University of Missouri’s Center for Agroforestry has developed new Black Walnut cultivars that can yield over 30% kernel with improved quality, flavor, and consistency. Hammons Products is working with universities and other Missouri producers to plant 5,000 acres of grafted Black Walnut orchards on private farms by 2020.

However, harvest efficiency remains a significant roadblock for Black Walnuts to be a profitable specialty crop. Today, Black Walnuts must be harvested by hand, and handled multiple times from field to processor. The resulting harvest costs consume much of the potential profit for producers.

The goal of the project was to develop a harvesting and hulling machine that could eliminate much of the cost needed to currently harvest Black Walnuts. Hammons Products took an existing pecan harvester, modified it to harvest and hull Black Walnuts. After testing and improvements, we now have a combined harvester huller machine that can be reproduced by a manufacturer for sale to Black Walnut producers.

### **Project Approach**

Hammons Products has developed specialized Black Walnut hullers that will remove the hull from Black Walnuts without cracking or crushing them. Hammons then worked with Savage Equipment, Inc. (Madill, OK) to modify a Savage 8261 pecan harvester to efficiently pick up Black Walnuts from the orchard floor. After testing the modified harvester with good harvest results, Hammons took the modified pecan harvester to their shops to add equipment for hulling black walnuts.

The goal of the project was to re-engineer the two pieces of equipment to be conjoined into a mobile, highly-efficient Black Walnut harvester-huller that will collect and hull the nuts in a streamlined, single-step process. Hammons personnel built a chain huller and attached it to the Savage harvester; modifying the storage bin, removing the auger, and including a short drag elevator to feed the huller. Preliminary tests showed the combined harvester huller would work, but real testing in actual conditions had to wait for the fall harvest season.

During fall harvest testing, the machine harvested and hulled the Black Walnuts as hoped. But the short drag elevator feeding the huller portion of the machine proved unreliable and broke chains after minimal use. It was decided to replace the short drag elevator with an auger system. The auger worked as hoped, but additional testing revealed heavy wear with the belt and pulleys driving the huller portion of the machine. It was determined the single belt system was not robust enough for the stresses presented during the harvest of black walnuts. The single belt and pulley system was replaced with a heavier double belt and pulleys system. Further testing of the harvester huller showed good harvest results with machine reliability during the Fall 2016 harvest season.

### **Goals and Outcomes Achieved**

The goal of the project was to overcome the high cost of harvesting black walnuts, such that a model could be developed for new producers to grow grafted black walnut trees in orchard like setting and sell nuts profitably. The original target for the harvester huller project was to harvest and hull 2000 pounds of nuts per hour with <20% of hull remaining. While the testing and harvests completed never reached 2000 pounds per hour, we did experience 800 pounds per hour with less than 8% of the hull material remaining on the Black Walnuts. Some factors impacting the harvest pounds were the machine was never tested in an orchard setting, and it was tested on several different varieties and sizes of black walnuts during the tests and harvest conditions. Additionally, the machine was stopped often during operations to check results of nut pickup, hulling and component wear.

The project allowed the fabrication of a harvester huller machine that works as hoped. The machine will be a big part of Black Walnut orchard development and a profitable model for Black Walnut producers in the future. Hammons plan for the machine is to provide it to current large Black Walnut producers for their use and testing in order to promote further growth and plantings of grafted, improved variety Black Walnut orchards for profit.

### **Beneficiaries**

The combined, single-step black walnut harvester-huller greatly increases harvest efficiency while opening doors to numerous new black walnut producers. This will enhance opportunities for specialty crops – particularly Black Walnut nuts and intercrops.

Beneficiaries are current and new BW producers – landowners who may incorporate Black Walnut nut-producing orchards into their farm program, with the ability to harvest and hull the nuts efficiently while removing as little organic matter as possible. Processors, plus industries that use the nutmeats and nut shells and their consumers, also will benefit from a greater and more stable supply.

The number of specialty crop beneficiaries to be immediately affected is probably a dozen or so current small nut orchard owners. But the future growth of Black Walnut orchard enterprises,

which is limited by the difficulties in economically harvesting nuts, could add dozens more individuals and organizations -- some with larger operations that involve many people in growing and harvesting processes. The potential economic impact is very difficult to measure, although an additional 1 million pounds of Black Walnuts harvested from orchards could be worth over \$500,000 (10 million pounds over \$5 million).

### **Lessons Learned**

The lesson learned was that our original target of 2000 pounds of hulled Black Walnuts was overly optimistic. The target was built on our company's experience of hulling already harvested black walnuts in a stationary hulling machine. What the target goal did not consider was time of travel across a field of trees harvesting the green nuts to hull. If planned orchards are developed, the pounds per hour would certainly increase by the mere fact of running down orchard rows versus the current need to drive in and around unplanned, wild grown trees.

Also learned was the need for persistence. Despite our best plans on paper, we did experience problems in building a combined harvester huller machine. Testing revealed some weaknesses in design and reliability that forced us to make some re-designs to get desired results. We were fortunate that we eventually found solutions and now have a machine that works as hoped. It is a solution we can build on and promote the ultimate goal of profitable, black walnut orchards for existing and potential new producers.

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### **Additional Information**



**Project 3: Exploring the Genetic Resources of Norton Grape for Fungal Disease Resistance**

## **Project Summary**

Developing cultivars with sustained disease resistance is of key importance with grapes, a woody perennial fruit crop with a productive life span of several decades. *Vitis aestivalis*-derived 'Norton', the official grape of Missouri, is grown in many U.S. regions where *V. vinifera* (the European grape used for most wine-making worldwide, e.g., Cabernet Sauvignon) production requires extensive pesticide use for fungal diseases. Tests on the F<sub>1</sub> progeny from a cross between Norton and Cabernet Sauvignon may elucidate the underlying genetic mechanisms of berry disease resistance and berry quality. To this end, we have developed a population of 182 F<sub>1</sub> genotypes from this cross that has yielded fruit for the past three years. We are currently in the process of constructing the first Norton genetic map using molecular markers. We also have developed protocols for the evaluation of powdery mildew, downy mildew and *Botrytis* bunch rot. In addition, we collaborate with Cornell University-based USDA-SCRI VitisGen program to ensure the success of this project. This proposed study aims to accelerate the direct release of Norton-based new cultivars. New cultivars with improved fungal disease resistance will decrease labor needs, energy consumption and pesticide use in the vineyard, resulting in greater environmental and economic sustainability.

## **Project Purpose**

Grapes are one of the most important horticultural crops in the world, and the vast majority of the world's grape industry is based on cultivars of *Vitis vinifera*. However, these cultivars are highly susceptible to a wide range of diseases caused by viruses, bacteria, fungi, nematodes and insects. For example, during the 19<sup>th</sup> century, powdery mildew (*Erysiphe necator*), downy mildew (*Plasmopara viticola*) and the root aphid phylloxera (*Daktyloshphaera vitifoliae*) were inadvertently introduced into Europe from North America and severely impacted viticulture at that time. These diseases and pests subsequently spread worldwide and changed the practice of viticulture by requiring the use of frequent and prophylactic spray programs. Recent pesticide reports document that European agriculture annually uses more than 500,000 tons of phytochemicals, 46% of which are employed in viticulture. In California vineyards, over 18,000 tons of sulfur was applied to control powdery mildew in 2008. Pesticide treatments are effective for disease control; however, multidrug resistant pathogen/pest populations have been recently identified and reported in the vineyards throughout the world. Thus, the integration of effective genetic resistance into grape cultivars would reduce the dependence of viticulture on chemical inputs and have significant environmental, health and financial benefits.

## **Specific Objectives:**

1. Develop a Norton linkage map using genetic markers.
2. Conduct segregation analysis of the populations for resistance against powdery mildew (*Erysiphe necator*) and downy mildew (*Plasmopara viticola*) as well as harvest rot diseases including bunch rot (*Botrytis cinerea*) and black rot (*Guignardia bidwellii*).

- Identify genetic markers that are associated with these fungal disease resistance to use in future marker-assisted selection for new cultivar releases

Plants develop defense strategies not only in vegetative tissue, but also in fruit such as grape berries, thus ensuring the maturation and survival of viable seeds. Grapevines in the Midwest United States possess effective defense strategies to protect berries from the rampant growth of fungal pathogens that proliferate in the high humidity and temperatures of this region. However, berries of North American *Vitis* species also contain chemicals that are not suitable for winemaking. Therefore, a need exists to breed for grapevines that would combine the superior wine quality of *V. vinifera* with the disease resistance and cold hardiness of Norton. Genetic analysis of the F<sub>1</sub> progeny from a cross between *V. aestivalis*-derived 'Norton' and *V. vinifera* 'Cabernet Sauvignon' will provide an excellent opportunity to elucidate the underlying molecular mechanisms of berry disease resistance. Our focus on controlling grapevine fungal diseases by developing varieties with durable resistance will significantly lessen the dependence by the U.S. grape industry on costly and environmentally harmful pesticides.

### Work Plan

Project Activity	Who	Timeline
Construction of the Norton genetic linkage map using simple sequence repeat (SSR) markers	Dr. Chin-Feng Hwang, Li-Ling Chen, Surya Sapkota, Brigette Williams and Mia Mann	October 2013 – December, 2014
Construction of a Norton linkage map based on single nucleotide polymorphism (SNP) markers via genotyping-by-sequencing (GBS) platform	Dr. Lance Cadle-Davidson (USDA-ARS/Cornell Univ.) via VitisGen Program ( <a href="http://www.vitisgen.org">www.vitisgen.org</a> ), Dr. Chin-Feng Hwang and Surya Sapkota	October 2013 – January 2015
Develop and integrate a dense Norton genetic map with both SSR and SNP markers	Dr. Chin-Feng Hwang, Li-Ling Chen, Surya Sapkota and Dr. Lance Cadle-Davidson	October 2014 – June, 2015
Phenotyping powdery mildew (PM), downy mildew (DM), <i>Botrytis</i> bunch rot (BBR) and black rot (BR) disease index in the greenhouse and vineyard	Dr. Chin-Feng Hwang, Susanne Howard, Surya Sapkota, Daniel Adams and Logan Duncan	June – September, 2014 June-September, 2015
Map and localize the major quantitative trait locus (QTL) for PM, DM, BBR and BR for future new cultivar releases	Dr. Chin-Feng Hwang, Li-Ling Chen, Surya Sapkota and Logan Duncan	April – September, 2015

This proposed project is a continuation of the USDA-SCBGP Award Agreement #12-25-B-1471. The continuing funds allowed us to complete the following activities: 1). Norton and Cabernet Sauvignon mapping population has expanded to 253 genotypes and maintained at the State Fruit Experiment Station in Mountain Grove, MO; 2). The protocols for the assay of powdery mildew, downy mildew and *Botrytis* bunch rot have been developed; 3). Segregation analyses on both parents and F<sub>1</sub> progeny for these three diseases have been analyzed in summer 2014 and 2015; 4). The first Norton haploid linkage map has been constructed with 359 SSR

markers; 5). A major QTL for downy mildew resistance was identified on chromosome 18; 6). A total of 23,320 SNP markers have been identified from 182 genotypes via GBS; 7). One student graduated with a Master's degree during the funding period. With these continuing funds, a *V. aestivalis*-derived 'Norton' breeding program has been initiated at Missouri State University. Please see below for detailed activities.

Project Activities

**1) Develop a Norton linkage map using genetic markers**

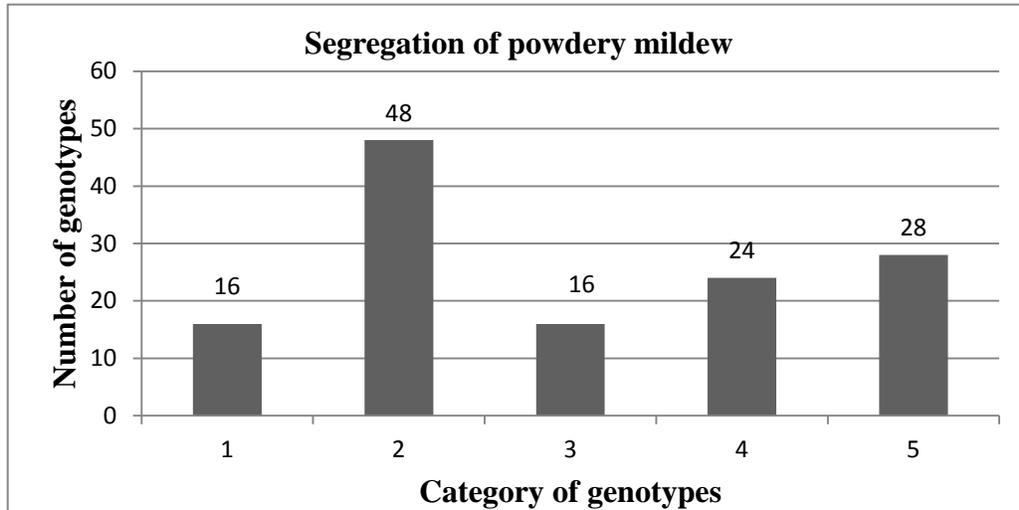
Crosses between *V. aestivalis*-derived "Norton" and *V. vinifera* "Cabernet Sauvignon" were made in Mountain Grove, MO in 2005 and resulted in 94 hybrid progenies. This F<sub>1</sub> population was planted in a Missouri State Fruit Experiment Station (MSFES) vineyard in 2007. Additional crosses were made in 2011 and 2012; we have acquired additional genotypes of 134 and 51 survived the winters of 2012 and 2013, respectively. There are more than 800 simple sequence repeat (SSR) markers that have been isolated in grapevine to date. The markers are publicly available and are described in the NCBI databases dbSTS and UniSTS <http://www.ncbi.nlm.nih.gov/>. Using 6 universal SSR markers, 253 out of the existing 279 genotypes were identified as true hybrids. Since it is possible to observe up to 30% off-types, this result indicated that 90.7% of hybrids were acquired. All six markers showed polymorphisms between the parents, Norton and Cabernet Sauvignon (Table 1).

**Table 1.** Genetic Profiles (allele sizes in bp) of two grape varieties at various microsatellite loci

Markers	VVMD5	VVMD7	VVMD27	VVS2	VrZAG62	VrZAG79
<b>Norton</b>	233/247	237/246	184/186	135/137	181/205	250/254
<b>Cabernet Sauvignon</b>	231/240	239/239	173/187	141/154	189/195	239/246

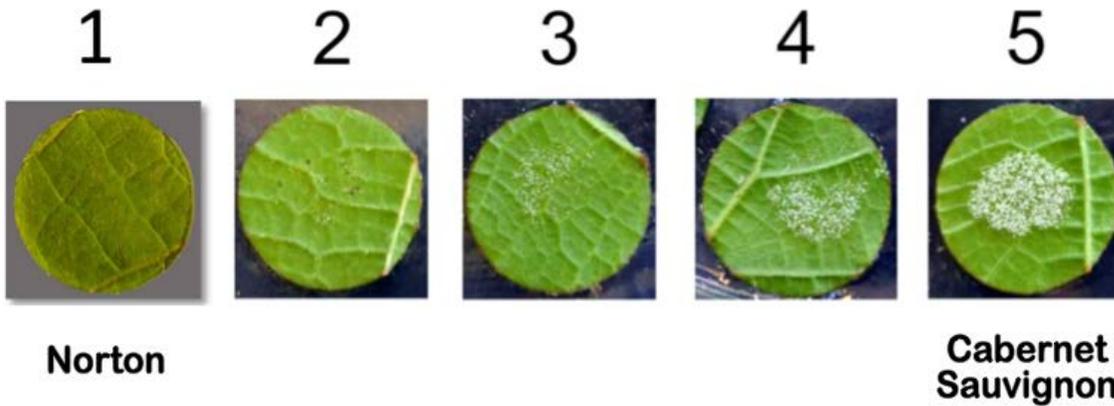
The parents and six F<sub>1</sub> individuals in the population were used to identify polymorphic markers from more than 800 publicly available SSR markers. Only informative markers polymorphic for the parents were used on the entire mapping population of 182 F<sub>1</sub> progeny. We have completed the construction the first Norton linkage map with 359 SSR markers on 19 chromosomes (Figure 1). This map has been further used to localize the markers associate with the downy mildew resistance loci. Genotyping-by-Sequencing (GBS) has been completed for the parents and 182 progeny of this population. Currently, 23,320 single nucleotide polymorphism (SNP) markers have been identified in this population. Also, additional 71 Norton x Cabernet Sauvignon progenies have been shipped to VitisGen program at Cornell University in August 2014 for the construction of a linkage map with SNP markers by using GBS.





**Figure 2.** Visual rating for powdery mildew phenotyping. 1 is no growth of sporangia, 2 is most restricted and restricted growth whereas 3, 4 and 5 are extended and most extended growth based on OIV452 descriptor adapted to the leaf disc assay. The category shows that ratings 1 and 2 show various degrees of resistance whereas ratings 3, 4 and 5 are more towards susceptibility.

The downy mildew (*Plasmopara viticola*) was propagated using the inoculants from the vineyard in the summer of 2015 to prepare for the inoculation experiment. Laboratory assays using detached leaves for downy mildew disease were developed and applied to the mapping population from Norton x Cabernet Sauvignon. Assessments were conducted using the parents and 182 hybrid progenies, and disease severity was evaluated as a visual semi-quantitative scale of notation ranging from 1 to 5. 1 = no visible disease system; 2 = 10% of the leaf area covered by the spores; 3 = 40% of the leaf area covered by the spores; 4 = 60% of the leaf area covered by the spores; and 5 = > 80% of the leaf area covered by the spores (Figure 3). A segregation analysis for downy mildew resistance was further performed, resulting in 88 resistant and 94 susceptible hybrid genotypes, fitting the expected ratio of 1:1.



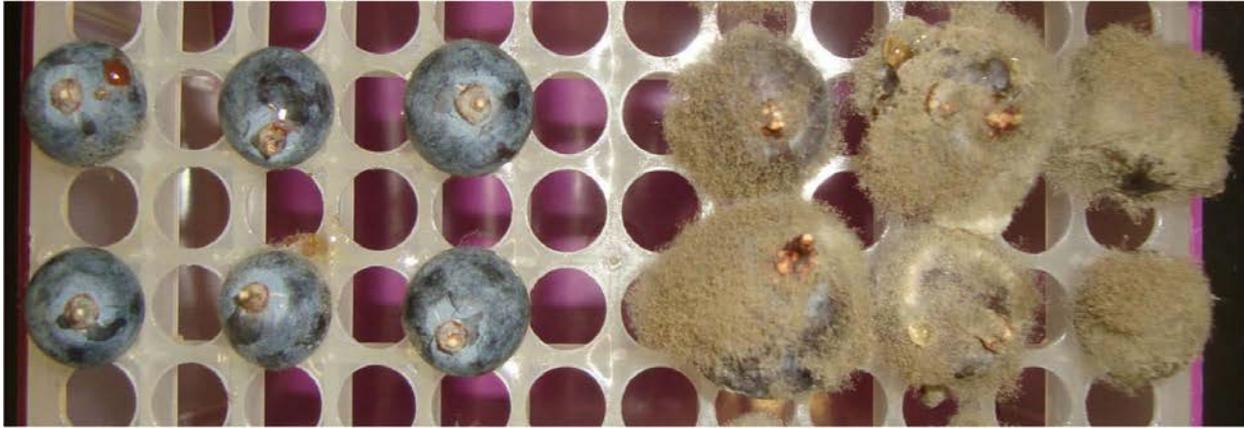
**Figure 3.** Visual rating for downy mildew phenotyping. Norton is resistant to *P. viticola* while Cabernet Sauvignon is highly susceptible.

A phenotyping assay was designed under laboratory conditions to analyze grape-*B. cinerea* interactions using a conidial suspension of concentration  $1 \times 10^5$  conidia/ml. Five post-veraison stages of Norton and Cabernet Sauvignon were analyzed for this purpose. Five 24-berry replications for each stage were used in the 2013 and 2014 experiments. The average disease incidence for Norton was 1.7% (ranging from 0 to 4.0%) in 2013 and 12.8% (ranging from 8 to 17%) in 2014. The average disease incidence for Cabernet Sauvignon was 95% (ranging from 83 to 100%) in 2013; and 99.16% (ranging from 96 to 100%) in 2014. The average disease severity for Norton was 0.7% (ranging from 0 to 2.0%) in 2013 and 6.7% (ranging from 3.0% to 10.8%) in 2014. The average disease severity for Cabernet Sauvignon was 93.18% (ranging from 81 to 100%) in 2013 and 95.68% (ranging from 87 to 100%) in 2014. Table 2 summarizes the disease incidence and severity of the two test cultivars at five different developmental stages. There were no significant ( $P > 0.05$ ) differences in Botrytis bunch rot incidence or severity between the five post-veraison stages within the two cultivars. Figure 4 showed that the greatest difference between the two cultivars occurs 10 days post-inoculation infection of berries at E-L stage 40.

**Table 2.** Average disease incidence and severity between two grape cultivars; Norton and Cabernet Sauvignon (CS) under different stages.

Harvesting Stage	Disease Incidence				Disease Severity			
	2012		2013		2012		2013	
	Norton	CS	Norton	CS	Norton	CS	Norton	CS
E-L Stage 36	4.2	100.0	8.3	100.0	1.7	96.7	3.3	96.7
E-L Stage 37	0.0	83.3	12.5	95.8	0.0	80.8	5.8	86.7
E-L Stage 38	0.0	91.7	16.7	100.0	0.0	91.7	6.7	96.7
E-L Stage 39	4.1	100.0	16.7	100.0	1.6	96.7	10.8	100.0
E-L Stage 40	0.0	100.0	10.0	100.0	0.0	100.0	6.7	98.3

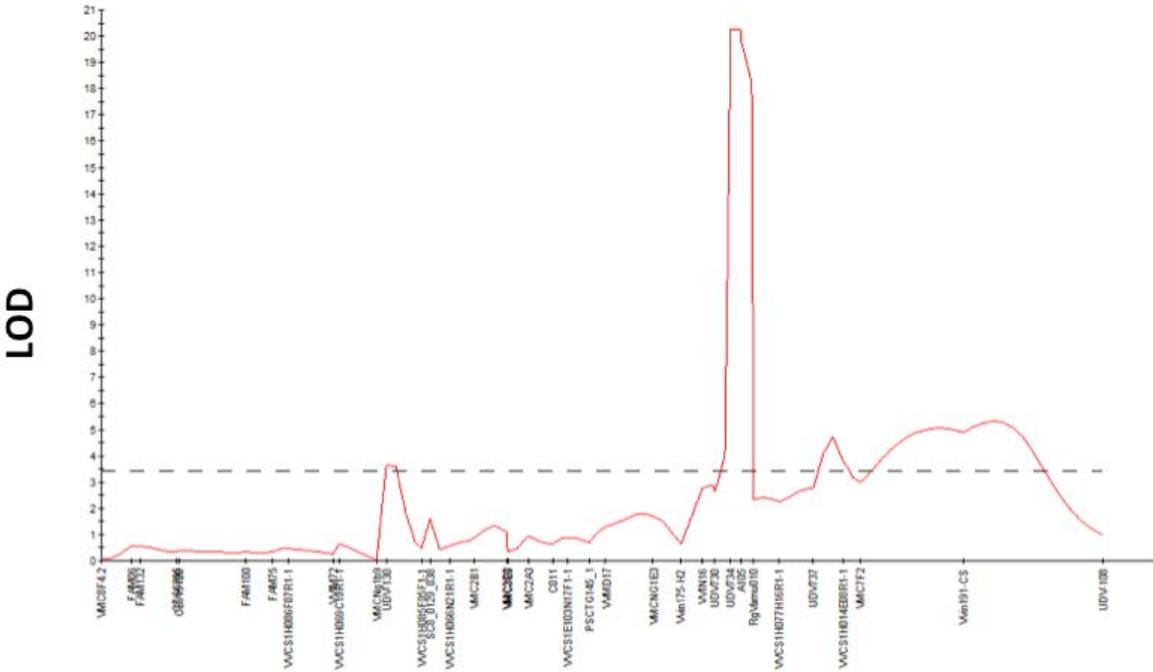
Values are mean for five replicates for each stage between two cultivars for both years. Significant differences (two-sampled t test) are designed at  $P > 0.05$ .



**Figure 4.** Botrytis bunch rot exhibited by two different grape genotypes under laboratory conditions: Norton (left) and Cabernet Sauvignon (right). Photo was taken 10 days post-inoculation.

**3). Identify genetic markers that are associated with these fungal disease resistance to use in future marker-assisted selection for new cultivar releases**

As shown in Figure 3, genotypic data of the 182 offspring of the cross 'Norton' x 'Cabernet Sauvignon' were used for phenotyping analysis. Quantitative trait loci (QTL) analysis was performed using interval mapping and multiple-QTL mapping algorithms of MapQTL 6.0. A significant QTL was identified on linkage group 18 flanking by markers of VVIN 16 and A105 with a LOD value of 20.27 explaining 40% of the total phenotypic variation (Figure 5).



**Figure 5.** Localization of genetic determinants of downy mildew resistance in *V. aestivalis*-derived ‘Norton’ on linkage group 18. The LOD threshold of 3.4 ( $p < 0.05$ ) was determined after 1,000 permutations.

### Goals and Outcomes Achieved

1. Using 6 universal SSR markers for the screen of F<sub>1</sub> population to eliminate the off-types (not true hybrids, Table 1) and construct a mapping population with 182 genotypes
2. Tested >800 SSR markers for potential polymorphism on a small set of DNA including parents and 6 F<sub>1</sub> genotypes and 373 of which have been identified as polymorphic markers for Norton. A 19-chromosome Norton genetic linkage map with 359 SSR markers using JoinMap 4.1 software (Figure 1) was constructed.
3. Genotyping-by-Sequencing (GBS) has been completed for the parents and 182 progeny of this population. Currently, 23,320 single nucleotide polymorphism (SNP) markers have been identified in this population.
4. Laboratory protocol using detached leaves and berries have been established for the evaluation of powdery mildew, downy mildew and *Botrytis* bunch rot (Figure 2, 3, 4 and Table 2).
5. Segregation analyses on powdery mildew and downy mildew have been conducted (Figure 2 and 3) and quantified the phenotyping data using statistic software.
6. A major QTL for downy mildew resistance has been discovered between the SSR markers of VVIN 16 and A 105 on linkage group 18 and will be used for future marker-assisted selection (Figure 5).
7. 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 list of actual accomplishments with the goals established for the project:

Proposed Activities	Accomplishments
Identification of polymorphic markers using parents and 6 F <sub>1</sub> 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 <sub>1</sub> population. Using SSR markers, interspecific hybrids have been identified, and the mapping population has been expanded from 92 to 253 genotypes (Table 1). More than 800 SSR markers were tested and 373 of which were identified as polymorphic markers.
Genotyping the entire population with polymorphic markers for the construction of the Norton genetic linkage map	A 19-chromosome Norton genetic linkage map with 359 SSR markers was constructed using JoinMap 4.1 software (Figure 1).

Construction of a Norton linkage map based on SNP markers via GBS platform	23,320 SNP markers have been identified using 182 F <sub>1</sub> progeny from the mapping population.
Phenotyping powdery mildew, downy mildew and <i>Botrytis</i> bunch rot disease index in the laboratory	A segregation analysis on powdery mildew, downy mildew and <i>Botrytis</i> bunch rot resistance was completed with a resistant/susceptible ratio of 64/68 (Figure 2), 88/94 (Figure 3) and 44/47 (Figure 4 and Table 2), respectively.
Map and localize the major quantitative trait locus QTL for downy mildew resistance from Norton	A significant QTL was identified on linkage group 18 flanking by markers of VVIN 16 and A105 with a LOD value of 20.27 explaining 40% of the total phenotypic variation (Figure 5).

**A comparison list of baseline or benchmark data with quantifiable targets:**

<b>Proposed Measurable Outcomes</b>	<b>Achieved Outcomes</b>
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 253 genotypes and maintained by the professional field crew at Missouri State Fruit Experiment Station (MSFES), Mountain Grove, MO
Identify the interspecific hybrids from the new crosses in summers of 2013 and 2014.	More than 100 crosses between Norton and Cabernet Sauvignon were performed at MSFES in the summer of 2013 and 2014. A high percentage, 90.7%, of interspecific hybrids was obtained.
Construct a SSR Norton linkage map and identify SNP markers via GBS to lay a foundation for future grape breeding	A 19-chromosome Norton genetic linkage map with 359 SSR markers was constructed as well as 23,320 SNP markers have been identified.
Phenotype the entire mapping population for powdery mildew, downy mildew and <i>Botrytis</i> bunch rot diseases and associate the markers linked to the resistance of these three fungal diseases	A segregation analysis on downy mildew resistance was completed (Figure 3). Using the newly developed Norton linkage map, a major QTL was identified on chromosome 18 (Figure 5). New protocols for powdery mildew and <i>Botrytis</i> bunch rot resistance were developed and tested on the parents and F <sub>1</sub> progenies (Figure 2 & 4).

Evaluate the viticultural and enological traits and determine the commercial potential of Norton/ <i>V. vinifera</i> F <sub>1</sub> hybrids with <i>Botrytis</i> bunch rot resistance.	Six cultivars have been chosen and are being evaluated at two different locations in addition to MSFES. The two sites of testing are the Chaumette vineyard and winery at Sainte Genevieve, in southeast MO and the Meyers Vineyard at Mount Vernon, in southwest MO.
Provide summer internships to work on grape molecular breeding program	Ten summer interns in 2014 and 2015 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 degrees	“Interspecific Hybrid Identification of <i>Vitis aestivalis</i> -derived 'Norton'-Based Populations Using Microsatellite Markers. <i>Scientia Horticulturae</i> 179: 363-366. Pragya Adhikari graduated with a MS degree, December 2014. Please see “Additional Information” for details regarding conference attendance.

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 haploid Norton genetic map has been constructed with 359 polymorphic SSR markers clustered in 19 linkage groups. In collaboration with VitisGen ([www.vitisgen.org](http://www.vitisgen.org)), approximately 43,000 SNP markers generated GBS were identified in this population and will be integrated with SSR markers to construct a high-resolution linkage map. A major QTL for downy mildew resistance on linkage group has been identified and will be used for future marker-assisted selection. In preparation for placing other traits on this map, phenotyping assays for powdery mildew and *Botrytis* bunch rot resistance have been established and will be applied to the population. Careful genetic mapping of this population provides the foundation and tools to associate molecular markers with these three fungal disease resistance traits 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.

**Beneficiaries**

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), 11<sup>th</sup> International Conference on Grapevine Breeding and Genetics (ICGBG), Missouri Grape and Wine Research Symposium (MGWRS) and the Missouri Grape and Wine Research Symposium (MWGRB). A manuscript on the construction of Norton mapping population has been published; 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 MSU 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 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. 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. The location of this work at the Missouri State Fruit Experiment Station at Mountain Grove is situated in a rural region of Southern Missouri and serves Northwest Arkansas. The project provides access for science education and training of biotechnology for high school students and teachers to strengthen their Science, Technology, Engineering and Mathematics (STEM) curriculum. Based on the data in Table 3, there are approximately six thousand people worldwide affected by the distribution of this new knowledge.

**Table 3. The number of people affected by the distribution of this new knowledge**

<b>Dissemination Sources</b>	<b>ASVE (June 25-26 &amp;17-18, 2014 &amp;2015)</b>	<b>VitisGen( Feb 20 &amp; Jan 8, 2014 &amp; 2015)</b>	<b>ICGBG (Aug 1-4, 2014)</b>	<b>MGWRS &amp; MWGRB (2014 &amp; 2015)</b>	<b>VESTA (2015)</b>
<b>Number of people participated</b>	<b>2,500</b>	<b>300</b>	<b>1,500</b>	<b>400</b>	<b>900</b>

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, genomics and plant pathology with a specific focus on viticulture. The grape and wine industry will be aided by new grape varieties. 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 students and ten summer interns to work on grape powdery mildew, downy mildew and *Botrytis* bunch rot resistance. These focal areas target three of the most destructive diseases in the wine and grape industry.

### **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 92 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 will continue shopping the rest of the mapping population by April 2016. 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

planned 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.

### **Contact Person**

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### **Additional Information**

#### **Publications**

Pragya Adhikari, Li-Ling Chen, Xu Chen, Surya Sapkota and Chin-Feng Hwang (2014). Interspecific Hybrid Identification of *Vitis aestivalis*-derived 'Norton'-Based Populations Using Microsatellite Markers. *Scientia Horticulturae* 179: 363-366.

#### **Conferences**

Dr. Chin-Feng Hwang; our research specialist; and one graduate student, were invited to attend the third annual meeting of the Cornell University-based VitisGen program February 20-21, 2014. The TASSEL software workshop was provided for us to learn how to construct a Norton linkage map using single nucleotide polymorphism (SNP) markers.

Dr. Chin-Feng Hwang and five students, all Plant Science Master's students, attended the 65<sup>th</sup> American Society of Enology and Viticulture (ASEV) National Conference June 25-26, 2014 in Austin, Texas. Three of the students presented posters on their research and participated in the flash talk where students gave timed, three-minute presentations on their research.

- One presented a poster entitled "Fungal Diseases in Grapevine: Phenotypic Assays on a *Vitis aestivalis*-derived 'Norton' Based Population"
- Another presented a poster entitled "Identification of True Hybrids of *Vitis aestivalis*-derived 'Norton'-Based Populations Using Molecular Markers"
- Lastly a student presented a poster entitled "Are Norton and Cynthiana Synonyms? – A Genome-Wide Comparative Assessment Using Microsatellite Markers"

Dr. Chin-Feng Hwang was invited to attend the 11<sup>th</sup> International Conference on Grapevine Breeding and Genetics, Beijing, China, August 1, 2014. Dr. Hwang presented a talk entitled "Mapping Genetic Loci for Resistance to Botrytis Bunch Rot in Grapevine."

***The USDA-SCBGP funds were not used for the trips listed above; however, the results from this project were presented in these conferences as opportunities to promote the USDA-SCBGP.***

Dr. Chin-Feng Hwang was invited to give a seminar entitled “Optimization of *Vitis aestivalis*-derived ‘Norton’ Grape Breeding using Molecular Genetic and Genomic Approaches” on March 24, 2015 at the USDA Crop Diseases, Pests & Genetics Research Unit, Parlier, CA.

Dr. Chin-Feng Hwang was invited to give a seminar entitled “Optimization of *Vitis aestivalis*-derived ‘Norton’ Grape Breeding with Marker-Assisted Selection” on May 08, 2015 at 4<sup>th</sup> Grape and Wine Research Symposium, University of Missouri, Columbia, MO.

Dr. Chin-Feng Hwang and four students, all Plant Science Master’s students, attended the 66<sup>th</sup> American Society for Enology and Viticulture (ASEV) National Conference June 17-18 in Portland, Oregon. Dr. Hwang was invited to serve as a moderator for a “Viticulture Pests and Diseases” session.

All four students presented posters on their research, three of which were supported by this funding that allowed them to attend the conference. One student was also selected to participate in the flash talk where students gave three-minute presentations on their research.

- The first presented a poster entitled “Genetic Study of Downy Mildew Resistance in *Vitis aestivalis*-derived ‘Norton’ Based Population”
- Another presented a poster entitled “Interspecific Hybrid Identification and Linkage Map Construction of a Chambourcin x Cabernet Sauvignon Population”
- The last student presented a poster entitled “Investigation into the Genetic Basis of Leaf Shape in Grapes”

In general, the School of Agriculture at Missouri State University offers about 10 summer internships every year. The four graduate summer assistantships provided from this funding were awarded to four MS graduate students. Working together with our Research Specialist, the graduate students and undergraduate summer interns were able to gain teaching experience by directing 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 4: High Tunnel Production Rotation of Primo Cane 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. This limits productivity and profitability. Putting the raspberries in a container, such as a grow bag, would allow for the plants 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. This method opens the space in the tunnel to be utilized by other crops when the raspberries are removed. The present project determined which varieties are suitable for this system in this region.

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 farmers have recently constructed high tunnels due in part to the federal funding available through the NRCS High Tunnel System Initiative and information is needed to help growers 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.

This project was not built on previous funding.

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.

### **Project Approach**

The experimental design is a randomized complete block with 5 treatments (cultivars) and 4 blocks. Blocking was done according to initial plant size and 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 planted in the grow bags in 2014. In 2014 and 2015, 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 5 per bag. The raspberries were irrigated/fertigated and moisture and air temperature were monitored. Harvest data and dormant cane weights 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). SWD was not detected after pesticide application was discontinued on September 28, 2015 in the high tunnel during the time when Crimson Giant was harvested.

Information dissemination included general tours and individual consultations at the Missouri State Fruit Experiment Station (MSFES), posts on the MSFES Blog, the 2015 High Tunnel Workshop held at Mountain Grove, and presentations made at the 2016 Great Plains Growers Conference, the 2016 Midwest Winter Vegetable Conference, and the 2016 North American Raspberry and Blackberry Conference (see Table 4. Quantitative data concerning beneficiaries of the project).

An agriculture graduate student chose to work on this project as the subject of her master's thesis in spring of 2015.

Results showed that the raspberry cultivars planted in grow bags bore a commercially acceptable and potentially profitable crop in 2014 and 2015 and overwintered successfully in the 2014 /2015 and 2015/2016 dormant seasons.

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 2014 and 2015 and data on marketable yield, average berry weight, and weight of dormant canes 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 High Tunnel Workshop at Mountain Grove.

It was also presented at two statewide grower meetings and one national meeting (see Table 4 Quantitative data concerning beneficiaries of the project).

Two years of data have been collected and analyzed at this point. Additional years of data would reveal if the favorable levels of yield and quality are sustainable as well as how long the grow bags will last before they need to be replaced. Additional years of data would also strengthen the possibility of publication in a professional refereed journal.

**Goal** – The goal to provide information on containerized raspberry production in high tunnels was achieved. Five primocane bearing varieties of raspberries were successfully grown, harvested and overwintered in the rotation between field and high tunnel.

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

**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 based on its performance in an earlier demonstration trial at the Missouri State Fruit Experiment Station. All cultivars in this trial exceeded the average three year yield of Josephine (5.4 pounds per 5 foot of hedgerow) in the previous in-ground high tunnel demonstration (see Table 1). The three year average yield of Josephine in the early trial included 2011 (establishment year); 2012; and 2013. In 2013, marketable yield was significantly decreased due to Spotted Wine Drosophila (SWD) damage. SWD arrived in Missouri in June 2013 when control recommendations had just become available (Pinero, 2013). The marketable yield of Josephine in the previous in-ground planting in 2012, the year the hedgerow was fully established and SWD was not present, was 8.3 pounds per 5 feet. In 2015, the second year of the raspberries in bags trial, all cultivars exceeded the yield of Josephine in 2012. Even the Josephine planted in grow bags as the reference cultivar in the trial exceeded the yield of Josephine in the earlier in-ground demonstration trial.

Berry weight among all cultivars was similar to Josephine. Crimson Giant exceeded the average berry weight of all cultivars in the trial.

All cultivars to date have performed well compared to the reference cultivar, Josephine. 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 (See figure 1). The differences in percent yield through time will offer growers several options in fitting the raspberries into their high tunnel production systems.

Weight of dormant season canes did not appear to impact yield. In general, the earlier season bearing cultivars tended to have a lower dormant cane weight and the late season bearing cultivars (Josephine and Crimson Giant) tended to have a higher dormant cane weight. This is probably related to the fact that the primocanes do not increase as much in height after they begin to flower and produce berries, so the early bearers will not grow as late into the season as the late bearing cultivars (see Table 2).

Pinero, Jaime C. 2013. Detecting larval infestations and insecticidal options for Spotted Wing Drosophila, a significant pest of small fruit crops in Missouri. MEG 4 p.

**Table 1. Yield and weighted average berry weight of raspberry cultivars in grow bags in a high tunnel**

Treatment	Yield* lb./5 ft. row 2014	Adjusted** yield lb./5 ft. 2014	Yield lb./5 ft. 2015	Average berry weight grams 2014	Average berry weight grams 2015
Crimson Giant	2.1 c	9.0 ab	10.6 b	4.5 a	4.3 a
Himbo Top	5.1 b	5.6 c	13.8 ab	3.2 c	3.1 b
Josephine	5.3 b	6.5 bc	11.1 b	3.8 b	3.3 b
Joan J.	8.2 a	9.0 ab	16.2 a	3.3 c	3.4 b
Polka	9.1 a	9.5 a	14.2 ab	3.6 bc	3.2 b

Experiment is a randomized complete block with 5 treatments (cultivars) and 4 replications. Statistics – ANOVA 2 way, means separated by Tukey-Kramer Multiple Comparison Test at the 0.05 level of significance.

\*Yield per 5 foot of row translates to yield per 5 grow bags. Grow bag diameter is 12 inches and each replication was composed of 5 bagged plants.

\*\*Harvest was discontinued October 31, 2014 in the establishment year and the number of green fruit left at that point was counted. Adjusted yield is the 2014 yield + (unharvested berries X average berry weight).

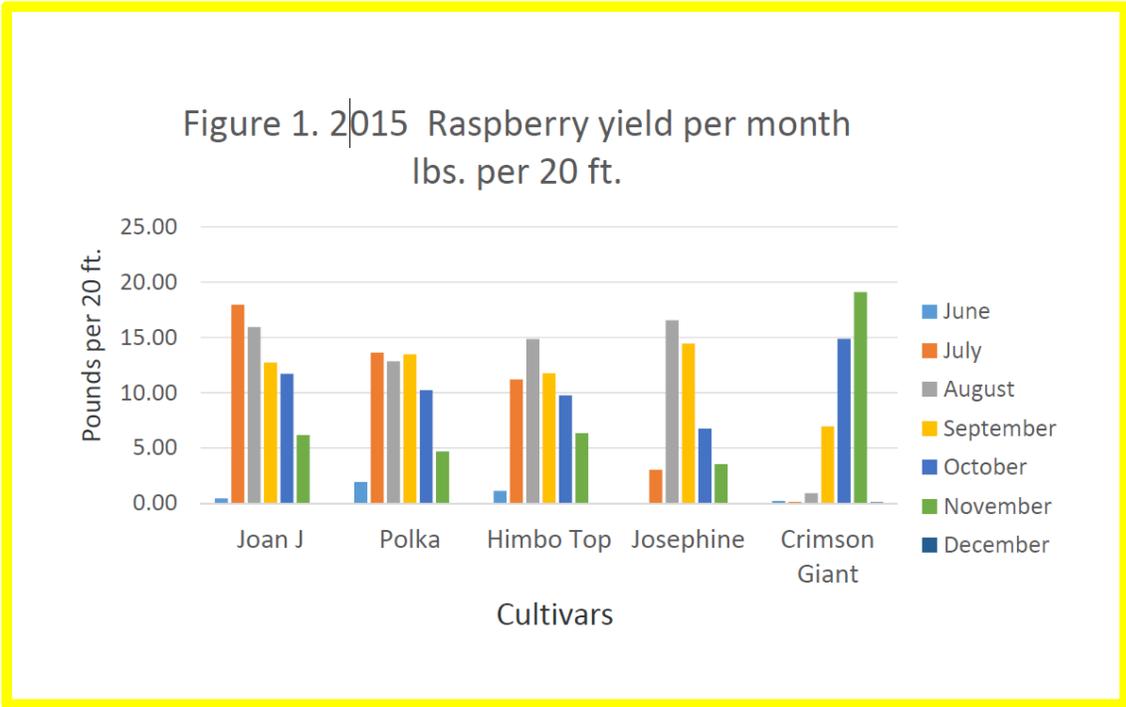


Table 2. Pruning weight of dormant canes raspberry cultivars in grow bags in a high tunnel

Treatment	Pruning Weight lbs/5 bagged plants 2014	Pruning Weight lbs/5 bagged plants 2015
Crimson Giant	2.14	3.69
Himbo Top	1.19	2.38
Josephine	2.14	3.00
Joan J.	2.20	2.05
Polka	1.44	2.59

**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 be able to use the information concerning raspberry variety performance in high tunnels in bag culture for advisement. The larger research community will 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 will also be the thesis project in training a plant science graduate student, in her pursuit of a master’s degree through Missouri State University.

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.**

<b>Dissemination source</b>	<b>Presentation</b>	<b>Number of persons</b>
<b>Masters student</b>	Presented project information in Graduate Seminar, Fall semester 2015.  Presented project information in Agricultural Research Models in Spring semester, 2016.	30 students and faculty
<b>SFES Blog</b> What's Happening in the Field	19 blog posts detailed project happenings (see 8. Additional Information).	Estimated 5 – 6,000 visitors annually
<b>High Tunnel Open House 2015</b> July 23  Presentations posted on website <a href="http://mtngrv.missouristate.edu/commercial/workshop-2015.htm">http://mtngrv.missouristate.edu/commercial/workshop-2015.htm</a>	<b><u>Introduction to Raspberry Production in the Ozarks</u></b> and <b><u>High Tunnel Raspberry Production in Grow Bags</u></b> Oral presentation. Planting was featured on tour.	Over 100 participants
<b>North American Raspberry and Blackberry Conference 2015</b> February 24 – 27, Fayetteville, Arkansas  Presentation is posted on website (password for members only) <a href="http://www.raspberrylblackberry.com/members-only/2015-conference-proceedings/">http://www.raspberrylblackberry.com/members-only/2015-conference-proceedings/</a>	<b>Raspberry Demonstration and Distillation at the Missouri State University Fruit Experiment Station.</b> Odneal, M. B. and K. Wilker. Poster presentation.	Over 200 participants. 240 members.
<b>Great Plains Growers Conference</b> St. Joseph Missouri, January 9, 2016  Presentation is posted on website <a href="http://www.greatplainsgrowersconference.org/saturday-presentations.html">http://www.greatplainsgrowersconference.org/saturday-presentations.html</a>	<b>High Tunnel Raspberry Production in Grow Bags</b> Oral presentation	Approx 400 – 500 participants  (concurrent sessions)
<b>Midwest Winter Vegetable Conference</b> , Webb City, Missouri, January 22, 2016	<b>High Tunnel Raspberry Production in Grow Bags</b> Oral presentation	Over 100 participants.

<p>Presentation is posted on website <a href="http://www.webbcityfarmersmarket.com/winter-production-conference.html">http://www.webbcityfarmersmarket.com/winter-production-conference.html</a></p>		
<p><b>North American Raspberry and Blackberry Conference 2016</b> Williamsburg, Virginia, March 3 - 4</p> <p>Presentation is posted on website (use password for non-members <b>Williamsburg-Berries</b> to enter) <a href="http://www.raspberryblackberry.com/2016-conference-proceedings-williamsburg-va/">http://www.raspberryblackberry.com/2016-conference-proceedings-williamsburg-va/</a></p>	<p><b>Progress Report – High Tunnel Raspberry Production in Grow Bags – Poster presentation</b></p>	<p>Over 200 participants. 240 members.</p>

**Lessons Learned**

Resulting from questions posed during the presentations made at grower meetings, we decided that we should wait until the raspberries were beginning to flower to move them inside the tunnel. This extends the period of time a grower would have to grow other crops in the space before the raspberries were rotated in.

Spotted Wing Drosophila (SWD) was discovered in Missouri in 2013, therefore, pesticide applications needed to be made on a weekly basis during harvest. Prior to this pest, mites were the only observed problem in raspberries in the high tunnel, and this was a minor problem. We gained experience with the pesticides used for SWD management in this trial and this will aid our advisement activities. Pesticides for SWD were applied weekly during harvest. We realized the best time to apply the pesticides in order to avoid pollinators is at night, so lights were installed in the high tunnel to make this easier.

Based on advice from Dr. Marvin Pritts, Cornell University, experience was gained in taking foliar samples of primocane bearing raspberries for tissue analysis. Published guidelines are not presently clear for this process. This experience with help with our advisement activities.

Crimson Giant is a very late bearing cultivar and we did not expect any of the cultivars to produce into December. In fact, we made a mistake in 2014 when we discontinued harvest of Crimson Giant since we believed that the late production was due to the fact that Crimson Giant was planted a month later than the other cultivars. In our previous work in in-ground high tunnel raspberry production, we observed that berry quality (taste) and production declined after the end of October.

We also thought that lack of pollinators would limit fruit set in November and December. We found that pollination was not an issue with Crimson Giant production in November and December of 2015. Bumblebees were still active at that time in the tunnel. While attending the North American Raspberry and Blackberry Conference in Williamsburg, Virginia, we found that raspberries were not as dependent on insect pollinators but can be pollinated by moving the plants around and by wind (personal communication Dr. Courtney Weber, Cornell and Dr. Fumi

Takeda, USDA.)

An interesting observation was made in 2015 when we discontinued pesticide application for Spotted Wing Drosophila (SWD) on September 28 but continued to harvest raspberries. We did not observe any drosophila larvae through early December (berries were tested weekly for larvae by submerging them in a salt float). This suggests that late season producing cultivars, like Crimson Giant, may avoid some SWD pressure in our area.

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. Chris Eckert of Eckert's Belleville Country Store and Farms, Belleville, Illinois, had a similar system and communicated that he had the same problem. He upgraded to a system that streamed the information directly to a computer. From this experience, we would advise a grower to use a system that streamed directly to a dedicated computer since the data is instantly accessible.

### **Contact Person**

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### **Additional Information**

The "**Raspberries in Grow Bags**" project was subject of the "Ozarks Fruit and Garden Review" newspaper/web article for the week of May 5, 2014

SFES Blog "What's happening in the field?" Posts listed as follows  
<http://blogs.missouristate.edu/fruitexperimentstation/>

**Planting raspberries in grow bags**, April 22, 2014

<http://blogs.missouristate.edu/fruitexperimentstation/2014/04/22/planted-raspberries-in-grow-bags/>

**High tunnel raspberries and veggies**, May 21,

2014 <http://blogs.missouristate.edu/fruitexperimentstation/2014/05/21/high-tunnel-raspberries-and-veggies/>

**Putting the raspberries to bed for winter**, December 10, 2014

<http://blogs.missouristate.edu/fruitexperimentstation/2014/12/10/putting-the-raspberries-to-bed-for-winter/>

**Setting up overhead irrigation in the high tunnel**, January 23, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/01/23/setting-up-overhead-irrigation-in-the-high-tunnel/>

**Lettuce Planted in high tunnel**, Friday, March 5, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/03/08/lettuce-planted-in-high-tunnel-on-friday-march-5/>

**Raspberries in grow bags fertilized today**, April 17, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/04/17/raspberries-in-grow-bags-fertilized-today/>

**Thinning shoots in bagged raspberries**, April 21, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/04/21/thinning-shoots-in-bagged-raspberries/>

**First half of lettuce in the high tunnel harvested today**, April 24, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/04/24/first-half-of-the-lettuce-in-the-high-tunnel-harvested-today/>

**Veggies harvested and raspberries rotated in**, May 11, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/05/11/veggies-harvested-and-raspberries-rotated-in/>

**Putting duraline on the raspberry trellises**, May 15, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/05/15/putting-duraline-on-the-raspberry-trellises/>

**Larkspur blooming in high tunnel**, June 8, 2015 (flower crop observed to determine potential rotation with raspberries)

<http://blogs.missouristate.edu/fruitexperimentstation/2015/06/08/larkspur-blooming-in-high-tunnel/>

**Digging potatoes**, June 29, 2015 (vegetable crops are observed to determine potential rotation with raspberries)

<http://blogs.missouristate.edu/fruitexperimentstation/2015/06/29/digging-potatoes/>

**Drosophila larvae on raspberry**, June 6, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/07/06/drosophila-larvae-on-raspberry/>

**High Tunnel Workshop**, July 23, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/07/23/high-tunnel-workshop/>

**Raspberries keep on going and going . . .**, November 6, 2015

<http://blogs.missouristate.edu/fruitexperimentstation/2015/11/06/raspberries-keep-on-going-and-going/>

**Raspberries moved out of the high tunnel for overwintering**, December 16, 2015

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

**Weighing raspberry canes after pruning**, January 6, 2016

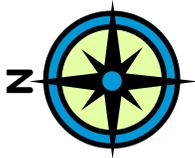
<http://blogs.missouristate.edu/fruitexperimentstation/2016/01/06/weighing-raspberry-canes-after-pruning/>

**MSU Grad Student presents research at Great Plains Growers Conference in St. Joseph**, January 10, 2016

<http://blogs.missouristate.edu/fruitexperimentstation/2016/01/10/msu-grad-student-presents-research-at-great-plains-growers-conference-in-st-joseph/>

**Veggies planted in the high tunnel today**, March 1, 2016

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



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

KEY:

Block A – Largest initial plant size, north-west location in tunnel.

Block B – Large to moderate initial plant size, south-east location in tunnel.

Block C – Moderate to small initial plant size, north-east location in tunnel.

Block D – Small initial plant size, south-west location.

Note: All but Crimson Giant were dormant bare root plants. After growth began in the bags, the bare root plants had some differences in initial plant size, so this difference was blocked in the experimental design. Bags were arranged from smallest plant size to largest and the largest plants were put in Block A to the smallest plants in Block D. There was not much difference in plant size for Crimson Giant raspberry since the plants were plugs.

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 5: Home and Community Gardening Kansas City**

**Kansas City Community Gardens**  
Ben Sharda  
Final Performance Report

**Project Summary**

From October 1, 2013 to September 30, 2014, Kansas City Community Gardens (KCCG) participated in the Specialty Crop Block Grant program with a project to promote specialty crops through urban gardening. The purpose of “Home and Community Gardening Kansas City” is to increase the number of individuals and organizations that are able to grow specialty vegetable and fruit crops in community and home garden spaces in the Kansas City, Missouri, area.

The mission of Kansas City Community Gardens is to assist low-income households and community groups in the Kansas City metropolitan area to produce vegetables and fruit from garden plots located in backyards, vacant lots, and at community sites. KCCG’s work focuses on providing gardening resources, including education, supplies, and technical assistance, to help make gardening affordable for everyone.

This project was designed to address food insecurity in urban Kansas City by providing free gardening education, free and low-cost specialty crop seeds and plants, community garden

space, raised bed construction supplies, and other support to Kansas City's low-income families and community groups. Whether for family meals or to donate to local food pantries, all of KCCG's gardening efforts are devoted to helping the Kansas City community produce specialty vegetable, fruit, and herb crops, making this project an ideal fit with KCCG's organizational mission.

Fruit and vegetable production through gardening is imperative not only for increasing the competitiveness of specialty crops, but also for improving access to healthy food in our communities. As Agriculture Secretary Tom Vilsack recently noted, "Specialty crops make up the bulk of what we eat—all of our fruits and vegetables, tree nuts and dried fruits—as well as things like cut flowers and nursery crops. They are half of MyPlate at every meal, and the daily source for most of our vitamins and nutrients."<sup>1</sup>

Here in Missouri, food banks continue to become even more overburdened, with many turning away clients because they ran out of food. Families visiting food banks report making difficult choices between paying for food and paying for other essential items, such as medicine or medical care, utilities, and housing.<sup>2</sup> Jackson County, Missouri, where KCCG is located, received a food insecurity ranking of "very high" in 2013, with 15.9% of households experiencing food insecurity in comparison to 13.9% statewide.<sup>3</sup> Our state is experiencing a hunger crisis, with food insecurity continuing to rise. Missouri and Tennessee are tied for the second-highest rate of growth in food insecurity this year, trailing behind only Nevada.<sup>4</sup> Promoting community and home gardening can help to increase food security and reduce reliance on food assistance for Missouri's families.

This project was not a continuation of a previously funded project; however, the Home and Community Gardening Kansas City project was recently approved to continue through September 2015.

## **Project Approach**

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### **Activities**

As described in the original project workplan, KCCG staff implemented the following project activities during the grant period, with the goal of increasing the competitiveness of specialty vegetable, fruit, and culinary herb crops through home and community gardening:

Crop selection: During the project period, KCCG offered more than 90 varieties of vegetable, fruit, and culinary herb seeds pre-selected by KCCG's experienced staff for productivity, disease resistance, appropriateness for Missouri's climate, and other criteria. In addition, project staff grew more than 90 varieties of vegetable, fruit, and herb plants in the KCCG greenhouse, producing more than 80,000 transplants during 2015. Selection criteria included:

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<sup>1</sup> "Secretary's Column: Farm Bill Supports Specialty Crop Growers, Improves Access to Healthy Food," 4/18/14, <http://blogs.usda.gov/2014/04/18/secretarys-column-farm-bill-supports-specialty-crop-growers-improves-access-to-healthy-food/>.

<sup>2</sup> Hunger in America 2014 for the State of Missouri, Feeding America and the Missouri Food Bank Association, <http://feedingmissouri.org/news-and-events/hunger-in-missouri-2>.

<sup>3</sup> Missouri Hunger Atlas 2013, Interdisciplinary Center for Food Security, University of Missouri, <http://foodsecurity.missouri.edu/projects/missouri-hunger-atlas/>.

<sup>4</sup> Perot, Marine, "USDA: Missouri Hunger is On the Rise, KCUR, 11/5/14, <http://krcu.org/post/usda-missouri-hunger-rise>.

- 1) **Varieties that grow well in the Kansas City area:** Although seed catalogues provide an plethora of choices, many varieties offered do not grow best in our climate. Varieties that grow well in Missouri growing conditions are selected in order to increase gardening success. This includes varieties such as ‘Beauregard’ sweet potato, which only needs 90 days of hot weather to produce, and the short-vining ‘Sweet Ann’ sugar snap pea, which can also be grown in the fall.
- 2) **Productivity:** Urban gardeners often have limited space in which to grow. Many varieties (such as ‘Jambalaya’ okra and ‘Gypsy’ bell pepper) produce more fruit, allowing for a greater harvest from the same space.
- 3) **Gardener interest:** KCCG considers the knowledge and experience of its gardeners when selecting seed and plant varieties. From time-honored varieties that have been grown by Missouri families for decades to new varieties with unique attributes, our growers are a vast source of collective knowledge on which crops work well in Kansas City. ‘Georgia,’ a standard collards variety, has been grown by gardeners for generations, while ‘Top Bunch,’ a more recent collard variety addition, becomes increasingly popular among KCCG’s gardeners every year. KCCG also offers essential crops used in traditional African American and Hispanic cooking, such as collard greens, okra, cilantro, and epazote, to remain responsive to our gardeners’ cultural preferences.

Specialty crops selected for use in the program included the following:

***Fruit trees and plants:***

Berry plants selected for bulk purchase and distribution to members included strawberry (‘Cavendish,’ ‘Eversweet,’) blackberry (‘Natchez’ thornless), and raspberry (‘Heritage’ fall-bearing). KCCG selected a variety of fruit trees, including apple (‘Enterprise,’ ‘Liberty,’ ‘Pristine,’ ‘Winecrisp’), cherry (‘Black Gold,’ ‘Danube,’ ‘Montgomery’), Asian pear (‘Chojuro,’ ‘Korean Giant,’ ‘Seuri,’ ‘Shinko’), pear (‘Harrow Delight,’ ‘Potomac,’ ‘Sunrise’), peach (‘Contender,’ ‘Harrow Diamond’). KCCG also provides seeds for several varieties of canteloupe, watermelon, muskmelon, and other fruit crops.

All fruit trees and berry plants were ordered bare-rooted and stored temporarily in KCCG’s on-site refrigerated storage unit upon shipment until picked up by participating families and community groups. Individuals and community groups ordered fruit plants in February and picked them up in April at planting time. For a complete listing, please see Additional Information section.

**Vegetable and Herb Seeds and Plants:**

KCCG also made vegetable, herb, and selected fruit seeds available to participating gardeners both at our Swope Park location and during “satellite” seed and plant distribution days at the Independence Health Department. For a complete listing, see Additional Information section.

Seeds and plants available from KCCG during the project period included cool season vegetable crops recommended by KCCG included broccoli, cabbage, cauliflower, kale, lettuce, radish, turnip, and many others. Cool season herbs included chives, cilantro, oregano, parsley, rosemary, and thyme. Warm season vegetable and herb crops offered to participating gardeners included beans, corn, cucumber, peppers, sweet potatoes, squash, tomato, and others, along with basil and dill. Other special order crops available to gardeners included onions, asparagus, sweet potatoes, and garlic (hard neck and soft neck).

Educating gardeners: During the grant period, KCCG staff provided 46 free educational garden skills workshops for Missouri gardeners from February-September 2014 at KCCG's Swope Park location, the Independence Health Department, Ivanhoe Community Center, St. Paul's United Methodist Church (Independence, MO), and the Urban Impact Center in Kansas City, MO.

KCCG's educational workshops were an essential aspect of this project to help maximize gardeners' successful production of specialty crops. Sessions are designed to improve basic garden skills for all gardeners with such topics as "Vegetable Garden Basics" and "Fruit Trees and Berry Bushes," while building confidence for more advanced gardeners to build on their knowledge with workshops like "Growing Under Lights," "Cooking from the Garden," and "Extending the Garden Season." KCCG's Executive Director, Ben Sharda, who holds a Bachelor of Science degree in Horticulture from the University of Missouri, led approximately half of all workshops. Mr. Sharda, KCCG's Executive Director since 1989, has been a recognized leader of KCCG's community gardening efforts for over twenty-nine years. Program Director, Andrea Mathew, M.S.W., and Get Growing KC Team Members Sharon Goldstein and Bobby Wright led the remaining workshops, including "Early Spring Crops," "Get Growing a Community Garden," and "Cooking with Summer Harvest."

Producing specialty crop transplants: Project staff produced more than 80,000 seedlings in KCCG's on-site greenhouse during 2014, providing the majority of these to Missouri's low-income gardeners and other growers enrolled in KCCG's Self-Help Gardening program. (Note: KCCG serves the entire metropolitan area, including Kansas gardeners). Staff grew exclusively vegetable and culinary herb crops in the greenhouse to improve access to healthy food in Kansas City, focusing on high-yield crops such as tomatoes, peppers, and sweet potatoes. Including such productive, easy-to-grow, and Missouri-adapted varieties such as 'Sun Gold' tomato and 'Red Knight' bell pepper helped to ensure successful specialty crop production for more Missouri home and community gardeners.

Providing fruit trees and plants: KCCG staff processed more than 175 fruit tree and berry bush orders in 2014, purchasing these in bulk from suppliers such as Stark Bros. and Rain Tree Nursery then providing them at a discounted rate to KCCG's Missouri members. For instance- Missouri's low-income home gardeners were able to purchase fruit trees for \$20.00 and raspberry plants for \$2.50.

Providing community garden space: KCCG staff provided more than 136,000 square feet of community garden space throughout the Kansas City area during the project period. KCCG maintains and rents garden space at a low cost (\$8 for a raised bed, \$10 for a ground plot for qualified low-income families) at the Swope Park Community Garden (6917 Kensington, Kansas City, MO); Eastwood Hills Community Garden (8100 Ozark Rd., Kansas City, MO); Freeway Park Community Garden (1402 Indiana, Kansas City, MO), and Ivanhoe-Richardson Community Garden (3515 Park, Kansas City, MO). In addition, the new Prospect Community Garden at 5008 Prospect, Kansas City, MO, opened in 2014, providing an additional 35 raised beds for families living in the surrounding food insecure neighborhoods.

Providing specialty crop vegetable and herb seeds: With the help of dedicated volunteers, KCCG packaged 35,967 packages of vegetable, herb, and fruit seeds and provided these to low-income families and community groups at a reduced cost of \$.20 per package. Higher-income families enrolled as KCCG members were also able to purchase seeds at a cost of \$1.00 per package.

Providing other garden support to Missouri families and community groups: KCCG provided other supplies and technical assistance to Missouri's low-income families enrolled in the KCCG Self-Help Gardening program, along with Missouri Community Partner Gardens maintained by nonprofits, hospitals, neighborhood associations, and other community garden groups. Resources shared with gardeners included: straw mulch, fertilizer, tomato cages, tilling services and tiller rental, raised bed garden supplies and technical assistance, rainwater harvesting supplies and technical assistance, garden tools, and other resources.

Testing best practices in the KCCG Demonstration Garden: With Specialty Crop Block Grant support, KCCG staff were able to build and maintain a new 20'x25' ground plot and 6 raised bed demonstration garden area located on-site at KCCG's administrative headquarters in the Swope Park Community Garden. Project staff tested best practices such as utilizing intercropping methods to plant for all seasons, watering with perforated tubes, and growing new vegetable varieties such as 'San Juanito' tomatillo and 'Bounty' hybrid banana pepper. Produce grown was used in KCCG's "Cooking from the Garden" workshop series, led by trained chef Sharon Goldstein, to share seasonal healthy cooking methods and recipes with interested gardeners. The garden served as an outstanding visual tool to demonstrate technique to community garden groups like Bocia Group Youth Garden. The youth garden's coordinator visited KCCG before building a new raised bed garden to view how the final version might look, and to receive hands-on planting instruction in the demonstration garden.

### ***Partnerships***

Since community gardening is possible only with community engagement and neighborhood or volunteer participation, partnerships have been integral to the success of the Home and Community Gardening Kansas City project. During the project, Specialty Crop Block Grant funds helped to support 179 Missouri Community Partner Gardens, garden projects started and managed by neighborhood associations, nonprofits, hospitals, or other community groups in the Kansas City area. As part of the Community Partner Gardens initiative, KCCG provides seeds, plants, fertilizer, mulch, garden tilling, raised bed construction supplies and technical assistance, rainwater harvesting supplies and technical assistance, and other resources to these groups. During the project year, Missouri Community Partner Gardens participating included Squire Park Community Garden, Blue Hills Community Garden, Paseo West Community Garden at Hope Faith Ministries, several community gardens maintained by the Independence Health Department, a demonstration garden project at Harvester's, Crown Garden (maintained by Hallmark employees and other community volunteers) at Ronald McDonald House, and many others.

Other key partnerships essential to the project's success included:

- The City of Kansas City, Missouri- who provides land, funding, support for community gardens in the form of water access mini-grants and other resources in support of KCCG's efforts.<sup>5</sup>
- The Get Growing KC collaborative initiative in partnership with Cultivate Kansas City and Lincoln University, and with major support from the Health Care Foundation of Greater Kansas City.<sup>6</sup>
- Gardening expertise and resources such as soil testing and growing guides from University of Missouri Research and Extension agents.

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<sup>5</sup> KC Grow, <http://kcmo.gov/news/2014/citys-kc-grow-program-waters-urban-crops/>.

<sup>6</sup> For details, please visit [www.getgrowingkc.org](http://www.getgrowingkc.org).

## Goals and Outcomes Achieved

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As home and community gardening in Kansas City continues to enhance access to healthy food among food insecure families and communities, it simultaneously achieves other Specialty Crop Block Grant programmatic goals, including: (1) facilitating education about specialty crops through KCCG's free garden skills workshops and technical assistance, and (2) Expanding local/regional markets and distribution channels for specialty crops.

With Specialty Crop Block Grant funds, KCCG provides educational workshops that create a new generation of knowledgeable specialty crop producers, while supporting both families and community-based organizations that are focused on distributing produce for hunger prevention and relief. Although KCCG serves families and organizations with an interest in producing homegrown produce for market, the central focus of our service to Missouri Community Partner Gardens through this project is to help neighborhood and community groups grow and donate produce that helps to feed families and raise the nutritional profile of the food available through Kansas City's food pantries.

### ***Helping Families and Communities Grow Fresh Produce***

The goal of the Home and Community Gardening Kansas City project was to increase production of specialty food crops, including vegetables, fruit, and cooking herbs, in the Kansas City metropolitan area through community and home gardening. This project directly supported KCCG's efforts to purchase specialty crop items (seeds, fruit trees and plants, onion sets, garlic bulbs) and related supplies, combined with relevant education and support to make the process of growing fruits and vegetables easier for hundreds of participating gardeners.

KCCG's target was to provide garden supplies and technical assistance to increase the number of low-income Missouri households and Missouri nonprofits and other community organizations enrolled in KCCG's Self-Help Gardening program, by 15%, and help at least 95% of gardeners surveyed successfully harvest produce from home and community gardens during KCCG's Fiscal Year 2014 (10/1/13- 9/30/14). KCCG exceeded the goal of helping 95% of gardeners surveyed successfully harvest produce, with 98.7% of low-income gardeners responding that they had harvested produce from their gardens with KCCG support. KCCG fell just short of a 15% increase in low-income Missouri gardeners participating, with a 14% increase in Missouri's low-income families served (growing from 978 in 2013 to 1,138 in 2014) and a 12% increase in Missouri community and youth groups served during the project (increasing from 172 Missouri organizations in 2013 to 193 in 2014).

KCCG's Self-Help Gardening program supports Kansas City's low-income households in their efforts to successfully grow fresh vegetables, fruits, and culinary herbs. This program provides education, supplies, and technical assistance to gardeners, making growing healthy food achievable and affordable for those who would otherwise be unable to garden due to income and physical limitations or inadequate space. The Community Partner Gardens initiative, part of Self-Help Gardening, allows community groups including neighborhood associations, nonprofits, congregations, and hospitals to sign up along with individuals for KCCG's services. This initiative has a significant impact on preventing hunger and improving healthy food access for Kansas City's communities, since organizations typically donate produce grown to local food pantries for hunger relief or share it within their neighborhoods.

To measure the impact of the Home and Community Gardening project, KCCG provided an in-person survey to participating low-income gardeners and community groups enrolling in the

Self-Help Gardening program for a second year, also collecting enrollment data from participating families and Community Partner Gardens. Nearly 80% of Community Partner Gardens surveyed also successfully harvested specialty crops from their gardens, and the vast majority reported donating produce for hunger relief.

### ***Gardening and Specialty Crops: The Nutritional and Economic Impact***

The project's impact in advancing specialty crops in Missouri through home and community gardening also becomes apparent when assessing the total amount of food grown by participating home and community gardeners throughout the Kansas City metropolitan area during the grant period.

For example, in spring 2014, more than 340 home gardeners and community garden groups ordered approximately 12,000 sweet potato plants (purchased in bundles at \$2.00/dozen) from KCCG for planting in May and June. KCCG staff purchased unrooted slips and seed stock (tubers) to produce rooted sweet potato slips sold from the KCCG greenhouse. This made it possible and economical for many small growers to produce nutritious sweet potatoes for home use or to donate for hunger relief. With yields averaging two pounds per slip, plants distributed provided opportunities for Kansas City's growers to produce an estimated 24,000 pounds of nutritious sweet potatoes for their families, neighborhoods, or for donation. At an average retail price of \$.89/pound, KCCG's gardeners produced sweet potato crops worth an estimated \$19,360 (after plant costs of 16.7 cents per slip).

Though some plants were undoubtedly lost to disease, pests, poor growing conditions, or other barriers to success, KCCG offered a host of related workshops to growers during the spring months to help overcome these barriers, ranging from "Growing Tomatoes, Peppers, and Sweet Potatoes" in April to "Insects in the Garden" and "Dealing with Animal Pests" in May. The "Vegetable Garden Basics" course offered several times each year also focuses on core garden preparation tactics such as proper siting and soil health, so that gardeners enrolled in the Self-Help Gardening program receive the foundational knowledge needed for garden success early in the growing season.

KCCG's work focuses on making it possible for families and communities to eat more nutritiously through gardening. Thus, the Home and Community Gardening Kansas City project also demonstrated a significant health impact for thousands of Missouri families working to grow their own specialty crops. Lewis Jett with University of Missouri Extension writes, "Sweet potatoes are an excellent vegetable crop to include in the field or garden in Missouri. They are high in fiber and in vitamins A and C and low in fat, making them a very nutritious vegetable."<sup>7</sup>

Overall, KCCG estimates that 1,138 participating low-income Missouri home gardeners may have harvested as much as 340,000 pounds of specialty crops in backyard gardens and in KCCG's large-scale community gardens during the project, valued at approximately \$680,000. According to a 2009 study by the National Gardening Association, the average garden harvest for a home garden is ½ pound per square foot, the average garden size is 600 square feet, and the cost of fresh produce at market approximately \$2 per pound.<sup>8</sup> With approximately \$1 worth of produce harvested per square foot, KCCG's low-income gardeners realized significant savings, grew their knowledge and use of specialty crops, and increased their access to healthy food by growing their own specialty crops with support from KCCG. An additional 195 Missouri community groups are estimated to have grown 200,000 pounds or more of specialty crops

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<sup>7</sup> Growing sweet potatoes in Missouri, Publication G6368, available at: <http://extension.missouri.edu/p/G6368>.

<sup>8</sup> Butterfield, Bruce "The Impact of Home and Community Gardening in America," 2009.

during the project (valued at \$400,000), based on garden size and average yield of specialty crops, with the majority donated to food pantries for hunger relief, used to feed at-risk nonprofit clients, or used to feed food insecure urban families.

For this project, KCCG targeted Kansas City's low-income population to help these at-risk families save money on food costs, while promoting healthy eating and active lifestyles. Families meeting income guidelines based on federal poverty criteria were able to enroll as KCCG members at a reduced cost of \$2 per year (in comparison to a \$12 annual membership fee for higher-income families). This program serves the entire Kansas City metropolitan area, with the majority of Missouri members (1,127 of 1,138 Missouri families, or 99% during the past year) residing in Jackson County, Missouri, where nearly 19% of the population currently lives with household income levels below the federal poverty level (U.S. Census Bureau, 2012 American Community Survey).

Approximately 40% of low-income gardeners served through this project were aged 60 or greater, including more than 15 gardeners over the age of 90. Gardening is particularly important to help seniors "age in place" by maintaining their physical activity levels and community engagement. Gardening not only provides an affordable source of nutritious food for Kansas City's seniors, but offers a regular means of physical activity as seniors work to plant and maintain their garden plots or beds. Community gardening provides critical social connections for seniors and other gardeners, as they visit their garden plots or beds regularly to plant, weed, water, and harvest produce alongside other community members of all ages and backgrounds. George, a community gardener at KCCG's Swope Park Community Garden and longtime KCCG member in his 90s, visits the Swope Park location and office nearly every day during the garden season and has developed deep friendships with fellow gardeners, KCCG staff, board members, and volunteers.

Even more Missourians benefited from this project due to the amount of garden produce donated to Kansas City area food pantries and shared in food insecure neighborhoods by KCCG's Community Partner Gardens. Just a few of the 195 community and youth garden projects enrolled as KCCG Community Partner Gardens this year were:

- Carol's Garden at the Community Assistance Council, where neighborhood residents grow fresh fruits and vegetables that are used to feed the more than 600 families who frequent the Council's on-site food pantry each year;
- God's Garden at Colonial Presbyterian Church provides 80 plots available to the community and the Harvest for Hunger garden, 25 raised beds to feed the hungry, and 3 raised beds used to teach children in the church's preschool program how to grow healthy food. In partnership with food pantries such as the Salvation Army, the church garden donated more than 2,000 pounds of produce for hunger relief in 2012 and nearly twice that in 2013;
- Developing Potential, a nonprofit devoted to serving adults with developmental disabilities, created a triple-height raised bed to provide access to adults with mobility issues to practice cooking, math, science, and other skills through gardening.

For a complete list, locations, and descriptions of KCCG's Community Partner Gardens, please visit: <http://kccg.org/garden-with-us/garden-finder/>.

## **Lessons Learned**

This project provided an opportunity for KCCG to incorporate growing best practices and lessons learned from the KCCG Demonstration Garden, as well as from greenhouse production, into the Self-Help Gardening program. Testing new specialty crop varieties and growing techniques provided new knowledge to share with gardeners, improving the chances of gardening success for Kansas City's low-income households and community groups. The following are lessons learned from the various project activities and KCCG's recommendations for growers resulting from the Home and Community Gardening Kansas City project.

### Community Partner Gardens

- *KCCG recommends helping community garden groups establish a planting plan at the beginning of the growing season, in order to help groups develop garden projects of a size and scale that they can reasonably maintain.*

During the project, KCCG's Community Partner Gardens placed orders for their seeds and plants, sometimes ordering more than they needed. Planting too many crops not only unnecessarily depleted KCCG's seed and plant stock, but also adversely affected some community garden projects, when groups prepared and planted more space than they were able to maintain. In order to ensure that Community Partner Gardens used their space, and the seeds and plants that they ordered, efficiently, project staff developed a Microsoft Excel-based planting plan system. This allows staff to sit down with gardeners and input garden size, crop selection, and timing in order to create a planting calendar, three garden maps (one for each growing season), with order forms and an estimated budget for each season.

- *KCCG recommends raised bed gardening for community garden success whenever possible, particularly for youth garden projects.*

Although they can be more expensive, raised bed gardens can provide numerous benefits to community and youth garden groups. Better soil quality and moisture retention combined with a protected, easy accessible space for multiple gardeners (especially young children) to work in makes raised bed gardens superior to ground plots for the majority of community garden projects. Covering part of the cost of raised bed supplies was a great benefit of this project to participating community and youth groups.

### Demonstration Garden/Greenhouse Production

1. *KCCG recommends using intercropping methods in order for gardeners to maximize growing space and increase harvests during all three planting seasons.*

For example, project staff planted lettuce in the demonstration garden during early spring 2014, then removed enough lettuce plants to add tomatoes when warmer weather arrived. By the time the tomato plants reached full size, the surrounding lettuce was ready to be harvested, while some went to seed. Although this is a good practice, KCCG did not give our tomato plants enough room to grow and they were stunted. Clear a 12" diameter circle around the tomato plant in order to give the plant enough room to grow.

2. *KCCG recommends that gardeners use drip irrigation to more thoroughly soak the soil and to monitor how much water is needed for various crops.*

Both individuals and groups often had a hard time knowing how much to water their gardens. KCCG staff tested various watering methods, including installing black corrugated pipe that was perforated to slowly let out water. This method allows groups to know how much water they are giving their plants and for the water to soak more deeply into the soil.

3. *KCCG recommends using row cover for both season extension and pest control.*

We used row cover in the demonstration garden both as a method for insect exclusion (especially for Harlequin Bugs) and as a method for extending the season.

4. *KCCG used the demonstration garden to show community gardeners how to maximize space and grow more produce using intensive gardening.*

In the 20'x25' ground plot, KCCG staff created 4' "raised beds" without walls, with 2' paths in between. Many of our community gardeners still plant in single rows with a path in between each row. By demonstrating the bed-method of planting, we were able to show gardeners how to get more produce out of their garden.

5. *KCCG recommends fall gardening to improve the quantity and flavor of garden produce.*

KCCG offered a wide variety of transplants started in the KCCG greenhouse throughout the 2014 gardening season. KCCG tested one of these crops, Napa cabbage (also known as Chinese cabbage, widely used in East Asian cooking), in the demonstration garden, and learned that due to its shorter season it grows well during both the spring and fall gardening seasons. Many gardeners who planted in the fall were more pleased with the taste of the cool season vegetables offered by KCCG than when the same crops were planted in the spring. A broccoli plant planted in the spring grows into heat, lessening the flavor. Broccoli planted in late July and harvested in November after a light frost is often sweeter. KCCG is one of the only places in Kansas City where gardeners can purchase fall transplants. Although we promote fall gardening, many of our gardeners are still not growing in the fall. More outreach and education needs to be shared with our gardeners about the benefits of fall gardening.

6. *KCCG recommends creating custom seed blends when appropriate to provide a wider variety for gardeners.*

Project staff tested multiple beet varieties in the demonstration garden and created a custom seed mix (Mixed Beet Blend) to provide a wider variety to gardeners who may have limited space to devote to a single crop. KCCG also offered a custom lettuce blend. This option increased the nutritional value of crops for gardeners, while providing a colorful mixed crop that was particularly pleasing to youth gardeners.

### Workshops

7. *Garden skills education was essential to success for home and community gardeners participating in this project.*

Although KCCG offered workshops from February through late fall, spring workshops had the highest attendance. KCCG staff had more time available to provide garden

education in the summer and fall, but attendance was much higher in the spring due to gardeners' eagerness to prepare for the season ahead.

Workshop attendees were asked to complete a survey. Of 92 gardeners responding:

- 70% were KCCG members;
- 66% of members attending were non-low-income, 34% low-income;
- 55 years was the average age of participants;
- 74% were female;
- 60% were from Kansas City, MO, 16% were from Kansas, and an additional 25% were from other areas in Missouri;
- 9.7 years was the average time they have been gardening;
- "Garden Challenges"- responses to this question were mostly "pests," and the majority of those were "bugs." Other concerns included "time to garden," "water issues," "soil health," and "weeds."

### **Overall Lessons Learned**

Although interest in home and community gardening continues to grow rapidly in Kansas City, KCCG overestimated the number of Missouri families and community groups that we anticipated would remain in the program from 2013 to 2014. Health problems for seniors and frequent moves among low-income families are two common issues that lead KCCG's home and community gardeners to leave the Self-Help Gardening program and/or give up gardening each year. KCCG will continue to work toward better gardener retention during the next phase of the project by conducting site visits to home gardens and using gardener survey results to identify other program improvements.

During the next phase of this project, KCCG staff will focus on providing even more resources to Kansas City's home and community gardeners. A planned expansion of the KCCG greenhouse will allow us to produce more specialty crop transplants for community and home gardeners in 2015. Increasing workshop attendance during the next phase of the project will enhance both basic and advanced gardening skills for Kansas City's gardeners. As a result of this project, KCCG has also developed a community outreach plan to be implemented by staff prior to the 2015 gardening season. In combination with new marketing tools that we have recently developed to increase awareness of our services, KCCG anticipates reaching even more Missouri gardeners through the Home and Community Gardening Kansas City project in the coming year.

### **Contact Information**

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[Ben@kccg.org](mailto:Ben@kccg.org)

### **Additional Information**

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Sample project photos, plant lists, workshop schedule and media coverage related to this project.

Please also see:

Bauman, Caroline, "Seeds of recovery sprouting from court's community garden," *The Kansas City Star*, 6/10/14, <http://www.kansascity.com/news/local/article519647/Seeds-of-recovery-sprouting-from-court%E2%80%99s-community-garden.html>)

Pulliam, David, "The Conversation: Cancer diagnosis spurred Francine Nelson into growing health foods," *The Kansas City Star*, 9/13/14, <http://www.kansascity.com/living/star-magazine/article2051827.html>).





## Kansas City Community Gardens Fruit Plant List - 2014

### Ordering Information:

Fruit plants should arrive at our office the beginning of April.

We will contact you upon plant arrival. All plants are bare-rooted and should be picked up and planted quickly for good success. We recommend having your planting bed prepared and tree holes dug ahead of time in case of rainy weather.

Order your fruit trees soon because varieties sell out quickly.

### Berries:

**'Cavendish' Strawberry – June bearer**                      **10 plants for \$2.50 – Member Price**

High yielding with large high quality berries. Plants are disease resistant and hardy.

**'Eversweet' Strawberry - Day Neutral**                      **10 plants for \$4.00 – Member Price**

Large, intensely delicious berries. Heavy spring crop with intermittent berries through the season. This is the most heat resistant day neutral variety.

**'Natchez' Thornless Blackberry**                              **\$3.50 per plant – Member Price**

Large berries have excellent flavor. Plants are upright, vigorous and hardy. The earliest blackberry!

**'Heritage' Fall bearing Red Raspberry**                      **\$2.50 per plant – Member Price**

Starts bearing in August and continues until frost. Very productive and hardy with good flavor and berry size. Easy to grow and easy to prune.

### Fruit trees:

#### Apple:

**'Pristine' Apple** (needs a pollinizer)

This PRI (Purdue, Rutgers, and Illinois Universities) selection ripens in late July, producing large crops of beautiful yellow apples that are crisp and tasty. They are mildly tart and excellent for fresh eating, baking or in applesauce. The trees are healthy, highly resistant to apple scab, cedar apple rust and somewhat resistant to powdery mildew and fireblight. Semi-dwarf (M7 rootstock 12-15')

**'Liberty' Apple** (needs pollinizer)

Liberty is very similar to appearance to McIntosh, but its flavor is a bit more tart and its flesh is crisper. It has a wonderful flavor all its own. It is a good dependable choice because it is highly productive, an excellent pollinizer, keeps well and is resistant to all the major apple diseases. It ripens early September which is about mid-way between Pristine and Enterprise. Semi-dwarf (G.202 rootstock 12-15')

**'Enterprise' Apple** (needs a pollinizer)

A glossy red apple with an excellent spritely flavor that improves with storage. The tree is productive, vigorous and spreading. Fruit ripens about October 10. It is an excellent keeper and is immune to scab and resistant to fire blight, cedar apple rust and mildew. Semi-dwarf (M7 rootstock 12-15')

**'Winecrisp' Apple** (needs a pollinizer)

A PRI (Purdue, Rutgers, and Illinois Universities) selection that features excellent disease resistance to scab and fire blight. Ripens to a deep red in mid-October. Flavor is sweet, juicy and crisp. An excellent keeper, storing up to 8 months. Semi-dwarf (M7 rootstock 12-15')

Kansas City Community Gardens 6917 Kensington Kansas City, MO 64132 816-931-3877 [www.kccg.org](http://www.kccg.org)

### Cherry:

#### **'Black Gold' Cherry** (no pollinizer needed) (On Krmysk5 rootstock 12-15')

Late blooming, disease resistant sweet cherry that has a better chance of missing spring frosts. This variety is self-pollinating and fruits are large, deep red and crack resistant. Ripens mid-June. Needs well-drained soil.

#### **'Danube' Cherry** (no pollinizer needed) (On Mazzard rootstock 10-15')

A selection from Hungary, where delicious cherries have been grown for centuries. The dark red fruit has a wonderful sweet/tart unique flavor. It is a cross of the sweet and tart cherry. It is delicious eaten fresh or in baked goods. It is self fertile and productive and ripens in early July.

#### **'Montmorency' Cherry** (no pollinizer needed) (On Mazzard rootstock 12-15')

An old standard pie cherry (sour) variety with bright red skin on yellow fruit and clear juice. The Montmorency is upright, vigorous and a heavy producer. This cultivar is more productive than others and the fruit has a long ripening season (from late June to early July).

### Asian Pear:

#### **'Chojuro' Asian Pear** (needs a pollinizer) (OHx333 rootstock 10-12')

Round shape fruits, ripening to a russet orange in September. Flavor once fully ripe is incredibly sweet like butterscotch with a wonderful crisp texture. Medium storage life to 4 months.

#### **'Korean Giant' Asian Pear** (needs a pollinizer) (Betufoia rootstock 15-18')

One of the largest Asian pears sometimes weighing 1lb per or more. Ripens to russet orange in mid-October. Long storage life to 6 months.

#### **'Seuri' Asian Pear** (needs a pollinizer) (OHxF 97 rootstock 15-18')

Round fruits ripen to a russet-yellow. Flavor is sweet and floral. Ripens in late September, with a storage life of 1 month. Fire blight resistant.

#### **'Shinko' Asian Pear** (needs a pollinizer) (OHxF 97 rootstock 15-18')

Round fruits ripen to a russet brown in late September. Fruits are sweet, juicy and crisp with a storage life of 3-4 months. Highly fire blight resistant.

### Pear:

#### **'Harrow Delight' Pear** (needs a pollinizer) (OHx333 rootstock 15')

Excellent blight resistance. This high-quality, early August ripening, fresh-market variety produces medium fruit resembling Bartlett in appearance. Red blushed yellow skin covers a fruit with excellent flavor and smooth flesh.

#### **'Potomac' Pear** (needs a pollinizer) (OHxF 87/97 rootstock 15-18')

A crisp sweet pear ripening to a light green in early September. Excellent fire blight resistance. Two month storage.

#### **'Sunrise' Pear** (needs a pollinizer) (OHxF 87 12-15')

A fragrant, sweet, juicy pear ripening to a red blush in mid-August. Excellent fire blight resistance. Stores two months.

**Peach:**

**'Contender' Peach** (self-pollenating) (Redleaf rootstock 15-20')

This hardy, late-blooming peach escapes late spring frosts. Beautiful, large freestone fruit is firm, sweet and delicious. Good for fresh use, freezing or for pies. Ripens in mid-August

**'Harrow Diamond' Peach** (self-pollenating) (Redleaf rootstock 15-20')

This selection is the first peach to ripen in our area. Blooms are late enough to avoid frosts and are very cold tolerant. Skin blushes red, flesh is yellow and freestone. Resistant to bacterial spot. Ripens in early July

**Other: Asparagus 'Jersey Knight'** This all male hybrid variety produces thick, tender, tasty spears. Highly tolerant to Fusarium, Crown and Root Rot. More tolerant of heavy clay soils than standard varieties.



Name: \_\_\_\_\_

Address: \_\_\_\_\_

Phone Number: \_\_\_\_\_

E-mail: \_\_\_\_\_

## Berry Plants and Fruit Trees Order Form - 2014

**DEADLINE TO PLACE YOUR ORDER: Friday, Mar. 14<sup>th</sup>, End of Business.**

Item	Green Card Member Price	Yellow Card Member Price	Non-Member Price	Quantity	Total
<b>Berry Plants</b>					
'Cavendish' strawberry	\$2.50 per bundle of 10	\$2.50 per bundle of 10	\$4.00 per bundle of 10		
'Eversweet' strawberry	\$4.00 per bundle of 10	\$4.00 per bundle of 10	\$5.00 per bundle of 10		
'Natchez' thornless blackberry	\$3.50 each	\$3.50 each	\$5.00 each		
'Heritage' fall-bearing raspberry	\$2.50 each	\$2.50 each	\$4.00 each		
<b>Fruit Trees</b>					
'Enterprise' apple	\$20.00 each	\$30.00 each	\$40.00 each		
'Liberty' apple	\$20.00 each	\$30.00 each	\$40.00 each		
'Pristine' apple	\$20.00 each	\$30.00 each	\$40.00 each		
'Winecrisp' apple	\$20.00 each	\$30.00 each	\$40.00 each		
'Black Gold' sweet cherry	\$20.00 each	\$30.00 each	\$40.00 each		
'Danube' cherry	\$20.00 each	\$30.00 each	\$40.00 each		
'Montmorency' cherry	\$20.00 each	\$30.00 each	\$40.00 each		
'Chojuro' Asian pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Korean Giant' Asian pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Seuri' Asian pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Shinko' Asian pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Harrow Delight' pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Potomac' pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Sunrise' pear	\$20.00 each	\$30.00 each	\$40.00 each		
'Contender' peach	\$20.00 each	\$30.00 each	\$40.00 each		
'Harrow Diamond' peach	\$20.00 each	\$30.00 each	\$40.00 each		
<b>Other</b>					
'Jersey Knight' Asparagus	\$1.00 each	\$1.00 each	\$2.00 each		
<b>GRAND TOTAL</b>					

**All orders must be accompanied by cash, check or money order.**

Kansas City Community Gardens 6917 Kensington Kansas City, MO 64132 816-931-3877 [www.kccg.org](http://www.kccg.org)

In the future, KCCG plans to map the location of fruit trees. Check here if you prefer your trees NOT be included in this map.

For KCCG Use Only: _____SYG	_____CPG	_____GG	_____YG
_____ Paid In Advance	_____ To Be Invoiced (Group Gardens Only)		
Picked Up By: _____	Date: _____		

## Kansas City Community Gardens Summer 2014 Workshop Schedule

*All workshops are approximately 1.5 hours. Workshop space is limited. Please Call 816-931-3877 to register.*

### **Swope Park Workshops: 6917 Kensington Kansas City, MO 64132 (in Swope Park by the KC Zoo)**

<b>May</b>	<b>2</b>	Friday	12:00pm	Insects in the Garden
	<b>16</b>	Friday	12:00pm	Dealing with Animal Pests
<b>June</b>	<b>6</b>	Friday	12:00pm	Freezing your Harvest
	<b>7</b>	Saturday	10:00am	Gardening with your Family
<b>July</b>	<b>18</b>	Friday	12:00pm	Fall Gardening
	<b>25</b>	Friday	12:00pm	Cooking: Summer
<b>August</b>	<b>22</b>	Friday	12:00pm	Extending the Season
	<b>29</b>	Friday	12:00pm	Cooking: Summer

### **Independence Workshops: Independence Health Department, 515 S. Liberty St. Independence, MO 64050**

<b>June</b>	<b>16</b>	Monday	6:00pm	Insects in the Garden
<b>July</b>	<b>21</b>	Monday	6:00pm	Fall Gardening and Extending the Season

### **Kansas City, KS Workshops: Bethany Park Community Center, 1120 Central Ave. Kansas City, KS 66102**

<b>April</b>	<b>28</b>	Monday	6:00pm	Growing Tomatoes, Peppers and Sweet Potatoes
<b>May</b>	<b>5</b>	Monday	6:00pm	Cooking: Spring
<b>July</b>	<b>28</b>	Monday	6:00pm	Fall Gardening and Extending the Season
<b>August</b>	<b>18</b>	Monday	6:00pm	Cooking: Summer

### **Kansas City, KS Workshops: Rosedale Development Association, 1403 Southwest Blvd. Kansas City, KS 66103**

<b>May</b>	<b>6</b>	Tuesday	6:00pm	Spring Harvesting and Growing and Cooking with Herbs
<b>August</b>	<b>12</b>	Tuesday	6:00pm	Fall Gardening and Extending the Season

### **Ivanhoe Community Center Workshops: 3700 Woodland Kansas City, MO 64109**

<b>May</b>	<b>13</b>	Tuesday	5:30pm	Growing and Cooking with Herbs
<b>August</b>	<b>12</b>	Tuesday	5:30pm	Fall Gardening and Extending the Season

### **Get Growing Workshop: Kansas City Community Gardens, 6917 Kensington Kansas City, MO 64132**

<b>July</b>	<b>10</b>	Thursday	6:00pm	Get Growing: Water
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Kansas City Community Gardens 6917 Kensington Ave. KC, MO 64132 (816) 931-3877 [www.kccg.org](http://www.kccg.org)

## Workshop Descriptions:

**Cooking- Spring:** Everyone knows greens are good for you, but not everyone knows how to prepare them. Come learn some easy and delicious recipes. You will also learn how to put together simple salad dressings. We will focus on whatever produce is ready to harvest.

**Cooking- Summer:** Come learn how to prepare the beautiful, fresh produce that you have harvested from your garden. Don't know what to do with Swiss chard? Have zucchini coming out of your ears? No problem. Come sample some creative and healthy veggie recipes featuring summer's bounty.

**Dealing with Animal Pests:** How do I keep the squirrels out of my tomatoes? Although there is no sure-fire solution to this problem, this workshop will discuss common animal nuisances and talk about different ways to deter them from your garden.

**Extending the Garden Season:** Harvest from your garden through the fall and into the winter. This workshop will discuss season-extension techniques, such as row covers and cold frames. We will also discuss how to get your garden started earlier in the spring.

**Fall Gardening:** Plant in July and August for a fall garden! Learn the details of what and when to plant for a successful fall harvest.

**Freezing your Harvest:** Join us in this demonstration workshop as we explore the craft of preserving your garden-fresh produce. We'll focus on freezing - one of the easiest and most timely preservation methods.

**Gardening with your Family:** Bring your family to this hands-on workshop featuring easy gardening methods that involve every member of the family. Share the time-honored life-skill of gardening with your family as we look at basic gardening tasks and provide fun ideas for engaging everyone. We will talk about starting your home garden, fun seeds and plants for children and recipes from the garden that everyone will enjoy.

**Get Growing- Water:** Water is essential for healthy productive crops. Come see the different ways farmers and gardeners are accessing water throughout the city. We will talk about rain water catchment systems, water meters, and water conservation.

**Growing and Cooking with Herbs:** Fresh herbs are a tasty addition to your cooking. Learn the best ways to grow and preserve the most popular varieties. We will cook with several easy to grow herbs. Bring your appetite!

**Growing Tomatoes, Peppers and Sweet Potatoes:** Are you overwhelmed by the number of tomato varieties available? Are you confused about heirloom tomatoes? Do your pepper plants not produce as many peppers as you would like? Are you disappointed when you dig up your sweet potatoes? Come learn how to select, plant and care for tomatoes, peppers and sweet potatoes.

**Insects in the Garden:** Do you ever wonder whether the insects in your garden are helping or harming your plants? Learn about the common insects found in our area so that you can identify garden pests as well as the beneficial insects. We will also discuss how to control problem insects.

Kansas City Community Gardens 6917 Kensington Ave. KC, MO 64132 (816) 931-3877 [www.kccg.org](http://www.kccg.org)

# THE KANSAS CITY STAR.

## NEWS

KANSASCITY.COM

SATURDAY, SEPTEMBER 14, 2013

**LOCAL FOOD** | Number of urban gardeners blossoms

### KC harvests a crop of gardens

■ **Community plots, urban farms mean vegetables for schools, churches, individuals.**

BY LYNN HORSLEY  
The Kansas City Star

As Ben Sharda, director of Kansas City Community Gardens, surveys this month's bountiful harvest at the Swope Park headquarters garden, he can't help but celebrate a different bumper crop.

He is witnessing the blossoming of community gardens themselves throughout the metro area. From schools to churches to neighborhood groups to high-powered corporations, everyone is getting into the act.

The organization's community garden partnerships have jumped from 125 three years ago to 230 this year, and the schoolyard gardens from 88 to 140 over that same period. Most are in Kansas City, but dozens are in Wyandotte and Johnson counties and other suburbs.

"There's been an explosion of interest," he said.

The same is true for area urban farms, defined as growers who sell their produce or use farm production methods. Katherine Kelly, executive director of Cultivate Kansas City, which assists urban farms throughout the area, has seen those numbers jump from about 74 farms in 2008 to 125 this year, about evenly split between Wyandotte and Jackson counties.

"It's exciting," she said. "There's demand from consumers. There is land available. There are people aware that farming is an entrepreneurial activity or just is something that's good for your family."

It's all being driven by several factors. An appetite for more local, fresh, healthy food. The push to fill weedy vacant lots and turn cheap land into productive use. And don't discount Michelle Obama and the example of the White House kitchen



DAVID EULITT | THE KANSAS CITY STAR

George Batts (left) picked peppers with James Antwine at Kansas City Community Gardens, 6917 Kensington Ave., across from Swope Park. Batts, 92, grows corn, tomatoes, peppers and okra in his garden.

**"We were blessed with a great harvest. It's turned out to be a lot of fun."**

DIONNE POWELL-GREEN AT OAK GROVE  
MISSIONARY BAPTIST CHURCH

garden. To get on a community garden waiting list or for more information, call 816-931-3877 or go to [www.kccg.org](http://www.kccg.org).

"I've been asked once or twice if I knew Michelle Obama," said MaryAnna Henggeler, who has been inundated with requests as manager of Kansas City Community Gardens' schoolyard program. "It's getting fit and going local."

#### CULTIVATING COMMUNITY

Many of the newest gardens fill a void and a craving:

**Fresh veggies.** Dionne Powell-Green helps cook dinner every Monday for the youth group at Oak Grove Missionary Baptist Church, 4545 Benton Blvd. She

wanted to supplement the small food budget, so she got help from KCCG to create a church garden. She and five kids were the gardeners, and now the congregation is savoring tomatoes, peppers and potatoes. Next year she plans more vegetables and some fruit.

"We were blessed with a great harvest," she said. "It's turned out to be a lot of fun."

**Neighborhood oasis.** Joy Snyder, longtime volunteer with Hope Faith Ministries, which assists homeless people, wanted to transform a crime-plagued vacant lot next to three transitional houses just east of Eighth Street and Troost Avenue. This spring, students from William Jewell College and other volunteers turned it into a beautiful garden, complete with a fountain donated by the Water Garden Society of Greater Kansas City.

The 24 raised beds have produced an abundant harvest of tomatoes, corn, peppers, all kinds of greens, strawber-

ries, broccoli, radishes and other goodies. Neighborhood children and other residents have learned how to prepare the produce in on-site cooking classes.

It's become a community gathering spot.

"I would call it an outreach of ministry," Snyder said.

**Educational accomplishment.** Mia Monarca, who works with about 100 Garcia Elementary School students in the before- and after-school program, started four raised beds with the students this spring, and they added more plantings a few weeks ago. She said the kids love the fresh salads they grow and the sky-high sunflowers. And they get something more.

"I think it's nice for kids to be able to see hard work pay off," she said.

Kansas City municipal officials and philanthropic organizations have taken note and are working closely with Sharda and Kelly on their endeavors. Kansas City's funding for community gardens has more than doubled this year from \$35,000 to \$78,000 and the city is making urban agriculture a priority, said assistant city manager Kimiko Gilmore.

#### NATIONAL MOVEMENT

It's a national trend, but one in which Kansas City is catching up to other cities. When Sharda attended a national 2012 community gardening conference in San Francisco, he felt Kansas City could hold its own against many West Coast cities.

"I'd say we are competitive right now with other top cities as far as the number of community gardens and the (large) size of community gardens we have," he said.

One feature that distinguishes Kansas City's program nationally, Sharda said, is that in addition to community gardens, it works with more than 1,000 low-income families on backyard or vacant lot gardens, teaching them how to supplement their budgets and pantries with home-grown food.

In addition to advising aspiring urban farmers and working on local government policies, the Cultivate Kansas City program has several working farms in Wyandotte County that train refugee families and others to operate their own farm businesses, Kelly said.

University of Wisconsin associate professor Alfonso Morales, who tracks urban agriculture nationally, said Kansas



DAVID EULITT | THE KANSAS CITY STAR

The Kansas City Community Gardens across from Swope Park feature plots of land and planters for volunteers to grow vegetables. Go to [KansasCity.com](http://KansasCity.com) for a photo gallery.

City is ahead of the game "in the sense that the community-based organizations are terrific and creating many opportunities across the spectrum of urban agricultural activities."

But he said Kansas City could do more in terms of governments crafting regulations and incentive programs to promote urban agriculture.

Gilmore said that's starting to happen and Kansas City's next challenge is to move beyond a lot of "hobby gardens" to create more agricultural businesses with a bigger economic effect.

Advocates see more promising developments in the near future.

Sharda says six more gardens should soon be in place in Kansas City. A large community garden will be installed this fall in Northrup Park — marking the first time Wyandotte County has offered parkland for a community garden.

Another new KCCG initiative involves planting hundreds of fruit trees throughout the metro area.

Kelly and Gilmore are most excited about the commercial ventures coming on board to provide local produce year-round and reduce the reliance on food from California and Mexico.

"What's happening now, I think, is we're starting to see more ambitious growers," Kelly said.

She cites the example of BrightFarms, a New York company that plans a \$4 million hydroponic farm on 5 acres next to Berkley Riverfront Park, intended to grow 1 million pounds of fresh vegeta-

bles annually. Bright-Farms had hoped to break ground this year, but that has been delayed.

Marketing manager Kate Siskel said the company still is negotiating to get its produce into local grocery stores and hopes to complete construction next year.

"The momentum, that's what attracted us to Kansas City," she said.

Other greenhouse and educational farming initiatives are in the works for Kansas City's municipal farm property, a 400-acre site east and west of Interstate 435, southwest of the Truman Sports Complex.

And developer Adam Jones is close to opening a large West Bottoms greenhouse operation to supply restaurants, in collaboration with Goode Acres farm.

"It would be year-round produce," he said. "We have more demand than supply."

For gardeners who gathered recently at the Swope Park community garden, there's no downside to this movement toward more homegrown food.

As 92-year-old George Batts said while he filled big bags to overflowing, nothing can compare with a tomato fresh off the vine.

Community gardening creates lasting friendships and keeps him active and feeling young.

"This is the best thing in the world to be in," he said.

To reach Lynn Horsley, call 816-226-2058 or send email to [lhorsley@kcstar.com](mailto:lhorsley@kcstar.com).

## **Project 6: Increasing the Competiveness of Missouri Grown Specialty Cut Flowers for Major Holiday Markets**

### **Urban Buds: City Grown Flowers**

Miranda Duschack and Karen Davis

Final Performance Report

### **Project Summary**

This project was essential to our success as small farmers. It enabled us to determine that early spring anemone, ranunculus, poppies, digitalis, tulips, stock, snapdragons, rudbeckia, summer lisianthus, summer tuberose, and early fall celosia are the best mix of flowers for production and profitability within a high tunnel; these finds were made all while making an income off these flowers to reinvest in the farm. These flowers were highly desired by area florists, farmers' market customers, and brides because they were available for the spring holidays, especially Easter, the spring bridal season, early farmers' markets and Mother's Day, and at time when local flowers are not available in St Louis. The early flowers were vital money makers during March, April, May, and early June—if we were exclusively growing flowers in the field without season extension tools we would not be in the marketplace until mid-June. The income from the high tunnel flowers enabled us to start our season without taking production loans to meet the spring expenses and payroll.

This project was critical in expanding local cut-flower production in the St. Louis area. High Tunnel production enabled our operation to offer blooms to our customers earlier and later in the season than we would have been able to do with only field grown flowers. The St Louis flower market was void of early and late season flowers and this project enabled us to meet that market need. The high quality and long lasting high tunnel crops encouraged customers to purchase more local cut-flowers during extended seasons.

The locally grown vegetable movement is alive and well in St Louis and the nation as a whole, however locally grown flowers are still a rarity in most parts of the country, and specifically in the St Louis region, and so the conditions were right for us to fill this niche with high tunnel grown product. We've noticed that in past five years of sales that customers have become more conscious of the environmental and social impact of purchasing imported flowers and are eager to purchase locally grown products grown using sustainable practices. Promotions such as the Slow Flowers Movement and American Grown Flowers labeling initiative are capitalizing on consumers' desires to buy local and/or US grown flowers. Additionally, wide reaching social media has driven the market demand for locally grown, seasonal flowers. Our florists inform their clients that they use locally grown product and customers ask for Urban Buds flowers by name.

This project did not build upon a previously awarded Specialty Crop Block Grant awarded to Urban Buds.

### **Project Approach**

We approached this project by focusing on extending the local cut flower availability on both ends of the growing season, earlier in spring and later in the fall. However, we learned that we

would really need two high tunnels because planting for the early spring harvest happens ideally in early and mid-October. If we cleared the beds for the October planting we would miss out on Thanksgiving sales. Our approach changed once we learned this lesson and we decided to focus on the early spring sales instead of the last fall sales because the appetite for fresh, locally grown flowers is greater in the spring and we need the money much more in the spring. Ideally we would have two separate high tunnels in production.

**Work Accomplished During the Grant Period:** On November 7, 2014 the major construction on our high tunnel was completed. Norman Kilmer of Morgan County Seed Company returned on January 20, 2015 to install the motor for the sidewalls. We finished making the raised bed shapes with the heavy walk behind rotary tine tiller, and prepared the beds with a two inch layer of finished compost tilled on November 16, 2015. Landscape fabric was laid down on the beds and holes were burned into it on November 17. We also laid a foot of landscape fabric as a weed barrier next to the side walls; the beds against the sidewalls are planted one foot from the baseboard, this is to prevent flooding from the runoff rainwater from the roof of the high tunnel. We started planting the beds on November 19, 2014, and we began harvesting the first high tunnel crop, anemone, on January 21, 2015. The heavy high tunnel ranunculus crop was harvested in earnest beginning April 22, 2015. The dates are similar in 2016. Poppies, digitalis, tulips, stock, snapdragons, rudbeckia, late spring tuberose, summer lisianthus, and early fall celosia.

Beds and flowers were maintained through fertilization, spraying, weeding, and harvesting as need. In the winter months daily attention was given to removing the Remay cloth during the warmer daylight hours and then putting them back on during the cool nights. Throughout the grant cycle we experienced successful weed control in the high tunnel through the use of landscape fabric, mulching the aisles and regular hand weeding, however we noticed that bindweed is established in the southeast corner of the high tunnel and this will require rigorous attention to prevent it from spreading. We remain committed to following organic farming practices. Plants were caged to encourage the development of straight stems. We used a new caging system on the farm for this project; concrete wire mesh is cut and bent on the sides at right angles to create a foot high cage that is 4' x 10'. Each bed was fully caged and this caging system did indeed prevent the stems from falling over as the plants grew. This was large expense, but we believe it is worth the investment as the cages will be used for years to come.

It was our intent to share these outcomes with Missouri, Midwest and national cut flower growers, and we did at various conferences, workshops and field days. *Please see below under "Goals and Outcomes Achieved."*

### **Goals and Outcomes Achieved**

#### **1) Completion of cut flower variety trials to determine the best varieties and crop mixes for efficient production within a high tunnel for central Missouri.**

We determined that early spring anemone, ranunculus, poppies, digitalis, tulips, stock, snapdragons, rudbeckia, late spring tuberose, summer lisianthus, and early fall celosia are the best mix of flowers for production and profitability within a high tunnel. The best producer and highest income earner was lisianthus, which grossed \$4,000 in 2015 and \$4,200 in 2016. Lisianthus, or "poor-man's rose" looks very similar to rose, but is without fragrance and is long lasting, about two weeks in a vase. It is a favorite for wedding work with the florists, and the high tunnel lisianthus grows especially tall, multi-branching stems that are prized by designers. Lisianthus is a high earner; however the purchased plugs are expensive. Our second highest

earner was ranunculus, with a gross income of \$2,300 in 2015, and \$2,600 in 2016. The ranunculus flower can last three weeks in a vase and is prized by florist and brides for its beauty. There is great potential for Missouri growers to sell ranunculus. That said, ranunculus corms are expensive to purchase and the pre-sprouting treatment can be confusing growers. Because we followed the planting and harvest schedule outlined in the grant proposal, Urban Buds increased our FY2015 gross income by \$11,930. The high tunnel flowers increased our April-August 2016 gross income by \$13,610.

Dahlias were perhaps our biggest failure of the grant project! We high hopes for the our early dahlia crop, however it was too hot in the high tunnel for optimal growth, the plants theses were susceptible to powdery mildew, spider mites, and white fly. We may try again will dahlias, but at wider spacing to improve air circulation and ease of spraying.

Anemone:

2015: Planted 903, 120 ten stem bunches harvested and sold. GROSS: \$1,200

2016: Planted 500, 102 ten stem bunches harvest and sold. GROSS: \$1,026.50

Ranunculus:

2015: Planted 660, 166 ten stem bunches harvested and sold. GROSS: \$2,324

2016: Planted 1,594, 195 ten stem bunches harvested and sold GROSS: \$2,925

Poppies:

2015: Planted 452, crop damaged, destroyed by mice!

2016: Planted 900, 78 bunches harvested and sold, GROSS: \$975

Digitalis:

2015: Planted 106, crop failure!

2016: Planted 200, 59 bunches harvested and sold, GROSS: \$708

Delphinium:

2015: 75 transplants; planted out 12/14/14 (CROP FAILURE, too cold—should have planted it in February 2015)

2016: 75 transplants, 60 stems harvested and sold, GROSS: \$220

Tulips:

2015: 0

2016: Planted 997, 130 bunches harvested and sold, GROSS: \$1,857.50

Stock:

2015: Planted 480, 46 ten stem bunches harvested and sold. GROSS: \$552

2016: Planted 700, 63 ten stem bunches harvested and sold. GROSS: \$630

Snapdragons:

2015: 0

2016: Planted 1,152, 110 ten stem bunches harvested and sold. GROSS: \$1,358.50

Rudbeckia:

2015: Planted 265; 234 ten stem bunches harvested and sold. GROSS: \$2,340

2016: Planted 200, 157 ten stem bunches harvested and sold. GROSS: \$1,256

Tuberose:

2015: 0

2016: Planted 200; 190 stems harvested and sold. GROSS: \$460

Lisianthus:

2015: Planted 768; 252 5-7 stem bunches harvested and sold. GROSS: \$4,032

2016: Planted 900; 288 5-7 stem bunches harvested and sold. GROSS: \$4,413

Celosia:

2015: Planted 1720; 476 ten stem bunches harvested and sold. GROSS: \$5,236

2016: Planted 1140; 390 ten stem bunches harvested and sold. GROSS: \$2,920

Dahlias: 2015: 120 tubers planted; 240 stems harvested and sold. GROSS: \$408

2016: 200 tuber planted, 250 stems harvested and sold. GROSS: \$610

*See below under "Lessons Learned" for additional recommendations and the lessons that we learned*

## **2) Field days and other outreach efforts to transfer the technology and information generated by the trials directly to producers.**

We shared our findings with Missouri cut flower growers and vegetable farmers at national and regional conferences and workshops including the Association of Specialty Cut Flowers Growers Annual Conference Wilmington Delaware 2015, Missouri Organic Association Annual Conference 2014 & 2015, Great Plains Growers Conference Cut Flower Track 2014 & 2015, Grow Your Farm University of Missouri-Extension Jefferson County 2014 & 2015, Master Gardeners University of Missouri-Extension Kansas City 2014 & 2015. We also presented at a SARE Sponsored In-Service Education: Lincoln University Cooperative Extension High Tunnel Production Workshop, April 1, 2015. Topic: Season Extension of Cut Flowers Using the High Tunnel. LUCE, MUE, NRCS faculty, staff and a few area farmers were in attendance; thirty people total attended.

On January 29, 2015 the internet reality TV show Bloomtown about the horticulture industry in St Louis was released. Episodes featuring Urban Buds exclusively were released on March 27 and again on April 9th. The episodes can be viewed at: [www.bloomtown.tv](http://www.bloomtown.tv) February 9, 2015 we were interviewed for the KDHX 88.1 FM environmental show, "Earthworms" and spoke about the SCBG and our efforts to extend the season.

We hosted five on farm field days/tours 2014 & 2015. One tour on November 4, 2015 featured the Association of Specialty Cut Flower Growers board members, fifteen farmers, one Extension educator/researcher (listed in our grant as an advisor), and one representative of Ednie Bulb Company. Most of these farmers are rural growers and are inexperienced with urban farming and it's possibly of high production. The visitors expressed surprise and delight at our success. Our high tunnel production and the SCBGP were featured.

Approximately 500 specialty crop farmers heard our presentations and/or attended a farm field day. Our article in the Association of Specialty Cut Flower Growers quarterly trade publication, "The Quarterly" has a distribution of 950 farm business and growers. The farmers benefited most from our variety recommendation and planting schedule to meet early season demand. The potential economic impact of the project is hard to quantify, however we do know that because of our mentorship that one farmer significantly increased her gross income because of

cut flower sales, however we are not at liberty to share the specific numbers in this report, however she is pleased with income increase enough to keep growing flowers.

*See below under “Lessons Learned” for additional recommendations and the lessons that we learned.*

### **Beneficiaries**

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### **Lessons Learned**

**IMPORTANT LESSON LEARNED:** A killing frost did not hit our area until November 21, 2015. The USDA average frost date for our area is October 15. This extra month allowed us to hit Thanksgiving Day sales, but it also put us in a bottleneck as we were still harvesting crops into mid-November and this prevented us from pulling plants and preparing the beds for planting the ranunculus and anemone for the targeted 2016 Valentine’s Day sales. **In our estimation one cannot hit both Thanksgiving Day sales and Valentine’s Day sales out of the same high tunnel when there is such a late frost. Because of this unanticipated bottleneck and our decision to continue cutting flowers for Thanksgiving Day we did not plant the ranunculus and anemone in time to hit Valentine’s Day sales for 2016.**

NOTE: All flowers for our Thanksgiving farmers’ market, November 21, 2015 and our final delivery for the season on November 24, 2015 came out the high tunnel. We could not have hit this without the high tunnel.

**IMPORTANT GROWING PRACTICE:** During very cold periods Remy must be placed over the planted beds to prevent the frost from killing the plants.

**RECOMMENDATION:** We laid a foot of landscape fabric as a weed barrier next to the side walls; the beds against the sidewalls are planted one foot from the baseboard, this is to prevent flooding from the runoff rainwater from the roof of the high tunnel. It is important that any weeds are kept from growing by the sidewalls.

**RECOMMENDATION:** For dianthus and digitalis plants to grow tall, marketable stems the plants must go through a period cold stratification. They should be planted in the early fall and overwintered as green plants approximately two inches tall.

**RECOMMENDATION:** Damage from mice was extreme in 2015, but in 2016 we had a farm cat to control the mouse population with success. This cat was key in controlling the mice, which overwinter in the high tunnel and devour the tender green foliage of our plants.

**Varieties that do not make enough money to warrant the high tunnel growing space:**

Dahlias, perhaps our biggest failure of the grant project! We high hopes for the our early dahlia crop, however it was too hot in the high tunnel for optimal growth, the plants theses were susceptible to powdery mildew, spider mites, and white fly. We may try again will dahlias, but at wider spacing to improve air circulation and ease of spraying.

Sunflowers are not worth the space, it is best to avoid crops that are “one cut and done.” The best money makers are those that are “cut and come again.”

**Important physical characteristic of high tunnel:** Motorized sidewalls are vital for high tunnel cut flowers production in Missouri because of the dramatic shifts in the air temperature throughout early springs days in Missouri. There were days when the sidewalls would raise and lower six times. It would be a hardship to a farmer attempting to raise and lower the sidewalls manually as much as it requires maintaining optimal growing temperature within the greenhouse.

**WATERING RECOMMENDATION:** We have determined that we get optimal watering efficiency when we run four lines of drip irrigation in a four foot wide bed with an emitter spacing of 8” apart. This is up from our initial 3 lines with 12” emitter spacing in 2015. Because of mice and employee damage to the lines throughout the season, we replace out drip lines with new tape each year.

Winter Watering: Water when air temperature outside the tunnel is above 40 degrees F for a period of 8 hours to prevent cold damage. Unhook hoses after watering to prevent freezing, but flushing the drip tape lines in not necessary, they drain well on their own.

Spring Watering: Be careful of overwatering! Corms will rot in the ground. Water less frequently, but for a longer time so it soaks in the soil; the next watering should be when your feel soil moisture at the two inch point.

Summer Watering: A timer would be helpful because watering is more frequent, such as 40 minutes every other day to prevent wilting crops and soil dry out. Keep on it! As the old saying goes, “A farmer’s cheapest fertilizer is water!”

Fall Watering: Starting in October begin to water less frequently and deeper.

**INSECT PEST DAMAGE:** White fly and spider mites were our most abundant and tenacious pests. It was important to keep on a strict spray schedule. We alternately sprayed: Pyganic, Triact 70

**USE OF PLASTIC MULCH:** We had success growing in plastic that is white on the front and black on the back; the white plastic faced up in the high tunnel. This is a change from planting exclusively into black landscape fabric. The white plastic kept the plants cool longer and we extended the quality of the ranunculus harvested in the spring and extended the lisanthus harvest in the summer.

**Contact Person**

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### **Additional Information**

None.

## **Project 7: Establishment of Grape Industry Analysis Lab and Related Outreach**

### **University of Missouri, Grape and Wine Institute**

Dr. Misha T. Kwasniewski

Final Performance Report

### **Project Summary**

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Extensive analytical data is necessary to make good harvest and management decisions for the cultivation of wine grapes. Due to the diversity of production practices and climate/soil conditions within the state of Missouri, data must be obtained for individual sites and cultivars to have an accurate representation across the state. Unlike many crops where processing from individual small farms may take place at large centralized facility, wine grape and wine production tends to be conducted by smaller producers and processing facilities (wineries). These smaller operations typically do not have the resources or capacity to provide all the analytical resources needed to make good decisions and even those that do may benefit from additional extension support. As there was no in-state laboratory for wine grape growers to obtain advanced chemical analysis of their fruit, the industry was forced to either pay high prices for out-of-state analysis, that will have a slow turn around with no regional support, or to proceed without the valuable information. This lack of basic information can reduce the quality of the fruit produced and subsequently the wine produced from this fruit. With the initiation of basic analytical testing at the Grape and Wine Institute, timely information for harvest and management decision was provided for the growers. We were also able to use this information for tracking potential issues to prioritize our research and extension objectives to support the Missouri wine grape industry. Adopting a model used by a number of other states, the program plays a similar role that a soil analysis lab plays, in offering farmers detailed recommendations from chemical data, only with the focus on wine-grape fruit and juice chemistry. Beginning in the fall of 2013 this service was offered on a limited basis and expanded in 2014 with the installation of equipment provided through this grant. Also beginning in 2013 this service was used as a basis to for a series of publications and outreach briefs on utilizing advanced chemical analysis to inform industry decisions. This work was also presented at the 2014 Midwest Grape and Wine conference.

While part of this program's objective was to provide wine grape producers with timely access to necessary data it also offered those of us tasked with devising research and support objectives with essential information to continue the success of the industry. In addition to individual reports, data was also recorded anonymously on the county level for samples that are processed through the lab to construct a database of observed values of critical chemical parameters. As chemical information can provide evidence of viticultural, disease or other issues we then could use that information to diagnose problems within the industry and focus research and education at the Grape in Wine institute (GWI) appropriately. Without information

such as organic acid content, the concentrations of specific sugars, anthocyanins (pigment) and yeast available nitrogen, growers and processors are frequently forced to make harvest and management decisions without necessary information. For instance, low yeast available nitrogen (YAN) can cause problems during fermentation and often can be traced back to improper soil nutrition. Building off resources at GWI the service has already analyzed over 540 samples as of November 2014. Having the necessary equipment in place this service will continue as part of GWI operations.

This project was not built on a previously funded SCBGP project.

## **Project Approach**

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While the rollout of the project was delayed, ultimately the proposed work could be achieved. The first step in this projects work plan was to offer organic acid and YAN quantification for 500 samples in 2013. While this goal was not met in 2013 due to delays in installing equipment and advertising the service, by 2014 over 600 samples had been measure for these parameters. Additionally other parameters not originally included in the proposal were able to be included, such as total anthocyanin content, soluble solid content and tannin concentrations. Results from these findings indicate that of those sampled >5% of samples would be considered of low quality, or “faulted”. This is lower than our initial expected benchmark, but represents a substantial portion of this specialty crop area that warrants improvement. These results were presented at the 2014 Midwest Grape and Wine Conference in St Charles, MO along with best practices to improve quality moving forward. Ultimately the strength in this program comes from having an initial benchmark and then working to improve it. Now having a benchmark, members of GWI will continue to offer grape and wine analysis and use this information to inform project focuses. While it is impossible to make any determination of the overall program success interim of improvement of Missouri wine grape quality from one data point, the program has provided a point to discuss with over 50 producers. In extension and outreach one of the most challenging points is creating a forum for discussion, which has been achieved in situations, and with producers it had not in the past.

## **Goals and Outcomes Achieved**

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**Goal:** The goal of this project is to establish an in state analytical testing facility for Missouri wine grape growers and processors compliance with federal, state, and local quality compliance standards. This will be measured through evaluating the wine/juice provided to the Grape and Wine Institute to determine the percent of Missouri wine that meets these standards.

**Performance Measure:** The number of samples that do not meet basic quality or regulatory standards as determined by our analysis.

**Benchmark:** Preliminary results indicated that 80 percent of samples gathered met basic regulatory and sensory standards to not be considered “faulted.”

**Target:** Our target is to reduce faulted samples by 10 percent through this project, so that 90% of samples gathered to meet basic quality standards.

**Outcome:** We found that over 95% of the sample received where of acceptable quality by the metrics observed. However acetic acid levels in grapes and wine was found in access of acceptable level in 21 of the 623 samples analyzed. This represents a sizable portion of this

specialty crop that will be deemed as unacceptable and needs to be remedied for the continued growth of the Missouri wine grape industry.

### **Measurable Outcome 2:**

**Goal:** It is critical to the Missouri wine grape industry utilize the service provided as access to the information provided can help mitigate faulted products getting to the consumers. Even a small number of faulted wines can severely hurt the image of the industry and its economic prospect. As such, we aim to have a large portion of the industry participate in the project from the start; with the grape analytical service lab to be utilized by at least 30 producers, submitting at least 500 samples for analysis.

**Performance Measure:** The number producers participating and number of samples submitted.

**Benchmark:** In a preliminary project we were able to get 10 participants to submit 80 samples. Through communications by our extension agent with the industry we found that previously only two producers in the state consistently measured the chemical components offered through this project.

**Target:** Our target is to increase measurement of these critical chemical parameters by the Missouri wine grape industry to at least 30 participants submitting a total of 500 samples during this project.

**Outcome:** By the end of 2014 over 600 samples had been analyzed by 52 participants. Though we had originally hoped full rollout of the program would occur in 2013 this was delayed until the following season. Now having a large portion of the Missouri Wine grape industry familiar with our service it is expected that growth will continue in the 2015 season. Allowing us to track quality metrics for a larger portion of this sector in the future as well have more points of contact with stakeholders.

### **Beneficiaries**

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While those producing and purchasing wine grapes directly benefit from this service all related industry such as tourism, restaurants and distributors benefit through improved quality. The lab analyzed samples from 43 different producers. These producers were able to make harvest and processing decisions of from the data provided as well as when problems arose identify corrections for the future and avoid a faulted product going to market. The information generated has been disseminated to over 400 stakeholders through email and presentations. With the information obtained we have found that there is a small but important number of wines above legal limit for acetic acid (2% of those analyzed) as well as up to 6% that are above the concentration that would be considered "faulted." This sets a baseline for this problem as well has directed extension and research activities to minimize issues that may cause this problem in the vineyard and winery.

### **Lessons Learned**

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This project to offer analytical services to grape and wine producers was initially devised by the request of the industry members. However we all underestimated the time constraints of harvest and processing on everyone involved in the grape and wine industry. Despite being centrally located we found that industry members finding time to drop-off or mail samples was

the largest impediment to them utilizing this service. We quickly adjusted to this by bringing sample vials on extension visits, as well as, offering to periodically picking up samples on site.

While an additional cost, this offered an opportunity to develop industry relationships. Without a steady stream of samples it was a challenge to keep reagents fresh as well as to schedule time for analysis within our usual day-to-day activities. It was relatively easy to process a large number of samples over the course of a day but more difficult to analyze one unexpected sample without it taking too much time. As more team members were trained on preparing samples for analysis it became easier to adjust to the unpredictable workload of this service.

We have found that as an individual or business utilizes the service they are more likely to use it more extensively in the future. The hope is as the usage grows the sporadic nature of receiving samples will even out.

### **Contact Person**

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### **Additional Information**

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Example of Monthly Announcement sent to industry stake-holders.

## GRAPES! News for Wineries and Growers

MU Grape and Wine Institute sent by MU Grape and Wine Institute

Sent: Saturday, August 31, 2013 at 7:59 AM

To: Kwasniewski, Misha T.

[100byvineyard@gmail.com](mailto:100byvineyard@gmail.com)

*The Grape Exchange* is an email listing service where you may advertise your grapes and used equipment for sale or solicit for grapes or equipment that you'd like to purchase. During the harvest season, the listing will go out by email to vineyards and wineries in Missouri and surrounding states.

To place a listing, simply email [Grapes@missouri.edu](mailto:Grapes@missouri.edu) and include your name, phone number, town or county where your vineyard/winery is located, email address, and the tons, by variety, that you either wish to sell or purchase. For more information or to place a listing, please contact [grapes@missouri.edu](mailto:grapes@missouri.edu)

## Enology Service Lab

**The Grape & Wine Institute is now offering  
Organic Acids & YAN Testing Services!**

[Download and print a description and instructions from the Enology Service Lab here.](#)

[An "Analysis Request Form" is also available as a separate link & required for each sample submitted. The form is here & includes a price list.](#)

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You are receiving this email as a service from the Grape and Wine Institute (formerly the ICCVE) at the University of Missouri.

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The Grape and Wine Institute (ICCVE)  
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Extension Publication on Yeast available Nitrogen

### Enology News and Notes, Fall/Winter 2013-2014

#### Why, When, and How to Measure YAN

By managing fermentation, winemakers today have many options to enhance the varietal characteristics of their wines, and to express regional attributes. For instance, temperature is a management tool that affects the rate of fermentation; similarly the presence of grape solids enhance yeast survival. Very importantly, adequate nitrogen (N) is necessary for a successful fermentation.

Grapes contain a variety of nitrogenous compounds, the sum of which may be affected by viticultural practices. For instance, research has demonstrated that N concentration is 2X greater with application of foliar N and appropriate irrigation use than without foliar N and irrigation. Other research suggests that foliar N application around veraison appears to be an effective way of increasing N in the fruit, regardless of water-supply status of the vines. (5) Studies comparing varying crop levels (e.g. 100%, 70%, 40%) have concluded that N concentration was significantly higher in X% cluster thinned vines, given the vineyard conditions, at the latest maturity stage. (2) (4)

Yeasts metabolically adapt to their fermentation environment; such adaptation may have either positive or negative flavor implications. At the time of inoculation, yeasts are subjected to a range of stresses to which the cell must adapt in order to exploit its new environment. Some of the known stresses are osmotic pressure, oxidative conditions, sulfite toxicity and temperature shock. The concentration of nutrients, whether too great or too little, can induce stress and lead to different concentrations of flavor compounds. For instance, H<sub>2</sub>S formation is a well-known example related to *inadequate* nutrients leading to nitrogen depletion stress; H<sub>2</sub>S may also result from *excess* nutrient addition, as occurs when early DAP addition leads to increased biomass demanding more nutrients than available.

A common practice among winemakers is to make a standard addition of diammonium phosphate (DAP) to the juice or must (100-300 mg/L) at inoculation *without* measuring the nitrogen concentration. The objective of this article is to show that DAP addition has significant flavor (and ultimately, economic) consequences and that measuring the initial nitrogen concentration provides the opportunity to adjust DAP addition - not only to achieve an adequate fermentation rate, but also to more reliably guide the flavor profile and style of wine required.

### Definition and measurement of “YAN”

Grapes contain a variety of nitrogenous compounds of which the most important are the *primary* (alpha) amino acids, ammonium ions, and small peptides. Proline, a dominant *secondary* amino acid in many grape varieties, cannot be assimilated under anaerobic conditions, i.e. proline is not utilized by *S. cerevisiae*. The conversion of ammonium (NH<sup>4+</sup>) to nitrate (NO<sup>3-</sup>) is an important step in the soil nitrogen cycle, and results in nitrogen in the form most used by plants, i.e. nitrate. These three nitrogenous compounds - amino acids (excluding proline), ammonium ions, and small peptides - constitute what is commonly referred to as **yeast assimilable nitrogen (YAN)**.

YAN	The primary or alpha amino acids, ammonium ion and small peptides (proteins)
FAN	The free or alpha-amino group of the primary amino acids – “Free Amino Nitrogen (FAN).” Proline and protein are <i>excluded</i> from the FAN measurement.
NH <sub>3</sub> – N	Ammonia nitrogen
Summary	YAN = FAN + NH <sub>3</sub> -N

YAN measurements, ideally, should be performed directly on juice or must samples at the point of inoculation to avoid over-estimation due to processing losses which inevitably occur between

vineyard and the fermenter. Furthermore, juice samples taken from grape musts can underestimate total berry YAN due to an important proportion of amino acid contained in the grape skin. While an *early warning* for low YAN may be obtained by sampling in the vineyard one to two weeks prior to harvest, measurement *immediately* before fermentation is necessary due to the highly variable nature of YAN measurements during those last weeks before harvest.

Favored methods of measurement that allow for a single measurement of YAN (including both the FAN and the ammonia nitrogen) are (1) enzymatic assay kits, (2) the method known as the Formol titration, which consists of neutralizing a juice sample with a base, then adding an excess of neutralized formaldehyde, and re-titrating the resulting solution to an endpoint; and (3) expensive equipment such as the HPLC (high-performance liquid chromatography). Of these three options, the only one feasible for the small winery is use of the enzymatic assay kit; formaldehyde should be used with a laboratory-grade exhaust hood, and the HPLC is cost prohibitive for the small winery.

### Supplementing must YAN

As a benchmark, it is generally agreed that maximum yeast biomass yield and fermentation rate result when YAN exceeds 400mg/L, whereas 150mg/L YAN marks a transition zone below which the risk of slow or stuck fermentation notably increases. (7) (4) In general, in order to achieve an adequate rate of fermentation to dryness, a cellar bright juice containing <150mg/L YAN should be supplemented with nitrogen to at least 150-200mg/L when the respective vineyard has a history of low YAN fermentation problems, or a high nitrogen-demanding yeast has been selected. Nitrogen supplementation should be increased to the higher end of the range for higher °Brix juices, whereas juices containing grape solids, or fermentations that are aerated, are less susceptible to low YAN difficulties. (11) (4)

The primary technique used for increasing YAN levels in juice or must is the addition of yeast nutrients containing diammonium phosphate [(NH<sub>4</sub>)<sub>2</sub> HPO<sub>4</sub>], better known as “DAP.” The amount of nitrogen added per unit DAP supplement is typically reported in one of two ways: (a) 1g DAP/L increases yeast assimilable NH<sub>3</sub> (ammonia) by 258 mg/L, or (b) 1 g DAP/L increases yeast assimilable nitrogen by 212 mg/L.

These values are derived as follows:

1g DAP/L = NH<sub>3</sub> mol. wt./DAP mol. wt. = 2(NH<sub>3</sub>)/132 = 2 (14+3)/132 = 34/132 = 0.258 g NH<sub>3</sub>/L  
1g DAP/L = Total N mol. wt./DAP mol. wt. = 2N/132 = 2(14)/132 = 28/132 = 0.212 g N/L  
DAP is 25.8% ammonia (NH<sub>3</sub>) by weight or 21.2% nitrogen (N) by weight. (9)

DAP is widely used as a YAN supplement for this purpose. DAP contains 21% N, therefore, for convenience we can consider 100mg DAP to contain 20mg YAN. By way of an example, it will be necessary to add 500mg/L DAP to a juice to increase its YAN concentration from 100mg/L to 200mg/L. While this figure seems a large addition of DAP, the YAN equivalent of 1.5g DAP would be needed to reach the point at which maximum fermentation rate would be achieved. Visit this website to access the calculator to estimate DAP additions: <http://vinoenology.com/calculators/fermentation/>

Note that one disadvantage of DAP as a supplement is the acidification that can result in some juices, leading to a lower-than-expected wine pH.

## **Results of excessive or deficient YAN**

High must YAN leads to increased biomass and higher maximum heat output due to greater fermentation vigor. Overuse of DAP can also stimulate overproduction of acetate esters, especially ethyl acetate, resulting in the perception of volatile acidity (VA) and suppression of varietal character; indeed, high YAN (exceeding 450-500mg/L YAN) can stimulate ethyl acetate production by many yeast strains. Increased concentrations of haze-causing proteins, urea and ethyl carbamate and biogenic amines are also associated with high YAN musts. The risk of microbial instability, potential taint from Botrytis-infected fruit and possibly atypical aging character is also increased.

The greatest amount of H<sub>2</sub>S is produced when nitrogen becomes depleted during the exponential phase of growth or during growth on amino acids capable of supporting short doubling time. (8)

Starvation for assimilable nitrogen levels may produce H<sub>2</sub>S. The amount is dependent on the yeast strain, the sulfur precursor compound, the culture growth rate, and the enzymatic activity immediately before nitrogen depletion.

When working with very low YAN juices, researchers have observed that other nutrients can similarly be low. Thus, when YAN is low and other nutrient deficiencies are suspected, it may be useful to add a proprietary yeast food that contains more complex forms of N, as well as vitamins, lipids and minerals. Indeed, continued H<sub>2</sub>S production after DAP addition suggests a general vitamin deficiency (6), though other causes are also possible. Most yeast suppliers can advise on the use of yeast foods, which are generally produced from inactivated yeast. For instance, a recommended technique is to rehydrate with GoFerm (or similar additive) and add FermAid K (or similar additive) at recommended dosages at primary inoculation for a healthy growth phase. Then obtain YAN values and add DAP as needed at around 10 °Brix.

## **Main flavor changes that are affected by nitrogen**

Nitrogen metabolism, which is involved in the assimilation of nitrogen for the synthesis of protein and nucleic acids, also contributes to the pool of aroma and flavor compounds. Because nitrogen metabolism is central to cell growth, it regulates other pathways, including sugar and sulfur metabolism. Consequently, nitrogen availability can significantly impact on the production of many flavor-active metabolites. The nitrogen status of a juice or must, therefore, contributes to wine flavor as well as affecting yeast growth and the fermentation of sugars.

Ethanol is the major product of sugar fermentation. However, while DAP addition increases yeast growth and the rate of fermentation, it has little to no practical effect on final ethanol yield.

In general, YAN can affect TA and the balance of organic acids which can affect flavor. Malic acid consumption does increase with increasing DAP concentration, irrespective of yeast strain. (1)

From a practical point of view, the problem of juice nitrogen composition is primarily linked to the frequent occurrence of juices with suboptimal concentrations of nitrogen, and higher risk of

slow or stuck fermentation. Low YAN (< 150 mg/L) may lead to such a sluggish or stuck fermentation. Low YAN (< 200 mg/L) is associated with production of sulfur compounds, e.g. hydrogen sulfide, which results from the nitrogen demand for yeast growth.

Sulfur dioxide production during fermentation can also be stimulated by initial YAN concentration, but the response seems to be yeast strain dependent. Increased risk of MLF inhibition has also been associated with high YAN addition but this inhibition has not been conclusively correlated with SO<sub>2</sub> production. (10) Nevertheless, until better information is available, consideration should be given to limiting high YAN conditions when malolactic fermentation (MLF) is required.

### **YAN and volatile aroma compounds**

Low must YAN leads to low yeast populations and poor fermentation vigor, increased risk of sluggish/stuck/slow fermentations, increased production of undesirable thiols (e.g. hydrogen sulfide) and higher alcohols, and low production of esters and long chain volatile fatty acids.

High must YAN leads to increased biomass and higher maximum heat output due to greater fermentation vigor, and increased formation of ethyl acetate, acetic acid and volatile acidity. Increased concentrations of haze-causing proteins, urea and ethyl carbamate and biogenic amines are also associated with high YAN musts. The risk of microbial instability, potential taint from Botrytis-infected fruit and possibly atypical aging character is also increased.

Intermediate must YAN favors the best balance between desirable and undesirable chemical and sensory wine attributes. (3)

Higher alcohols, which are directly related to amino acid metabolism in the cell, exhibit a characteristic behavior. Therefore, when total nitrogen is increased by adding ammonium to a medium containing very low levels of YAN, the production of higher alcohols is initially increased, but then tends to decrease after a peak between 200-300mg/L YAN. This activity depends on various factors, including yeast strain and fermentation conditions. Higher alcohols are characterized by fusel-like odors, and are generally thought to contribute to the complexity of wine fermentation bouquet. However, when present in very high concentrations they can have a negative impact on wine aroma, mainly because they mask fruity characters. (1)

The production of fatty acids ethyl esters, as well as of acetate esters, including ethyl acetate, is generally increased when DAP is added to the juice prior to alcoholic fermentation. This can have interesting implications for wine flavor as fatty acids, ethyl esters, and acetates are generally responsible for the fruity character of wine. However, ethyl acetate, one of the dominant yeast-derived volatile metabolites, when present at very high concentrations, can give unwanted sensory characteristics, often described with terms like nail lacquer/solvent and volatile acidity.

### **Implications of nitrogen for white wine fermentations**

Results obtained in various winemaking trials conducted at the Australian Wine Research Institute with sub-optimal YAN juices have indicated that, under typical winemaking conditions, DAP

supplementation is an extremely powerful tool for modulating the production of esters, which are probably the most sensorially-interesting group of compounds generated during fermentation.

### **Implications of nitrogen for red wine fermentations**

It is generally believed that the conditions normally adopted for the production of red wine (i.e. higher temperatures, aeration of the fermenting must during cap management operations, extraction of YAN and other nutrients from skin during maceration) render fermentations less susceptible to slow or stuck fermentations, even when YAN concentrations approach the sub-optimal range.

Although during red wine fermentations YAN deficiencies are likely to have a more moderate effect on fermentation kinetics, they can still negatively affect the formation of important aroma compounds. (1)

A recent study suggested that DAP supplementation of a low YAN must fermented by maceration on skins can significantly affect the sensory properties of red wine. (12) Preliminary results also indicated that YAN supplementation of must can have an impact on red wine color composition. Analytical parameters related to color intensity and hue were indeed found to vary with DAP supplementation.

### **Summary: General Principles**

Low YAN level juices favor the production of wines with less fruity aromas, a combined function of low yeast populations and poor fermentation vigor, increased risk of sluggish/stuck/slow fermentations, increased production of undesirable thiols (e.g. hydrogen sulfide), higher alcohols, and low production of esters and long chain volatile fatty acids.

In addition to microbial instability, high must YAN leads to greater fermentation vigor, and increased formation of ethyl acetate, acetic acid and volatile acidity; to a lesser degree to increased concentrations of haze-causing proteins, urea, ethyl carbamate and biogenic amines. High YAN levels can lead to excessively estery wines.

The key is to have timely and accurate YAN must concentration data immediately before primary inoculation. Recognizing that measurement is difficult in a winery setting, we encourage use of commercial and extension labs that offer YAN measurements, so that the winemaker might make an informed decision regarding supplemental nitrogen additions.

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Extension publication explaining organic acid importance and analysis



## Acidity in Wine: The importance of management through measurement

The typical acidity measurements in grape juice and wine are pH and titratable acidity (TA). The pH measurement is used in the vineyard to assess the ripening pre-harvest, e.g., (Brix \* pH<sup>2</sup>), to calculate sulfur dioxide requirements after fermentation, and to assess oxidation risk because high pH wines are generally more prone to oxidation. TA is applied to sensory perception of a wine's acidity, i.e. its tartness, sourness, crispness. While pH and TA are related, pH is a measurement of the likelihood and speed of occurrence of pH dependent reactions, while TA is the best estimate of a wines perceived acidity.

Titratable acidity should not be confused with total acidity: total acidity only quantifies the molar weights of acids contained in a grape, must or wine; TA is an approximation of total acidity by titration with a strong base (NAOH) to a pH of 8.2, i.e. TA is the sum of both acid content and cation content, such as potassium (K<sup>+</sup>), sodium (Na<sup>+</sup>), and calcium (Ca<sup>++</sup>) (1). While the quantified TA is inflated with cations, measuring total acidity is difficult as it requires the ability to directly quantify organic acids.

In the winery TA is the best practical expression of the organic acid concentration within must or wine. The principal organic acids found in grapes are tartaric, malic; to a small extent, citric and others. Tartaric and malic acid account for over 90% of the total acids present, existing at roughly a 1:1 to 1:3 ratio of tartaric to malic acid. The actual acid composition and concentration within the must or wine is influenced by many factors such as variety, climatic region, and cultural practices; their presence contributes to both a wine's flavor and to its stability, color, and pH. By knowing the exact organic acid makeup of a wine or must a producer can make educated vinification decisions to optimize flavor and stability.

During the berry's progression to veraison, acids accumulate within the fruit. At veraison, the total

acidity in the fruit decreases, primarily due to the reduction of malic acid; at harvest, the fruit usually contains more tartaric acid than malic acid, the exact concentrations and ratios to one another being cultivar specific and harvest date dependent (3). Grapes are one of the rare fruits that contain tartaric acid. It is present as free acid and in its salt form, e.g. potassium bitartrate (KC<sub>4</sub>H<sub>5</sub>O<sub>6</sub>), sodium bitartrate (C<sub>4</sub>H<sub>5</sub>NaO<sub>6</sub>), and calcium bitartrate (CaC<sub>4</sub>H<sub>4</sub>O<sub>6</sub>).

The presence of the salt form is an important constituent, affecting pH and the cold stability of the wine (5).

### Basic difference between pH and TA

While one may think that TA and pH are directly correlated as acidity indicators, they are not: The measurement of pH is the number of H<sup>+</sup> ions in a solution using a *logarithmic* scale, with a lower number denoting a higher concentration of H<sup>+</sup> ions. Translation: the difference between a wine with a pH of 4.0 and with a pH of 3.0 is that the wine with the pH of 3.0 has 10x the number of hydrogen ions as the pH 4.0 wine (or 1x10<sup>-3</sup> versus 1x10<sup>-4</sup> H<sup>+</sup> ions). The measurement of acidic content is the acid's potential to liberate H<sup>+</sup> ions as it dissociates. While acid content affects pH, it is not directly predictive of pH (or vice versa). This non-direct correlation is partially due to pH "buffering" caused by a number of compounds in wines, such as sugars, acids, and phenolic compounds. Buffering occurs because these compounds exist in equilibrium between their acid and conjugate base forms; the ratio of the two forms to one another must be significantly shifted before a noticeable pH change can occur. Just as pH calibration buffer solutions effectively calibrate pH equipment due to their reliable stability, the addition of a given amount of acid to a wine may not reduce the pH as expected due to the wine's buffering capacity to maintain a stable pH.

In taking pH and TA measurement one is also measuring two different chemical attributes of the wine or must. With a pH meter one is measuring an electrical gradient created by the solution inside the cell of the pH probe and the wine. With TA one is measuring the amount of strong base that it takes to raise the solution to pH 8.2 accounting for both acid content and buffering capacity. Within the US wine industry, TA is typically quantified in terms of g/L of tartaric acid, as if it were a quantification of *only* tartaric acid; in fact, the number represents the concentration of all titratable acids, e.g. including malic, citric, lactic, succinic acids. (*Note*- some industries use Sulfuric acid as the acid of reference, so one may see values given in g/l as Sulfuric in some European publications).

Due to the presence of various kinds of acids and their salts, the relationship between titratable acidity and pH is necessarily a complex one. For instance, pH also depends on the ratio between tartaric and malic acids; so any loss of malic acid, i.e. in the vineyard from respiration during ripening in warm climates, or in the winery from unintentional MLF, will reduce TA and increase pH.

Briefly, understanding the role of pH and TA in winemaking is crucial to making good wines.

### Overview of the Acids in Wine

**Tartaric Acid**- A diprotic (two H<sup>+</sup> ions) acid - (C<sub>4</sub>H<sub>6</sub>O<sub>6</sub>), tartaric acid is relatively microbial stable and accounts for a large proportion of a wine's acidity (along with malic acid) and normally exists at a concentration between 2.5-5g/l at harvest.

**Malic Acid**- A diprotic (two H<sup>+</sup> ions) acid - (C<sub>4</sub>H<sub>6</sub>O<sub>5</sub>), the levels of malic acid in grape berries are at their peak just before veraison when they can be found in concentrations as high as 20 g/L. As the vine progresses through the ripening stage, malic acid is metabolized in the process of respiration, and by harvest, its concentration falls to around 1-4 g/l.

**Lactic Acid**- A monoprotic acid (one H<sup>+</sup> ion) - (C<sub>3</sub>H<sub>6</sub>O<sub>3</sub>), lactic acid bacteria (LAB) convert sugar and malic acid into lactic acid, the latter through MLF. This process can be beneficial for some wines, adding complexity and softening the harshness of malic acidity, but it can generate off flavors and turbidity in others. Note that lactic acid does not naturally exist within the grape, but can be produced during vinification.

**Citric Acid**- A triprotic acid (three H<sup>+</sup> ions) - (C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>), citric acid often has a concentration of less than 1 g/L at harvest; note that citric acid may be converted by LAB to acetic acid and diacetyl.

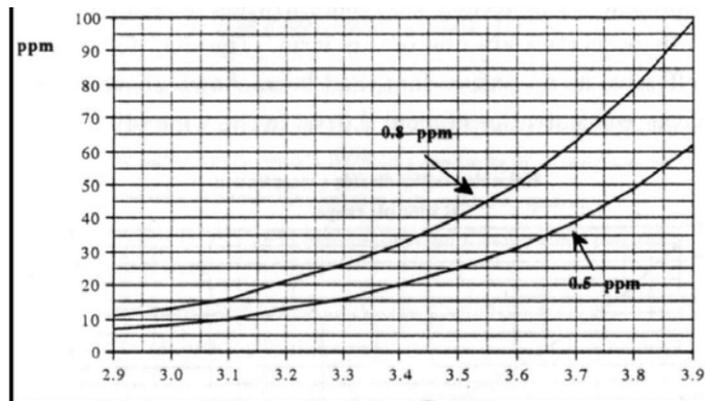
**Acetic acid**- A monoprotic acid (one H<sup>+</sup> ion) - (C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>), acetic acid is produced in wine during or after the fermentation period. It is the most volatile of the primary acids associated with wine and is responsible for the sour taste of vinegar. During fermentation, activity by yeast cells naturally produces a small amount of acetic acid if the wine is exposed to oxygen. The U.S. legal limits of Volatile Acidity are 1.2 g/L in red table wine and 1.1 g/L in white table wine.

**Succinic acid**- A diprotic (two H<sup>+</sup> ions) acid - (C<sub>4</sub>H<sub>6</sub>O<sub>4</sub>), succinic acid is more commonly found in wine, but can also be present in trace amounts in ripened grapes. While concentration varies among grape varieties, it is usually found in higher levels with red wine grapes. The acid is created as a byproduct of the metabolization of nitrogen by yeast cells during fermentation.

### The importance of precise measurement

It is recommended that pH for table wines be in the range of 3.1 to 3.3 for musts to ensure microbial and chemical stability (2); in reality Missouri white wines run close to 3.5 and MO red wines can exceed 3.6. At these pH values only a tiny proportion of SO<sub>2</sub> is in the active, molecular form; to shift the equilibrium to a point that will allow good stability, one must lower the pH.

**Free sulfur dioxide (SO<sub>2</sub>) ppm concentration required to maintain concentration of *molecular sulfur dioxide* between 0.8 ppm and 0.5 ppm at wine pH range (4)**



If the wine's pH is **3.35**, and the intent is to maintain **0.8 ppm** of molecular sulfur dioxide to stabilize the wine, then the winemaker must add the equivalent of **30 ppm** free sulfur dioxide concentration; if the wine's pH is **3.60**, and the intent is to maintain **0.8 ppm** of molecular sulfur dioxide to stabilize the wine, then the winemaker must add the equivalent of **50 ppm** free sulfur dioxide concentration; if pH is **3.75**, then add equivalent of **70 ppm**...

To achieve the recommended pH, one method to lower the pH of the must is to add an organic acid. The tricky part is calculating the amount to add to lower the pH without increasing the TA to an unpleasant level of excessive tartness or sourness in the wine. Given the continual chemical and microbiological reactions in wine, e.g. pH buffering, MLF, and tartrate precipitation, it is not always possible to add X amount of an organic acid and achieve Y reduction in pH.

Before adding organic acids to ultimately lower the pH, it is necessary to have baseline readings of both TA and pH.

Tartaric acid, in practice, is the preferred acid addition to wine because it is not as easily degraded microbiologically, as are malic and citric acids, which may lead to unexpected changes. Because tartaric acid is poorly soluble in ethanol in water solutions, e.g. wine, there is a limit to the amount of tartaric acid that a winemaker might add without causing cold instability.

While malic or citric could potentially be used, such practice is a riskier prospect: malic acid can degrade to lactic acid, and citric acid to diacetyl, the "buttery" aroma found in some wines. Citric acid may also degrade into acetic acid, which is federally regulated regarding maximum concentration in wine. There are also commercial acid "blends" that seek to mimic the proportions naturally found in the grape.

As many winemaking decisions will be affected not only by the total or titratable acidity, it is necessary to know concentration of the individual acids comprising the wine's overall acidity. There are a variety of measurement methods available to the winemaker:

One of the classic methods used by winemakers is paper chromatography, which separates acids dependent on the speed at which the samples travel up paper moistened by a solvent at one end. The problem with this method is that it is not quantitative and relies on hazardous chemicals.

Another method that has gained popularity within wineries is the enzymatic based method. This method employs an enzyme that selectively uses a given acid to cause a reaction that leads to a change in absorbance as measured by a spectrophotometer. These tend to be as accurate as an individual's ability to pipette. The equipment needed is a spectrophotometer; the consumable supplies include an enzymatic kit and appropriate micro-pipettes. It should be noted

though that these kits have expiration dates and need to be used soon after opening.

Another method is high performance liquid chromatography (HPLC). This works off the same basic principle as paper chromatography, but the solvent in this case is forced through a column at

high pressure. Unlike paper chromatography this method is both quantitative and very sensitive; the required equipment is not cost beneficial for the average winery. At the GWI we have such units in place for research; we plan to soon offer acid quantification and characterization to the Missouri industry on a trial basis.

### Organic Acid Quantification and Characterization Service

GWI will offer a pilot program to gauge interest in this acid measurement service. **This pilot program is for licensed, commercial wineries only.** If your winery is interested in participating, please contact Michael Leonardelli for information on how to prepare the sample and where to send it. Our plan is to initially offer this service for free during our testing period, and then charge a modest fee to cover costs when fully implemented. For any questions, concerns or suggestions for additional services, please feel free to contact either Michael Leonardelli [leonardellim@missouri.edu](mailto:leonardellim@missouri.edu) or Misha Kwasniewski [kwasniewskim@missouri.edu](mailto:kwasniewskim@missouri.edu) at the GWI.

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## **Project 8: Connecting Trained Sustainable Agriculture Interns to Mid-MO Farms**

### **Columbia Center for Urban Agriculture**

Heather Gillich

Final Performance Report

### **Project Summary**

The Columbia Center for Urban Agriculture (CCUA) serves as a liaison between interested novice farmers and successful farming efforts in Mid-Missouri. We began this project because we received requests from area farmers and farming projects to have more skilled labor available locally. CCUA is uniquely connected to significant numbers of people interested in learning more about farming and working hard to do so. This project helped to address this need by creating more opportunities for interested persons to learn some basic farming skills with CCUA and utilize our network to find connections for long-term internships on mid-MO farms. Our Garden Greenhorn intern program is quite popular and piques the interest of many applicants. With so many interested interns, we wanted to develop connections in the larger farming community to help other farmers benefit from these energetic new potential farmers.

Our project objectives were to train successful farming interns and provide opportunities for connection in the local farming community to increase the sustainability of local food with the following goals:

1. Train 72 interested persons to be successful farm interns through GG program by 2016.
2. Develop connections between farmers and interested interns at 9 CCUA -facilitated networking events by 2016.
3. Develop usable database to post 30 available internships and farm profiles by 2016.
4. Successfully place 9 trained interns at local farms by 2016.
5. Increase in reported knowledge of food systems and farming techniques by 50% interns in each cohort.

This project is not an extension of a previously funded project, but we will continue the work of this project in the future.

### **Project Approach**

<b>GOALS</b>	<b>PROJECT ACTIVITY</b>
<b>1</b>	Recruit, interview, and place GG interns
	Develop and implement lessons
	Evaluate program efficacy and get feedback
<b>2</b>	Organize and facilitate meetings with CCUA and supporting farms
	Promote networking events
	Schedule and host networking events
<b>3</b>	Develop database
	Create farm profiles
	Assist farms and organizations in developing intern positions

	Maintain database
4	Provide training and promote use of database
	Facilitate relationship development between interns and supporting farms/organizations
5	Teach and observe skill development
	Create and administer pre/post test to interns

Throughout the project, CCUA recruited and trained interns and volunteers at the Urban Farm. These interns and volunteers learned basic skills about farming practices and harvesting techniques through CCUA-developed lessons. Volunteers and interns were asked for feedback about the lessons throughout and at the end of their participation in the program. All interns and volunteer names were stored in an accessible database to track hours, interest, and connections.

CCUA staff ensured that project funds were used for specialty crops through Urban Farm lesson topics that provided information and skill-building about the production of specialty crops. All partner farmers are specialty crop producers. Project partners contributed to the project by hosting events, maintained attendance at networking events on the Urban Farm, and provided training to interns and volunteers.

CCUA organized and promoted networking events to connect interested interns with local farmers. These networking events were hosted primarily at the Urban Farm, with some trips to other local farms.

### **Goals and Outcomes Achieved**

PROJECT GOALS		TARGET	TARGET MET?
1	Train 72 interested persons to be successful farm interns through GG program by 2016	24 per year	<b>118 total trainees.</b>
2	Develop connections between farmers and interested interns at 9 CCUA -facilitated networking events by 2016	20 in attendance at each event	<b>6 networking events</b> were hosted with a total of <b>473 participants.</b>
3	Develop usable database to post 30 available internships and farm profiles by 2016	10 available internships posted per year	<b>23 total opportunities</b> were posted in the database (some recurring, some one-time). <b>231 people logged in to the database.</b>
4	Successfully place 9 trained interns at local farms by 2016**	3 placed interns per year	<b>34 total connections</b> were made between CCUA GG interns/trained volunteers and Mid-MO specialty

			crop growing operations (Farms or School Gardens).
5	Increase in reported knowledge of food systems and farming techniques by 50% interns in each cohort	12 interns report increase per year	Pre/post-test was not administered. Instead, feedback sheet was used to obtain information about participant's skills (self-report) and compared to an observational assessment by UF Farm Manager. <b>Performance and understanding were assessed to have increased at least 50% in the areas of production skills, feeling a part of the local food community, and likelihood to continue involvement in specialty crop agriculture.</b>

### Beneficiaries

How many benefited from the project?	How did they benefit from the project?
118 total trainees.	received training in urban farming.
473 participants in networking events	met other interested members of the mid-MO food scene
34 total connections with mid-MO farming projects	Farmers who were connected with locally trained workers

### Lessons Learned

- The database was not possible to maintain because of cost and lack of staff expertise, but the opportunities will continue to be posted to email listserv's, CCUA and MOYFC websites, and social media.
- CCUA staff learned about writing lessons for learners (with learning objectives and evaluation to match) through this project. We also learned about class recruitment by addressing how to create classes and networking opportunities that meet the needs of all participants.
- Because of this project, CCUA has improved recruitment procedures and developed better systems for collecting and utilizing participant feedback.

## **Contact Person**

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## **Additional Information**

None

## **Project 9: Does Mycorrhizal Fungi Benefit Fruit Production in Tomatoes and Cucumbers: Data Collection and Results Sharing**

### **Columbia Center for Urban Agriculture**

Caroline Hargrove

Final Performance Report

### **Project Summary**

Phosphorus (P) is an essential nutrient that is needed for proper flower formation, root growth, cell division, and energy transfer. Soil available P is generally low and immobile in the soil solution. Plant uptake of P is related to the size of the root system and is dependent upon root interception of P. Although P is essential and is included in many standard fertilizer mixes it can easily be mismanaged in agricultural fields. P is tightly bound to soil particles and soil erosion caused by tillage in addition to over application of fertilizers containing P can result in water pollution leading to hypoxia conditions as in the Gulf of Mexico. (Owens and Shipitalo, 2006). One way to economically and environmentally manage P uptake in crops is by adding appropriate species of mycorrhizal fungi to crop roots. Mycorrhizal fungi act as extensions of the plant root and greatly increase the uptake of P and possibly micronutrients and water. However through tillage and other management practices the correct mycorrhizal fungi for a specific crop is often not available.

Successful flower set is an important component of vegetable farming, and the possibility of managing P and micronutrients more effectively with the use of mycorrhizal fungi can greatly improve specialty vegetable production in the mid Missouri area. According to Colorado State University, Best Management Practices (BMPs) for P management in agricultural systems (row crop and diverse vegetable production) are to manage soil erosion, manage water movement and to apply foliar application of nutrients at appropriate levels, so as to reduce any nutrient leaching (Wilson, Bauder, N.D.). Agricultural nonpoint source pollution is the greatest form of waterway (streams and rivers) pollution in the United States, and much of that is due to nutrient P run-off from over fertilization ([epa.gov/polwaster/nps/outreach/point6.cfm](http://epa.gov/polwaster/nps/outreach/point6.cfm)). Neither of these publications mention the possibilities of mycorrhizal fungi in their swath of nutrient management tips. However, one way for specialty crop farmers to reduce their contribution to nonpoint source pollution would be to inoculate their crops with mycorrhizal fungi that would take advantage of the nutrient levels already present in their soils, thus reducing their fertilization regime. This would offer specialty crop farmers a more environmentally sustainable nutrient management program while still allowing them to achieve high quality yields. The objective of this project is to

assess the efficacy of using mycorrhizal fungi in tomato and cucumber fruit production, and to share these results with regional vegetable growers as a way to influence their fertility management programs.

This project has not been submitted for consideration to any other federal or state granting programs, nor does it build upon a previously funded project through the Specialty Crop Block Grant Program.

### **Project Approach**

<p>Started tomato replications. Each replication was divided into 4 subgroups of 5 starts each. The 4 subgroups were:</p> <ul style="list-style-type: none"> <li>Control</li> <li>Inoculated at seeding</li> <li>Inoculated at seed germination</li> <li>Inoculated at transplanting</li> </ul> <p>We did 4 replications, and all replications were started on the same day.</p>	<p>Carrie Hargrove, CCUA Tim Reinbott Bradford Research and Extension Center</p>	<p>April 2014, and again in late March 2015</p>
<p>Started cucumber replications. Each replication was divided into 4 subgroups of 5 starts each. The 4 subgroups were:</p> <ul style="list-style-type: none"> <li>Control</li> <li>Inoculated at seeding</li> <li>Inoculated at seed germination</li> <li>Inoculated at transplanting</li> </ul> <p>We did 4 replications, and all were started on the same day.</p>	<p>Carrie Hargrove, Tim Reinbott</p>	<p>June 2014, and again in June 2015</p>
<p>Measured tomato crop yield by weighing total of marketable tomatoes from a defined 30-day period for all subgroups of all replications.</p>	<p>Carrie Hargrove, Tim Reinbott</p>	<p>July-August 2014, August- September 2015</p>
<p>Measured cucumber crop yield by weighing total yield of marketable cucumbers from a defined 30-day period for all subgroups of all replications.</p>	<p>Carrie Hargrove, Tim Reinbott</p>	<p>June-July 2014, July 2015</p>
<p>Compiled harvest records for both trials</p>	<p>Carrie Hargrove</p>	<p>August 2014, September 2015</p>
<p>Distributed educational handouts during educational tours of the Urban Farm and of BREC</p>	<p>Carrie Hargrove</p>	<p>August- October 2014, September- October 2015</p>

Discussed research findings and pass out educational handouts at Bradford's Tomato Fest	Tim Reinbott	September 2014
Presented poster at Great Plains Veggie Growers Conference	Carrie Hargrove	January 2015 and January 2016

Our first goal was to form a better understanding of the relationship between inoculation timing and highest yield quality in tomato and cucumber production. Our second goal was to teach vegetable farmers how to sustainably manage soil fertility through the use of mycorrhizal fungi by offering tours of both facilities participating in research. While we accomplished our first goal, and gave tours and presentations on our project and the findings, we weren't able to do much except tell people what we found and the possible reasons for it. Our findings were not in-line with what we expected our results to be, so we had to somewhat alter our game plan. Originally, our goal was to increase the participants' usage of mycorrhizal fungi by 10%, however, we decided after the first growing season that we were not going to be able to accomplish that based on our findings, so we decided to expand the project for one more growing season. When we found similar results in 2015, again we could only present what our findings were to groups and give the possible explanations for what we saw.

Staff at the CCUA and at BREC fulfilled all planting, record keeping, and harvest responsibilities for this project. Carrie Hargrove, from the CCUA did most of the outreach work.

### **Goals and Outcomes Achieved**

Originally we had created pre and post surveys so that we could monitor people's change in behavior over time. After our unexpected results, however we changed our methods. At the beginning of each presentation we would informally poll audience members by asking questions to which audience members raised their hands. When we submitted our grant, we operated under the inaccurate assumption that we would find a direct correlation between fungal inoculation and increased vegetable production. We did not find this to be the case either year we ran the trials. Because our trials turned out to be not as simple or conclusive as anticipated, our presentations reflected that. Therefore, instead of trying to get farmers and gardeners to increase their usage of AM fungi (which we couldn't prove was a beneficial thing according to our trials), we set about to inform people on the complexities of the fungal/plant relationships, and inoculation practices that could negatively impact crop yield. By doing this informal survey and recording answers, we were able to calculate how many people and what percentage increase of knowledge had been gained on the subject.

Approximately 300 people total attended all sessions/tours. Approximately 200 people were surveyed because we were not able to complete the survey at the poster presentation at the Great Plains Vegetables Growers Conference since folks stopped by at random.

- 8/1/2014: Presented at University of Missouri Bradford Research and Extension Center Organic Field Day on MDA grant and cucumber and Tomato trials. Approx. 100 people in attendance
- 9/4/14: Presented MDA grant and cucumber and Tomato trials at Bradford Research and Extension Center Tomato Festival. Approx. 50 people stopped and listened to presentation

- 9/7/14: Presented on MDA grant and cucumber and tomato trials at a meeting of the Missouri Young Farmer’s Coalition. Approx. 20 farmers in attendance
- 1/8-1/10/15: displayed poster at the Great Plains Vegetable Grower’s Conference in Saint Joseph, Missouri. Approx. 50 people stopped and looked at the poster
- 9/13/15: Presented 2014 project data at the Missouri Master Gardeners Conference in Columbia, Missouri. Approx. 30 attendees
- 1/7-1/9/16: displayed poster at the Great Plains Vegetable Grower’s Conference in Saint Joseph, Missouri. Approx. 50 people stopped and looked at the poster

All informal surveys were tallied by hands and tracked for each event. The same two questions were always asked at the beginning of each presentation as a way to introduce the topic. Attendees of each presentation were asked the following two questions:

- Had anyone ever heard of mycorrhizal fungi?
- Had anyone ever used mycorrhizal fungi?

<b><u>Informal Survey Results</u></b>	<b>Organic Field Day 8/1/14</b>	<b>Tomato Fest 9/4/14</b>	<b>MO Young Farmers Coalition 9/7/14</b>	<b>Missouri Master Gardeners 9/13/15</b>
Number of audience members	100	50	20	30
Introduction questions				
Has anyone ever heard of Mycorrhizal fungi? (yes/total)	45/100	20/50	20/20	15
Has anyone ever used mycorrhizal fungi? (yes/total)	20/100	5/50	5/20	2
Number of people exposed to the topic	100	50	20	30
Percentage more people that know about the concept after presentation (calculated based on those who had prior knowledge of mycorrhizal fungi)	122%	150%	0%	100%

### **Beneficiaries**

The beneficiaries of this project are vegetable farmers and garden enthusiasts. These groups were impacted by this research because vegetable farmers (and to a lesser extent, gardeners) want to maximize their marketable harvests, and are constantly looking for ways to improve the

efficacy and economic stability of their operation. This project helped further educate specialty growers on the complex dynamics of utilizing mycorrhizal fungi in their operations.

As previously stated, approximately 300 people total attended all sessions/tours. Approximately 200 people were surveyed because we were not able to complete the survey at the poster presentation at the Great Plains Vegetables Growers Conference since folks stopped by at random.

### **Lessons Learned**

We believe that we saw the outcomes we did based on the fact that we started all plants for the trails in one greenhouse, using the same potting mix which included adequate amount of P for healthy starts. This high level of P most likely threw the mycorrhizal fungi and plant relationship out of whack. Once a plant identifies that the mycorrhizal fungi is there, the plant shuts down some of its metabolic processes, making it dependent on the fungi to provide necessary nutrition for the plant. After the plant shuts down its own metabolic processes, it begins channeling carbohydrates to the fungi, regardless of what it is receiving from the fungi. In addition, in an environment high in P, mycorrhizal fungi halt root colonization. Therefore, we believe that our trial plants were sending carbohydrates to the fungi, but that the fungi was not able to channel P to the plants, resulting in the control group out producing most other groups in all replications. If we were to re-do these trials, we would only inoculate the plants upon transplanting into the field.

Needless say, we did not anticipate these results, but they proved to be an important learning tool for us. We realize that sprinkling mycorrhizal fungi on plant roots doesn't simply correlate to huge harvest yields, but that the process is more nuanced than that. We hope that we adequately conveyed this message to our audiences.

### **Contact Person**

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### **Additional Information**

#### **Handout:**

## **DOES MYCORRHIZAL FUNGI BENEFIT FRUIT PRODUCTION FOR TOMATOES AND CUCUMBERS?**

Caroline Hargrove

The Columbia Center for Urban Agriculture

- The Columbia Center for Urban Agriculture
  - Outdoor Classrooms
  - Opportunity Gardens
  - Edible Landscaping

- Urban Farm Experiences
- Plant up take of phosphorus
  - Most P in soil is in the form of rock phosphorus, which is not water soluble
  - P uptake by roots is dependent the root actually intersecting with the P in the soil.
  - Phosphorous is hard for plants roots' to access, although Missouri soils have naturally high concentrations of Phosphorus (P)
    - It is common to fertilize with N,P,K + to compensate for these difficulties.
      - Erosion from ag land and fertilizer runoff are the main contributors to non-point water pollution
- If we can utilize the naturally occurring soil P better, then we could increase the fruit production while applying lower levels of fertilizer.
- How do we do this?
  - Arbuscular Mycorrhizae (AM)
    - AM fungi live in the soil and colonize the roots of most (80%) plants
    - Plants and AM fungi have evolved together to form a mutualistic relationship:
      - AM fungi help bring Phosphorous- a major nutrient- to the plant and the plant gives the fungi sugars to eat (up to 20% of what is created through photosynthesis).
  - Many common farming and gardening practices, like tillage and fallowing hurt indigenous AM populations
- Our project was designed to better understand the relationship between the timing of AM inoculation and fruit yield in tomatoes and cucumbers
  - Is there a life stage when inoculation works the best?
- Project set up
  - 4 groups:
    - Inoculated at seeding
    - At potting up
    - At Transplanting
    - Control
  - Weighed harvests from all groups over a one month period
  - Compiled the data from all group for both crops from both farms
- What did we find?

- The control subgroup produced heavier yields in both the tomato and cucumber trials at both trial locations.
- While AM fungi has the potential to increase harvest yields in fruiting crops, accurately using it is complex. Some potential reasons:
  - It is thought that when a plant is colonized with AM fungi, it shuts down its metabolic processes that take up P; in doing so the plant depends predominately on AM fungi for P uptake.
  - Potting mixes, fertilizers, and soils high in P can halt root colonization. If root colonization is stopped after the plant shuts down its own metabolic processes, uptake of P will be hindered.
  - In addition, if root colonization is halted and the plant continues to supply the AM fungi with carbohydrates, the plant's growth could be stunted.
- Conclusions
  - Just as any agroecological approach, there are many complex factors at play
  - Good gardening techniques to promote the good fungi and bacteria in your garden include:
    - Conservation tillage
    - mulching
    - Adding compost or manure from animals not fed hay that has been sprayed with herbicides
    - Crop rotation
    - Cover cropping
    - Interplanting and companion planting

# DOES MYCORRHIZAL FUNGI BENEFIT FRUIT PRODUCTION FOR TOMATOES AND CUCUMBERS?

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## What is Mycorrhizal Fungi?

- Mycorrhizal (AM) fungi live in the soil and colonize the roots of most plants.
- Plants and AM fungi have evolved together to form a symbiotic relationship: the fungus channels nutrients to the plant in exchange for carbohydrates.
- Many common farming practices, like tillage and fallowing, kill AM fungi in the soil so that crop plants never get a chance to form relationships with the fungus.
- AM fungi inoculants are commercially available, and are used to ensure good colonization of crop roots by the fungus when production methods negatively impact fungi populations.

## Plant/Fungi Relationship

- It is thought that plants whose roots are colonized by AM fungi produce heavier yields because the fungi are efficient at bringing Phosphorous (P) and other nutrients to the plant.
- P is hard for plants to take up because it is very tightly bound to soil particles and is insoluble in water.
- AM fungi transforms P into a form that is easily accessible to plants.
- Among other important functions, P helps facilitate proper flower formation. Better flower formation could lead to higher yield potential in fruiting crops.

## Benefits for Farmers

- Missouri soils are naturally high in P, so effective use of AM fungi can better utilize existing nutrient levels and potentially reduce fertilizer inputs.
- If soil is managed carefully, AM fungi populations can grow and live in the soil indefinitely which could increase efficiency by reducing fertilizer inputs while increasing harvest yields.
- AM fungi has the potential to greatly increase yields in commercially important crops like tomatoes, peppers, cucumbers, and squash.

## Project Scope and Methods

- This project was designed to better understand:
  - if AM fungi affects harvest yields in tomato and cucumber plants
  - if there is a relationship between inoculation timing and harvest yields in tomato and cucumber plants
- Plantings of tomatoes and cucumbers were divided into four subgroups that were inoculated with AM fungi at different times:
  - at seeding
  - at potting up
  - at field transplanting
  - not inoculated
- Each subgroup was replicated five times.
- These trials were replicated in two locations: at the Urban Farm, in Columbia, Missouri and at Bradford Research and Extension Center in Columbia, Missouri.
- A commercially available AM fungi inoculant was used for all inoculated groups, and all groups were inoculated at the same application rate.
- Harvest yields from each subgroup were weighed and recorded over a one month harvest period.
- Yields from all subgroups were extrapolated into pounds per acre.

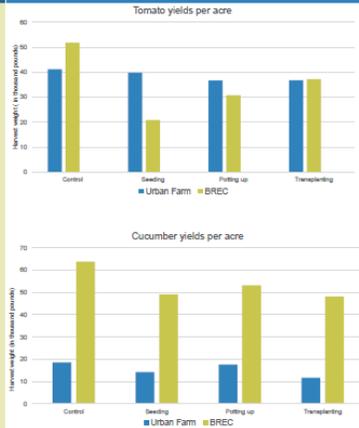
## Results and Conclusion

- The control subgroup produced heavier yields in both the tomato and cucumber trials at both trial locations.
- While AM fungi has the potential to increase harvest yields in fruiting crops, accurately using it is complex. Inoculation methods should be researched before implementing on-farm use of AM inoculants.

## Acknowledgements

This project was funded through the Missouri Department of Agriculture Specialty Crop Block Grant.

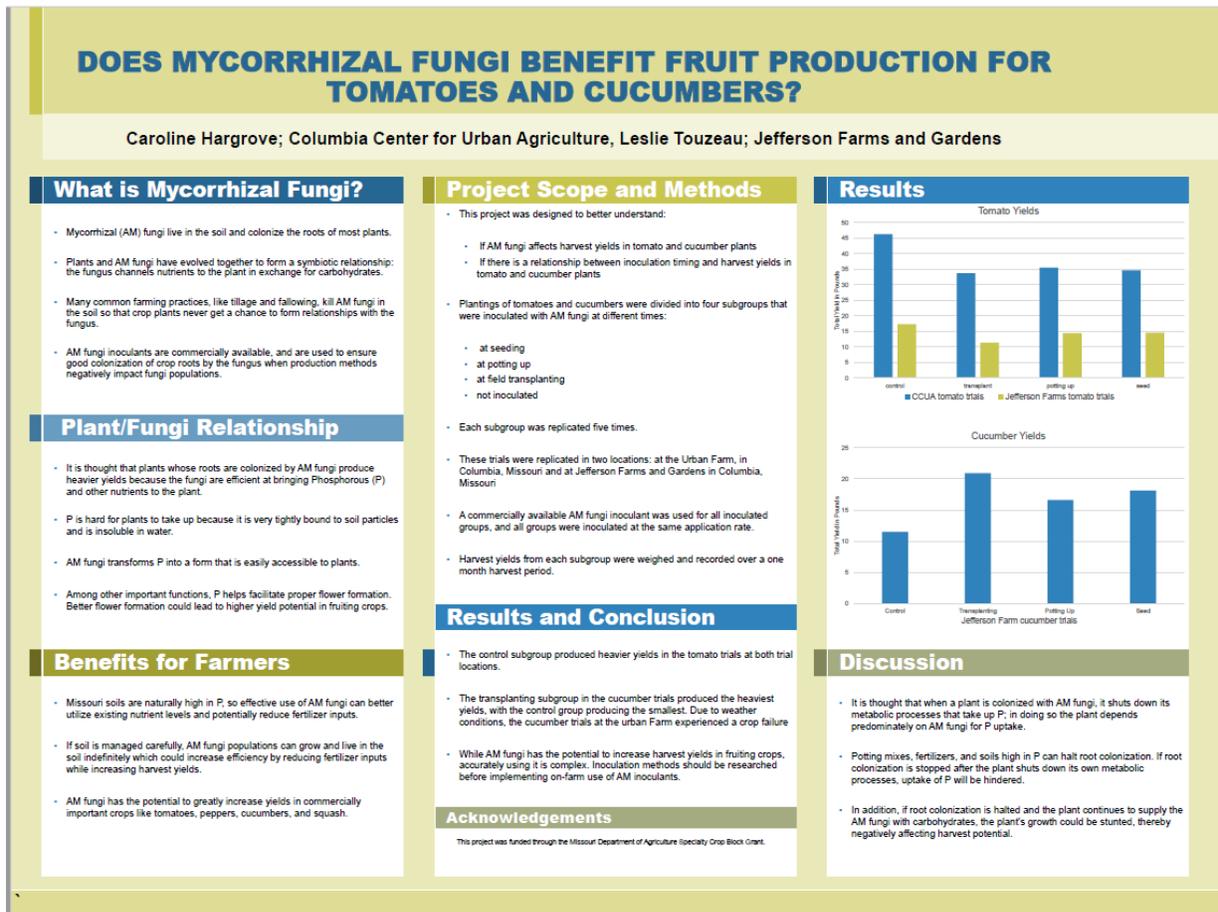
## Results



## Discussion

- It is thought that when a plant is colonized with AM fungi, it shuts down its metabolic processes that take up P; in doing so the plant depends predominately on AM fungi for P uptake.
- Potting mixes, fertilizers, and soils high in P can halt root colonization. If root colonization is stopped after the plant shuts down its own metabolic processes, uptake of P will be hindered.
- In addition, if root colonization is halted and the plant continues to supply the AM fungi with carbohydrates, the plant's growth could be stunted.

## Poster 2015:



## Project 10: Show-Me Missouri Specialty Crops – Missouri Made Better

### Missouri Department of Agriculture

Alan Freeman

Final Performance Report

### Project Summary

Originally scheduled to begin in 2014, the goal of this project was to increase awareness and consumption of Missouri Specialty Crops. Dovetailing on two previous Specialty Crop Block Grant Projects, "Taste the Freshness" in 2009 and "Enhancing Missouri Specialty Crop Opportunities through Training and Outreach" in 2010. Utilizing the results of these two projects, MDA would expand into creating awareness of the diversity, availability and affordability of Missouri Specialty Crops through regional advertising campaigns and trade shows. The Department hoped to reach a minimum of 300,000 Missouri residents through this campaign. This project was not a previously funded project through SCBGP or SCBGP-FB programs.

## **Project Purpose**

Show-Me Missouri Specialty Crops project was to enhance awareness of the diversity, availability, and affordability of Missouri specialty crops. The purpose of this project was to increase the number of Missouri individuals and families purchasing, preparing, and consuming Missouri grown vegetables, melons, potatoes, sweet potatoes and fruits, tree nuts and berries. Education and promotion would be the two key components of this project in order to connect Missouri producers and consumers.

Agriculture is the leading industry in Missouri; however according to the 2007 census, Missouri specialty crops only represent .878% of the total market value of agriculture products sold. This number is consistently increasing with the number of urban agriculture operations, entrepreneurial community gardeners, and diversification of farmers. With increased awareness and purchasing of specialty crops, the demand for Missouri specialty crops will increase as well as the market opportunities for producers.

A targeted educational and promotional message was to be compiled based on demographics and statistics across the state. Electronic Benefits Transfer (EBT) availability increasing at farmers' markets enhances opportunities for access to more consumers of fresh, healthy and local specialty crops.

In order to solely enhance the competitiveness of specialty crops, all promotion and marketing would only include images and education on those specialty crops found in Missouri and the producers that grow them. No funds would be spent on generic farmers' market or an overall buy local campaign where non-specialty crops would be promoted.

This project would have supplemented state funds as the State of Missouri Department of Agriculture does not have a specific mechanism or funding that is utilized for promoting specialty crops. This would allow collaboration with the Missouri Farmers' Market Association, Missouri Vegetable Growers, and other regional agricultural associations to identify our specialty crop growers and create a project to promote their business.

## **Project Activities**

From the original grant, the following activities were completed and goals achieved:

**Travel** - This covered travel expenses and registration fees for six conferences between December 2013 and March 2014. Each of these conferences pulled in a different group of producers of specialty crops. The promotion of the Show Me Missouri Specialty Crops was discussed with growers and allowed them to understand and give feedback on the program being implemented. The registration fees paid for the booth space, reservation at the venue and the programmatic information provided at the conference. These conferences were not intended to benefit the organization, but rather to benefit the producers and consumers that attended and allowed the Show Me Missouri Specialty Crop program to be showcased.

### **Great Lakes Expo-Grand Rapids, MI, December 10-12, 2013**

This is the largest grower and market show in the country with over 10,000 people in attendance. The show was a great opportunity to learn what other states did with their programs and learn from specialty crop marketers in the private sector.

**Great Plains Growers Conference – St. Joseph, MO – January 9-11, 2014**

This conference is the largest gathering of specialty crop producers, over 500 in Missouri each year. Hosted by the Missouri Vegetable Growers Association and the Missouri, Iowa, Nebraska and Kansas Cooperative Extension Services, it was the most effective place to preview perspective marketing concepts and receive producer feedback of the materials' effectiveness or lack thereof.

**Missouri Organic Association Conference – Springfield, MO – February 6-8, 2014;** Located at the opposite end of the state, in a less populated area this conference reached a different group of producers with more of a wholesale focus. Attendance and this conference is also swelling to over 500 producers. This audience revealed a greater need for traceability assistance, labeling and more marketing assistance from a regulatory assistance, especially in relation to the changing landscape of FSMA.

**MOSES-LaCrosse, WI-February 27 – March 1, 2014;** This is the largest organic grower and market show in the country with thousands of people in attendance. Much like the Minnesota conference, the greatest values was learning what other states did with their programs and hearing about the needs of organic producers.

**Midwest Grape and Wine-St. Charles, MO-February 4-6, 2014;** Missouri's largest specialty crop industry, the grape producers had little need for marketing assistance of their grapes, as input demand for their wine outpaces supply in the state. There was demand for suppliers to the restaurants at the wineries on the supply side for others' products, but they did not show substantial interest in marketing their grapes outside of their own supply chain.

**Minority and Limited Resource Farmers Conference – Jefferson City, MO-March 13-15, 2014;** In the third year, this conference is becoming one of the best venues to connect with underserved producers that are focused on specialty crops. One of the great benefits about attendance was finding producers interested in ethnic crops ideal for inner city bodegas and corner stores. These crops tend to be higher in profit and lower in inputs. Like all specialty crops, the supply is still far behind demand so the growers showed little interest in traditional marketing campaigns.

**Equipment** - No equipment was necessary for the completion of this project.

**Supplies** – Promotional items at the four conferences and other events continue to enhance the competitiveness of Missouri specialty crops. These promotional items with the tag line "Show Me Missouri Specialty Crops" are always a great hit. These particular items are especially effective as they do not get thrown away and are used by consumers when they are preparing specialty crops for consumption. While few growers liked the idea of increasing demand for product they could not deliver, most liked these items to give to their existing customers to build return demand and loyalty.

**Contractual (Marketing)** – Problems and delays occurred during the project and contractual marketing was not completed as it was determined early in the project and reported in the first annual report that:

- 1) Insufficient supply to support an increase in demand from advertising, as traditional retailers already could not find supply to meet local produce demand without the pressure created by additional advertising

- 2) Inability to identify the products in the store, as there is not a uniform labeling program in place for local produce that would allow sales results to be tracked to verify a 15% increase or for consumers to identify the product in stores if advertised
- 3) To reach the eight targeted markets, distribution from wholesalers needed to be coordinated to make sure the product was available at the time the product would meet the shelf and this would require request for proposals which the scopes in 1) and 2) above would have to be completed in order to issue,

### **Goals and Outcomes Achieved**

**Goal:** The goal of this project was to increase public awareness of the diversity, nutrition, availability, production, and affordability of Missouri specialty crops across eight regions between January and September of 2014.

While the education and outreach activities have been completed, when the marketing plan was being developed for the conventional advertising component, it became clear that some obstacles would keep the strategy from being effective. Problems and Delays detailed in the 2014 Grant Report is detailed below.

- 1) Insufficient supply to support an increase in demand from advertising, as traditional retailers already could not find supply to meet local produce demand without the pressure created by additional advertising
- 2) Inability to identify the products in the store, as there is not a uniform labeling program in place for local produce that would allow sales results to be tracked to verify a 15% increase or for consumers to identify the product in stores if advertised
- 3) To reach the eight targeted markets, distribution from wholesalers needed to be coordinated to make sure the product was available at the time the product would meet the shelf and this would require request for proposals which the scopes in 1) and 2) above would have to be completed in order to issue,
- 4) For a labeling program to be implemented, the traceability rule in the Food Safety Modernization Act (FSMA) needs to be finalized
- 5) In lieu of the messaging detailed in objectives five and six, advertising partners recommended working with the points of sale being promoted ensure a cohesive message and to leverage the research and efforts they are already performing in their current efforts.

After working with grocers, advertising agencies and distributors to determine the best solution to these problems was to develop a produce labeling and traceability program to assist growers with FSMA and ensure their products were identifiable on the shelf and in the marketplace prior to advertising. AgriMissouri staff has worked with all the necessary industry partners, regulatory agencies and Produce Traceability Initiative (PTI) – the agency drafting the rule for FSMA to develop such a program. However, due to a lack of final rules for FSMA, growers, distributors and retailers are not yet ready to finalize their plans while there is uncertainty in the regulatory requirements. As a result, MDA cannot create the rules to implement such a program and file them with the Secretary of State.

**Performance:** The performance will be measured by surveying key specialty crop producers (who want to participate in the promotion) to see if they have experienced an increase in sales volume during this time. Staff will also begin collaboration and possible surveying with the

Department of Elementary and Secondary Education to see if there is an increase in awareness and consumption with families who have their children in Missouri public school districts.

- 1) Inability to identify the products in the store, as there is not a uniform labeling program in place for local produce that would allow sales results to be tracked to verify a 15% increase or for consumers to identify the product in stores if advertised

**Benchmark:** As this is a new project, this information has not been acquired and will be determined during the advertising campaign.

- 1) In lieu of the messaging detailed in objectives five and six, advertising partners recommended working with the points of sale being promoted ensure a cohesive message and to leverage the research and efforts they are already performing in their current efforts.

**Target:** The target is for there to be an increase in awareness and interest in Missouri specialty crops of 75% and an increase in sales of 15% for those specialty crop producers participating in the promotion.

- 1) Insufficient supply to support an increase in demand from advertising, as traditional retailers already could not find supply to meet local produce demand without the pressure created by additional advertising

### **Beneficiaries**

The primary benefit of the small portion of this grant that was completed was realizing that it was not feasible in its written form, and what the constituents truly need was not implementable either, until the final produce rules for FSMA are published. While this was written to assist producers with their marketing, to expand their production, they could not make that expansion without clarity in the regulations.

Staff completing activities for this project estimate direct benefits to approximately 150 Missouri specialty crop producers through contact and information provided during the events. A undefined number of producers were benefited from materials received and reviewed at events without direct contact with staff.

In the end, everyone benefited from the outreach that was completed, as it prevented the department from spending money on marketing that would not have been effective. This will allow the remaining funds to be allocated to far more effective efforts.

### **Lessons Learned**

The most valuable lesson learned is that as a government, or interest group, one should not assume to know what is best for others (in this case retailers and producers) without asking them first. These programs should not be used as an internal promotion tool but for true researched, studied and verifiable marketing efforts. The programs should move the dial in the marketplace and the field with increased productivity for all, not just increase the number of people that grantee discussed specialty crops. The communication must have a purpose that is market based, not interest based.

### **Contact Person**

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### **Additional Information**

Total funds spent on project \$11,078.71

## **Project 11: “Missouri Grown” Specialty Crop Labeling and Branding**

**Missouri Department of Agriculture  
Ag Business Development**  
Alan Freeman  
Final Performance Report

### **Project Summary**

The primary purposes of this program are to: 1) Promote Missouri grown produce and specialty crop products with the “Missouri Grown” brand on boxes and packaging, 2) assist producers through the “Missouri Grown” brand, 3) assist consumers in identifying Missouri grown specialty crops and specialty crops products in the marketplace with the “Missouri Grown” seal and 4) provide cost share assistance to specialty crop producers for the purchase of boxes and packaging showing the “Missouri grown” seal.

Using the “Missouri Grown” brand on packaging for eligible specialty crops will enhance the competitiveness of these crops in the marketplace by allowing consumers to realize the purchase of locally grown fruits and vegetables and their products. Consumers are more interested in participating in buying locally produced and grown products to support the local economy, thus specialty crop producers using the “Missouri Grown” branding on their packaging will have another avenue to showcase their involvement with the local community.

The projects’ importance and timeliness was determined by the growing season. Producers were preparing for the planting and growing season and in turn purchasing packaging materials to utilize during the harvest season.

### **Project Approach**

The project approach was two-fold; first to provide outreach and information to Missouri specialty crop growers, producers and processors about the program and the opportunity for assistance through the program, secondly to provide outreach to consumers about how they can identify Missouri grown specialty crops and specialty crop products.

Missouri Department of Agriculture Ag Business Development staff developed the cost share program for implementation. The program provided specialty crop producers and value added processors cost share up to \$1,000 towards the costs of relabeling of packages and boxes with “Missouri Grown” branding.

Staff developed and posted a webpage for the cost-share program on the Missouri Department of Agriculture (MDA) website. Completed outreach and marketing activities to promote the program and the use of specialty crop labeling that identified Missouri grown specialty crop products. Outreach included; e-blasts to MDA list serves, participation in producer meetings, Missouri Farmers' Market Association Conference, Missouri State Fair, AgriMissouri govdelivery emails, site/farm visits with specialty crop producers, providing information at Farmers' Markets, through partner agencies and groups, KC Sourcelink Partner meetings, Missouri Agricultural Foundation, KC Healthy Kids Coalition, Naturally Meramec Consortium meeting, among others.

Staff then worked with specialty crop producers and processors to ensure they met the requirements of the cost-share program. Staff maintained positive communication with interested parties and feedback for correct documentation and application based on the cost-share guidelines.

Information about the program was provided to over 2,000 producers, processors and consumers from the efforts of 9 staff within the Ag Business Development Division, 3 staff from the Office of the Director, staff and members of Missouri Enterprise, and University of Missouri Extension program.

Missouri Enterprise staff provided considerable assistance disseminating information to specialty crop producers throughout Missouri during their contacts with growers and processors utilizing their services for value-added facilities.

The challenges faced working towards goals was the short timeline to accomplish objectives. Outreach and information dissemination through available channels were effective at getting information to the target audience however adoption of the labeling program took longer than anticipated. Many producers and processors of non specialty crop products were very interested in the labeling program and expressed considerable interest in participating in the program should it be made available to their sectors. This demonstrates the need and desire to identify products as locally/regionally grown or produced as these groups saw value in the program.

To ensure compliance with the grant program, labeling/packaging applications were submitted with evidence of the completed labeling of product which included imagery or submission of completed labeling/packaging completed through the program. Once the verification of correct application of the labeling/packaging program was verified, applicants were provided reimbursement for approved costs.

### **Goals and Outcomes Achieved**

The project goal was to provide cost-share assistance to 2% of producers that work to improve their labeling and branding programs. The desired measurable outcomes were for:

- 1) Improved labeling and branding for 2% of the 2,000 plus specialty crop producers.
- 2) Participation by 50 or more specialty crop producers, distributors and retailers.

The project goals were centered on improving labeling and branding of specialty crop producers with a participation expectation of 50 or more specialty crop producers, distributors and retailers. The quantifiable successes of the program were less than anticipated with 12 producers, processors or distributors participating in the cost share program. The successes that were not directly reported through cost share participation were significantly better.

The successes outside of the cost-share program included an improved awareness by consumers of Missouri grown/produced specialty crop products and how to identify the products on the shelf. Improved participation by retailers and improved conversations with retailers on how to procure specialty crop products for retail sales. Examples include the program has worked with 4 seasonal retailers that have added Missouri grown and produced products to their shelves this fall or intend to add products on their shelves in the next retail season. An improved understanding of consumers of the specialty crop products available to them through local retail outlets and how to better identify them for purchase. This was a central focus of the 3<sup>rd</sup> goal of the program to consumers in identifying locally/regionally grown specialty crop products through identifying products with the “Missouri Grown” seal.

The division will continue to promote Missouri Grown and produced specialty crop products through the use of the “Missouri Grown” seal and will continue to work with producers and retailers to utilize Missouri specialty crop products for easy access by consumers.

Ideally, the project needed more time to meet the expectations set out in the repurpose application, the efforts of staff to work with producers and consumers takes more time for effective turn around than had been anticipated. The project did provide assistance to specialty crop producers in developing new labeling and packaging materials with the “Missouri Grown” brand and did improve the ability of the average consumer to identify those locally/regionally produced products on the store shelf.

### **Beneficiaries**

The specialty crop producers and processors that benefitted directly from the project include produce and floral growers, apiaries, value-added producers of salsas, jams, jellies. Benefits included the financial assistance in developing labeling that accents their locally/regionally grown customer base, providing consumers an improved method for identifying locally/regionally grown and produced products. The potential economic impact is still being determined, the need to assess the success will take longer than the actual project timeline permits. As efforts continue, the division will work to assess the economic impact of the project.

The “Missouri Grown” Specialty Crop Labeling Program provided direct benefit to 12 Missouri specialty crop producers with updating their labeling and incorporating the Missouri Grown logo that helps identify the company and products of Missouri specialty crop producers. The project spurred additional interest from retailers Wal-Mart and Aldi that are planning to showcase Missouri specialty crop producers in the produce aisle in the coming year. The project generated enough interest that the Department’s Ag Business Development Division is offering a continuation of the Missouri Grown labeling program in the spring of 2017, funded by state resources.

### **Lessons Learned**

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

Ideally, more time should be devoted to a project of this scale, future projects with the same goals will be revised to allow the necessary time to assist producers that fall into the “early adopter” and “average adopter” categories for adopting new technologies and branding.

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### **Additional Information**

None