**Missouri Department of Agriculture**
**Specialty Crop Block Grant Annual Report**


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## Table of Contents

**Project 1: Leveraging Social Media as Farmers' Market Promotional Tools**
**University of Missouri**
**Final Performance Report**
**Dr. Joe Parcell and Dr. Mary Hendrickson**

***Project Summary***

The "Leveraging Social Media as Farmers Market Promotional Tools" project both identified and communicated easy-to-understand, easy-to-use social media strategies and best practices that farmers market organizers and vendors can adopt to begin or enhance a social media presence. Identifying and sharing these social media strategies and intelligence presents the opportunity for market vendors and organizers to build farmers market awareness and improve farmers' market attendance.

Two surveys were conducted to identify how farmers' market consumers use social media and assess how farmers market organizers and vendors involve social media in their current promotional mixes. The information obtained from both surveys was integrated into social media resources such as webinars and downloadable Extension Bulletin guide sheets. These resources are meant to provide ideas that farmers market organizers can use to promote their markets and their vendors' products. As the farmers markets incorporate social media tools into their promotional mixes, the intent is to provide new channels for farmers' market organizers and vendors to meaningfully connect with current and prospective customers and boost awareness of and attendance at farmers markets. Because of the social media guides and webinars, Missouri farmers markets are able to determine which social media practices they can adopt to achieve their promotional goals.

***Project Approach***

To determine social media strategies and best practices that farmers' market organizers can adopt to begin or enhance a successful social media presence, the Missouri Value Added Center at the University of Missouri developed and conducted two surveys. The first survey asked farmers market organizers to identify the social media and promotional activities that they use currently and measured the respondents' interest in learning more about social media tools that are available. More than half of respondents who organize farmers markets said that they use social media to promote their farmers markets. The most common forms of social media used by respondents who organize farmers markets were e-mail; social networks, such as Facebook and MySpace; and blogs. In cases when market organizers did not use social media, some cited the lack of appropriate training. Other respondents found social media were hard to understand, or they had limited time, which precluded them from using social media. Overall, respondents who organize farmers markets wanted to learn more about ways to begin or enhance social media efforts as a means of promotion. They were most interested in learning about website development, Facebook, YouTube, Twitter and blogging.

The second survey was meant to identify purchasing patterns of and social media use by Missouri farmers market consumers. Missouri consumers continue to show strong interest in buying locally grown fruits and vegetables directly from farmers or growers. According to the survey, consumers most commonly visit farmers markets monthly; 38 percent were monthly farmers' markets customers. Additionally, 25 percent of respondents visit farmers markets weekly, 22 percent visit bi-weekly, and 13 percent visit on rare occasions.

This is consistent with the continued growth of Missouri farmers markets, which have increased in number by 164 percent since 1997. Currently, 170 farmers markets operate in Missouri compared with 53 in 1997. According to consumers surveyed, most markets throughout the state do not operate year round but rather have seasons that begin in April and conclude by November.

To learn about farmers markets, consumers tend to reference word-of-mouth exchanges, newspapers and outdoor advertising more than other materials. Few learn about farmers' market news and updates via social media. However, social media awareness is high among the consumers surveyed. If farmers market organizers more frequently use social media to promote their markets, then consumers might depend more on social media to learn about farmers' market activities. Farmers market consumers tend to use Facebook, YouTube and MySpace more than other social media sites. Of those who do learn about farmers market news via social media, they're more likely to reference e-mail, social networks and blogs to learn about farmers markets than other forms of social media.

The information derived from the two surveys was analyzed and developed into University of Missouri Extension Publications and webinars. University of Missouri Extension Publications are available for viewing at: http://extension.missouri.edu/explorepdf/agguides/hort/g06227.pdf *Farmers Markets and Social Media: Social Media Use and Purchase Patterns of Missouri Farmers Market Consumers*

http://extension.missouri.edu/explorepdf/agguides/hort/g06228.pdf *Farmers Markets and Social Media: Promotional Media Use by Missouri Farmers Market Organizers*
http://extension.missouri.edu/explorepdf/agguides/hort/g06229.pdf *Using Social Media to Learn About Consumer Needs and Preferences*
Webinars may be requested by contacting Jill Fleischmann via e-mail at fleischmannJ@missouri.edu.

***Goals and Outcomes Achieved***
"Leveraging Social Media as Farmers Market Promotional Tools" goals:
1. Research social media preferences and behaviors of farmers market consumers and learn about the extent to which they would interact with farmers' market organizers and vendors in a social media environment.
*A survey was developed and administered by the Missouri Value Added Center at the University of Missouri to learn about the preferences and behaviors of Missouri farmers' market consumers. Data obtained was analyzed, and University of Missouri Extension Publications were developed from the material obtained. In addition to Extension Publications, webinars were created to share high-level survey findings and teach farmers market organizers and vendors about the capabilities of social media.*

2. Survey farmers market organizers and vendors to learn about their current use of social media and their comfort level with social media.
*A survey was developed and administered by the Missouri Value Added Center at the University of Missouri. The primary goal of the survey was to identify social media use by current farmers' market organizers and to evaluate their comfort with social media. The respondents identified that the most common forms of social media used by market organizers were e-mail; social networks, such as Facebook and MySpace; and blogs. Of the respondents who did not use social media, they felt if training resources were available, they would more likely be interested in social media and learn how to become more comfortable with social media tools*.

3. Study the data findings, and identify social media best practices and ideas, specific to farmers markets.
*The information obtained through both the Missouri farmers' market consumer survey and organizer survey was studied and analyzed by the Missouri Value Added Center at the University of Missouri. Data were compiled into software programs, which allowed for attractively displaying survey results and convenient viewing.*

4. Convey the social media best practices to farmers market organizers and Missouri Extension specialists via various outreach forms such as webinars, Extension Bulletins guide sheets and a website.
*Survey information that was studied and analyzed by the Missouri Value Added Center was developed into University of Missouri Extension Publications that are available online at:*
*http://extension.missouri.edu/explorepdf/agguides/hort/g06227.pdf,*
*http://extension.missouri.edu/explorepdf/agguides/hort/g06228.pdf and*
*http://extension.missouri.edu/explorepdf/agguides/hort/g06229.pdf. These publications offer detail about the project's research findings and ideas about social media best practices.*
*A series of 14 webinars were developed regarding social media tools and best practices. Each webinar focuses on social media tools available for farmers' market vendors and organizers and recaps highlights from the surveys. Some of the webinar topics include Facebook, YouTube, blogging, e-mail, Twitter and Google. Webinars are available upon request. Please contact Jill Fleischmann via e-mail at fleischmannj@missouri.edu to obtain a copy.*

***Beneficiaries***
The project has four beneficiary groups.
1. Farmers market organizers
2. Farmers market vendors
3. Extension specialists
4. Consumers

Farmers' market organizers and vendors at all Missouri farmers markets have access to the project's deliverables: webinars and online Extension Bulletin guide sheets. Therefore, the more than 140 Missouri farmers markets can utilize the data collected and best practices generated by this project. The webinars are directed to the farmers' market organizers and vendors. All Missouri Extension personnel that interact with farmers markets in their coverage areas can access the

requested webinars and the online Extension Bulletins. All Missouri consumers can benefit from the heightened attention focused on locally grown produce and where to find it.

***Lessons Learned***

Through the research conducted for this project, the Missouri Value Added Center staff identified that some Missouri farmers markets already use various forms of social media. These markets tend to use tools such as e-mail, social networks and blogs more than other social media forms. Some market organizers who do not currently integrate social media into their marketing efforts expressed that they don't have enough time to use the tools and that they need more demonstrations and instruction. The Missouri Value Added Center at the University of Missouri provided farmers market organizers and vendors with instructional webinars with step-by-step video instructions that teach about various forms of social media.

The farmers' market consumer survey showed strong interest from consumers to shop local and purchase from Missouri farmers markets. This coincides with the continued growth of farmers markets through the nation.

***Funding Expended To Date***

The University of Missouri has invoiced and received $20,079.00 of $20,079.00. There is a $0.00 balance for this grant project.

***Contact Person***

For more information regarding the "Leveraging Social Media as Farmers Market Promotional Tools" project, please contact Dr. Joseph Parcell at parcellj@missouri.edu or 573.882.8070.

***Additional Information***

The Extension guide sheets produced from this study have been reworked and sent to the *Journal of Extension* for publication as this research has sparked interest from different areas across the United States. Currently, the articles have been submitted to the JOE and are under review by the editor— These appear to never have been published at JOE.org

**Project 2: Educating from Seed to Market: Sustainable Heirloom Tomato and Lettuce**
**EarthDance**
**Final Performance Report**
**Molly Rockamann, EarthDance Founding Director**

***Project Summary***

This project focused on enhancing the competitiveness of sustainably-grown heirloom vegetables by increasing the number of new producers through an innovative apprenticeship program based in St. Louis, Missouri. As demand for locally and organically grown specialty crops has increased exponentially in recent years, the supply has only increased incrementally. There exists a substantial gap between the volume of organic vegetables and fruits supplied by area farmers, and that in demand by area consumers and large institutional purchasers. To narrow this gap, this timely and important project was designed to train beginner farmers in the production of a diverse array of vegetables and fruits with a specific emphasis on two high-value crops: heirloom tomatoes and lettuces. Training in greenhouse skills, the CSA distribution model and direct sales through farmers markets were incorporated into this project as a means of enhancing the competitiveness of the specialty crops grown by training new producers. While the project was only intended to span 1 year of the apprenticeship program, we have since continued the project and therefore have included some data from the second year.

***Project Approach***

- *Education of Beginning Farmers:*

EarthDance's 2010 Organic Farming Apprenticeship program had 31 participants enter the program in mid-February and 21 apprentices complete the 9-month program and graduate in mid-November.

In 2011, we began the season with 33 apprentices and 26 graduated. Over the course of the 9-month growing season, the apprentices engaged in first greenhouse and then field and greenhouse work; attended weekly enrichment sessions; went on educational field trips to local farms; assisted with the sales of produce at 2 farmers markets; and received training in Community Supported Agriculture (CSA) operations.

- *CSA Distribution Model:*

Early on, EarthDance made the decision to train the apprentices about CSA operations through an internal distribution system or pilot program for the 2010 season's CSA. In this relatively "lowerstakes" environment, EarthDance developed a CSA log and taught the apprentices how to coordinate and distribute CSA shares among themselves. The apprenticeship CSA began with 39 weekly shares; due to the natural attrition rate that occurred over the 9 months, the season ended with approximately 30 shares. The apprentices also got the chance to evaluate the CSA model and plans ways to improve the operation for the 2011 season.

In 2011, EarthDance expanded its CSA to a full 100 shares, including 40 allocated to apprentices, staff, and barter shares, and 60 allocated to the paying public. While this expansion allowed for the hiring of a full-time farm manager, it created a burdensome amount of pressure on both the EarthDance staff and apprentices. With the unfavorable weather conditions (wet cold spring + extremely hot and dry summer) and the misfortunes of the unpredictable used tractor we could afford, we had an extremely challenging growing season. Our yields for much of the season did not allow us to sell any produce at the farmers markets as it all needed to go to our CSA members. This meant that our apprentices missed out on a significant part of the training we'd planned to offer: interacting with the public directly at farmers markets. Despite the difficulties we experienced, our apprentices reported high satisfaction and mostly positive remarks regarding the value of the training program to them. In addition, though we refunded a few CSA members' payments due to dissatisfaction with quantities of produce, the vast majority of our members cite that they thoroughly enjoyed being a part of our first public CSA, and many are interested in renewing their membership.

- *Value-Added Product Development:*

Through the apprenticeship program's enrichment sessions, EarthDance created a series of "Preserving the Harvest" classes. In 2010, apprentices learned how to make and preserve salsa, pesto, and pickled okra. In 2011, apprentices learned how to can safely, how to make garlic jelly, and how to ferment vegetables to make sauerkraut. They also learned how to meet health department requirements for value-added products.

- *Demonstrates the Benefits of Locally and Organically Grown Food:*

During the 2010 growing season, EarthDance participated in the Live Well Ferguson Health Fair, promoted local foods at St. Louis Earth Day, the Green Homes Festival, Pesto Festo, and the Green Living Expo at the Missouri History Museum, presented at Slow Food St. Louis, hosted monthly community work parties and conducted many farm tours. EarthDance partnered with the Ferguson Cycling Club and Ferguson Community Gardens to present Tour and Taste, which was a bike tour of Ferguson's resident and community gardens, as well as the EarthDance farm. EarthDance also engaged in artistic collaborations. EarthDance partnered with the Northern Arts Council to host an En Plein Air painting session, which resulted in an exhibit of the farm-inspired artwork. EarthDance also participated in Art Dimensions' "Seeing Green," which was a bazaar for farmers and artists.

In 2011, EarthDance hosted Pesto Festo at the Ferguson Farmers Market, a family-friendly free event to encourage sustainable living practices and healthy eating. In addition, EarthDance participated in the Dutchtown Harvest Festival in honor of World Food Day, PARKing Day, the St. Louis Earth Day Festival, the Ferguson Earth Day celebration, the Food & Farmers Expo, and LouFest, a weekend-long music festival in Forest Park, St. Louis. In addition, EarthDance hosted numerous tours for groups as diverse as adults in a diabetic support group in St. Louis city to local high school students as part of a field biology class.

Significant Contributions & Role of Project Partners:

North County Technical High School contributed greenhouse and classroom space at no cost to EarthDance, as EarthDance does not have its own greenhouse nor classroom facilities. This enabled EarthDance to train apprentices in starting seeds in a greenhouse prior to the growing season, and to provide weekly enrichment sessions in a classroom environment before the weather was suitable for weekly field walks on the farm.

Maplewood Farmers Market provided a weekly farmers' market vendor space at no cost to EarthDance, and the Ferguson Farmers Market provided a discount on our annual vendor fee.

These two markets are not only markets at which to generate revenue for the apprenticeship program by selling produce and a real laboratory for our apprentices to learn direct sales at farmers markets, but also a community gathering space at which EarthDance is able to educate local residents about the benefits of eating locally- and sustainably-grown fresh foods.

St. Stephen's Episcopal Church contributed meeting, classroom, and kitchen space on a regular basis. This local church has been an excellent supporter of and partner to EarthDance for the past two years by providing us with a venue at which to host community potlucks, film screenings, enrichment sessions for our apprentices, info sessions about our CSA, and rainy day CSA pick-ups. They also have a food pantry for the community, so we've been able to assist their efforts in providing food to the needy by donating produce on a regular basis, including 1 CSA share during the 2011 growing season. Lincoln University was a partner by contributing extension staff that assisted with the delivery of enrichment sessions and overall planning of the curriculum.

Slow Food St. Louis contributed by offering a scholarship to an apprentice in our program, hosting the Meet the Farmer presentation via their SLOWednesday program, and publicizing our apprenticeship program and events to their members.

***Goals and Outcomes Achieved***

*Goal 1:* To increase knowledge and skills associated with organic vegetable production, from seed to market

*Performance measure:*

In 2009, we had 12 apprentices

In 2010, the target was to have 25, and we exceeded that goal at enrollment by starting the season with 31 apprentices. 21 apprentices completed the program.

In 2011, we started the season with 33 apprentices, and 26 apprentices graduated.

*Performance measure:*

# of weekly enrichment sessions, at which a different farming topic is covered

Our target was 36 enrichment sessions, and although the sessions were held weekly for 36 weeks, there were in actuality 33 sessions, due to holidays that fell on the days of the week that sessions are held (Mondays).

To ensure that the apprenticeship is making an impact through a demonstrated increase in the apprentices' knowledge and skills associated with organic vegetable production, progress was monitored via final evaluations.

Evaluations were used to modify the program as necessary to ensure its maximum educational impact.

*Measurable outcome:*

*Target:* 25 apprentices will have an increased understanding of organic vegetable production and heirloom tomato growing practices, as evidenced and quantified by the surveys and evaluations.

*Actual Measurable Outcome:* Over the two years of this project, EarthDance trained 64 apprentices, with 47 of those apprentices completing the 9-month training program.

*Goal 2:* To demonstrate an innovative model of marketing and distribution to beginner farmers – a full vegetable CSA and a Tomato Lover's CSA

*Note: EarthDance did not create a Tomato Lover's CSA. See Lessons Learned.

Performance toward meeting this outcome was measured through the number of CSA members participating in each year of the CSA (Target: 100), and the # of weeks that the CSA will distribute produce to its members (Target: 26).

*Actual Measurable Outcome:*

In 2010, EarthDance's CSA consisted of 30 - 39 shares, and lasted for 26 weeks.

In 2011, EarthDance's CSA consisted of 100 shares, and also lasted for 26 weeks.

Performance was also measured through the apprentices' learning of and participation in various components of the CSA process. Each year at least 3 enrichment sessions covered topics specifically relevant to the CSA model.

These enrichment sessions on how to create, market and execute a CSA, which sometimes included field trips to CSA farms, increased the apprentices' education of how to utilize the innovative CSA model to benefit their own farm enterprises.

*Goal 3:* To develop a value-added product for heirloom tomatoes, to demonstrate a method of attaining year-round farm income for beginner farmers

*Note: EarthDance did not create a value-added product due to unavailability of enough raw product to do so. *See Lessons Learned.*

Performance measure: # of EarthDance apprentices and SLU students engaged in this process

Performance measure: # of lbs produced, and # of units sold of value-added product

This goal was not met through this project in the form of actual development and sale of a value-added product. Instead performance was measured though the apprentices' learning of and participation in the process of creating value-added products, which was carried out each year through a Preserving the Harvest enrichment session.

*Goal 4:* To demonstrate to the greater St. Louis community the benefits of eating locally- and sustainably-grown fresh foods
Performance measure: # of major public outreach events (in addition to weekly farmers markets) done throughout the year, at which the benefits of eating locally and organically grown foods will be touted. (Target=5)
*Actual Measurable Outcome:* 16+ over two years
*See Activities Performed.*
Expected measurable outcome: An increased awareness of the greater St. Louis community on the benefits of eating locally and sustainably-grown fresh foods - measured by the number of major public outreach events that EarthDance participates in (minimum 5). This goal was significantly exceeded.

***Beneficiaries***

- 64 farmers-in-training participated in every aspect of this project – from starting the seeds in greenhouses, to cultivation in the field, to distributing and selling via CSA's and farmers markets, to developing value added products for year-round revenue. These individuals benefited greatly from the project, as they will be able to take what they've learned and implement it in their own operations in the near future, increasing the competitiveness of the specialty crop industry.
- 150+ families were beneficiaries of the exploration of a unique distribution model – a CSA – and gained an increased awareness of locally-grown foods through consumption, regular newsletters, and regular visits to the farm. (In 2011, many of the 60 public CSA shares were sold to two or more families.)
- 5000+ weekly shoppers at both the Maplewood and Ferguson Farmers Market are beneficiaries of the project, as the value of locally- and sustainably-grown produce was demonstrated to them in our display and through interaction with the apprentices selling at market
- 100 Slow Food St. Louis members, as they learned about the project through a "Meet the Farmer" dinner, slideshow, and lecture held one week after the Maplewood Farmers Market
- 150 community members who took a tour of the farm, as they learned about the production side of organic food and gained a greater appreciation for farming

***Lessons Learned***

- *CSA Distribution Model:* In late December of 2009, EarthDance realized that it had an apprentice with this prospect, EarthDance also recognized that its organization did not have the capacity to expand the apprenticeship program that dramatically and launch a public, 100-share CSA at the same time. By designing a pilot program CSA, however, that was predominantly for the apprentices, EarthDance could still incorporate CSA coordination and distribution into the apprentices' education. This model that EarthDance adapted also provided the apprentices the opportunity to be both the operators and the consumers of the CSA, which placed them in a unique position of full understanding and allowed them to eat and develop recipes for all of EarthDance's vegetables and fruits. Another result of this welcomed increase in the size of the 2010 apprenticeship program is that Karrie Johnson, a graduate of the 2009 program, felt that she was not qualified to be the farm manager. EarthDance appreciated Ms. Johnson's honesty and timeliness in leaving the position, especially since it led to the hiring of Vicki Lander, who was a highly qualified farm manager and took on some important leadership roles within the organization.

However, Ms. Johnson's departure from the organization meant that the Tomato Lovers' CSA, which was Ms. Johnson's project, was no longer part of EarthDance. The loss of projected revenue from the shares of the CSA and the Tomato Lovers' CSA also meant that EarthDance could no longer afford to pay for a videographer to shoot, edit, and produce 35 weekly educational online videos around CSA operations. In 2011 after expanding to a 100-member CSA in order to better meet the revenue needs of our young organization, we realized that the intense focus needed to sustain the production needs for a 100 CSA shares on a weekly basis did not enable us to focus on our best product, which is our Organic Farming Apprenticeship program. This has guided our decision to reduce the # of acres we are cultivating this year, as well as the number of CSA shares promised and sold.

- *Value-Added Product Development:* With the absence of Ms. Johnson's Tomato Lovers' CSA and the summer's unfavorable growing conditions for tomatoes in general, EarthDance saw that it did not have enough tomatoes to collaborate with St. Louis University (SLU) on value-added product development. The large-scale of SLU's processing facility was just not appropriate for what EarthDance was able to do

with its tomatoes in 2010. Instead, EarthDance dedicated one of its Preserving the Harvest enrichment sessions to making and canning salsa in St. Stephen's Episcopal Church's kitchen.

Overall, the greatest lesson learned with this project has been that more education of beginning farmers is needed, which is why we are proud to be entering our 4th season of training new growers this season (2012). We are very grateful for the support of the Missouri Department of Agriculture, and all of our partners and funders. Without this grant, we would not have been able to expand our capacity to serve so many eager individuals with their move into the field of sustainable agriculture.

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**Project 3: Assessing the Impact of Canopy Architecture, Microclimate and Cluster Exposure on the Norton Grape**
**University of Missouri**
**Final Performance Report**
**Dr. Keith Striegler**
**$1620.64 was not used of the $37,500 and the $2500.00 was not needed for this project.**
**$4120.64 is the total unused. This is going to go to Personal Service for the Program Contact as long as Missouri Department of Agriculture accounting approves and funds were obligated prior to September 30, 2012. This will be reflected in the SF-425 reporting.**

**Dr. Mary Ann Gowdy**
***Project Summary***
The overriding purpose of this project is to enhance the competitiveness of Missouri-grown Norton grapes and wines by assessing the canopy architecture and investigating means of maximizing fruit and resulting wine quality. From an enological standpoint, Norton presents a challenging combination of high acidity, high pH and high malic to tartaric acid ratio. Extensive research has been already initiated to address these challenges with canopy management studies but somewhat inconclusive results suggest deeper, more fundamental research is necessary to develop strategies to maximize fruit quality. The proposed project will assess the impact of row orientation and canopy management practices on canopy architecture and fruit microclimate of Norton grapevines in different regions of Missouri. The project will also examine the impact of exposing Norton grape clusters to sunlight. Together, these parameters may be integrated to maintain vine balance, optimize sunlight interception and adjust fruit exposure to improve yield, fruit and subsequent wine quality of Norton grapevines. The importance of the proposed project is narrated in detail below.

***a. Assessment of canopy architecture and microclimate of Norton grapevines grown in different regions of Missouri:***
Training and trellising systems are primary determinants of the light environment within grapevine canopies. Secondary impacts on fruit quality are made by canopy management practices such as shoot positioning, shoot thinning and leaf removal either alone or in combination with row orientation. Row orientation interacts with these practices by affecting light absorption and through the effects of wind "drift" on the grapevine canopy (Tarara and Hoheisel, 2009). Several workers have concentrated their research on the light environment within the grapevine canopies and the physiological responses attributed to environmental parameters such as light and temperature. The conclusions of those studies have revealed that treatments which increase fruit and leaf exposure to sunlight generally improve grape and wine composition. Sunlight-exposed fruits generally exhibited high concentration of sugars, anthocyanins, total phenolics and lower levels of malic acid, potassium and juice pH compared to fruits ripened in a shaded canopy. Thus, the relationship between available leaf area, the canopy light environment and fruit and wine composition has been established for several winegrape cultivars.

Norton is being cultivated in numerous regions of Missouri under different soil and climatic conditions. Due to its vigorous and procumbent growth habit, it is typically established on a high bilateral cordon training system. Canopy management practices that may improve yield, vine balance and fruit composition of Norton grapevines include shoot thinning, leaf removal and shoot positioning or a combination of any of these three practices. The microclimatic conditions under these canopy management practices will vary regionally, and it is necessary to assess changes in canopy architecture that result from utilization of these techniques to develop recommended practices for given climatic conditions. Although some researchers have made limited investigations into optimizing Norton yield and fruit quality (Main and Morris, 2004; Main and Morris, 2008), little published literature is available from comprehensive studies of canopy architecture, fruit microclimate, or canopy management practices on Norton. As a result, recommended canopy management practices for Norton grapevines are presently tentative. Accordingly, there is a need to assess canopy architecture with respect to light penetration in different layers of canopy such as the fruit zone, above and below the cluster, and also to study the influence of canopy microclimate on fruit composition. The ICCVE began ongoing Norton canopy managements in three regions of Missouri in 2006 but has previously been unable to fund the detailed research necessary to quantify the light microclimate and canopy architecture. This proposal seeks to expand these ongoing experiments to include such measurements. Similar work previously performed on other wine grape cultivars is narrated below.

Lauran et al. (2008) highlighted the problems of adopting training systems to both the canopy architecture of specific cultivars and climate and concluded that the free standing system of training had higher light interception and sunlit leaf area (SLA) than the vertical shoot position system, which in turn enhances fruit illumination for cultivars with procumbent shoots. Kliewer and Dokoozlian (2005) clearly showed in their field experiments including a large range of trellis and training systems that leaf area / fruit weight ratio required for fruit ripening to a given level decreased as the proportion of SLA increased. Kliewer and Smart (1989) reported that Cabernet franc berries exposed to 0.07 red: far red light ratio (R: FR) were lower in both sugar and anthocyanin compounds than fruit exposed to 0.62 R: FR. Dokoozlian and Kliewer (1995) reported that photosynthetic photon flux density (PPFD) in the canopy interior was reduced to 1% or less than ambient, while F: FR and sun flecks were 10% or more of their ambient values when leaf area was $\leq 4$ $m^2$ $m^{-1}$ canopy length. Tarara et al. (2008) concluded that anthocyanin accumulation and the anthocyanin profile of Merlot berries appear to be determined by a synergistic combination of solar radiation and berry temperature. Hunter et al. (2004) recorded improved light conditions in the canopy through leaf thinning without a noticeable effect on other microclimate parameters such as cluster and berry sap temperature. Treatments with leaf thinning impacted the fruit by increasing titratable acidity (T.A.), reducing pH, and increasing the glucose and fructose concentration without changing their ratios.

Judicious adjustment of the architecture of the leaf canopy also has physiological implications that nearly always modify the source: sink relationships of the grapevine and can make simultaneous improvements in photosynthetic activity and export of photo-assimilates from leaves to sinks such as berries. Sunlight intensity in the grapevine canopy fruiting zone has been shown to strongly correlate with key fruit composition parameters such as sugars, acids and variety of secondary metabolites involved in wine flavor and aromas including phenolics, methoxypyrazines, volatile compounds, etc. For these reasons, many grapevine canopy management practices are intended to manipulate the PPFD of the fruiting zone or the distribution of photon flux across the total leaf area of the canopy to achieve the desired metabolic effect. Point quadrant analysis (PQA) has previously been used by numerous researchers to characterize canopy architecture of grapevines trained to numerous trellis systems. PPFD is normally measured directly through use of a ceptometer placed at the location of interest. Measurement of both PQA and PPFD is relatively simple and easy to perform.

Considering the results obtained by several workers on canopy microclimate assessment under different training systems and canopy management practices in several other winegrape cultivars, it is apparent that microclimate assessment and canopy management studies of Norton are largely incomplete. Hence, this work is proposed to: 1) examine the relationship between training system, row orientation and canopy management practices, 2) assess the impact(s) of this relationship on the canopy architecture of Norton grapevines, and 3) determine the effect of canopy architecture via modified fruit microclimate on vine metabolism, fruit maturation and berry composition of Norton grapevines.

***b. Influence of cluster exposure to the sun on fruit composition of Norton grapes:***

We propose to conduct a second year of data collection in a study entitled "Influence of cluster exposure to the sun on fruit composition of Norton grapes" which was funded through this program for 2009 (data collection is presently under way). A Norton vineyard located in Gasconade County, MO will be used for this study with treatments including clusters

exposed to full sunlight, partial sunlight and fully shaded clusters in two different row orientations. More precise measurements of berry temperature and light intensity will be taken to examine berry metabolism under different light exposures. Analysis of phenolic compounds and anthocyanin profiles through high performance liquid chromatography (HPLC) will be conducted during the second year of this study in addition to the organic acid and sugar analysis that will be performed in 2009.

Microclimate variables such as light interception contribute to the variability in fruit composition and maturity normally seen among clusters of grapevines. There has been growing interest in defining the field conditions, especially canopy microclimate, that influences color development in grapes and by extension in wine (Cortell et al., 2007, Downey et al., 2004, Spayd et al., 2002). Spayd et al. (2002) also demonstrated the separate effects of solar radiation and temperature in the field on the concentration of individual and total skin anthocyanins in *Vitis vinifera L.* cv. Merlot at commercial maturity. Exposed fruit in the vine canopy normally have higher soluble solids and lower malate and titratable acidity than fruits from shaded fruit (Reynolds, 1986). Bergqvist et al. (2001), through their studies on the sunlight exposure and temperature effects on berry growth and composition of Cabernet Sauvignon and Grenache, suggested that the effects of light on fruit composition are heavily dependent upon the extent to which berry temperature is elevated as a result of increased sunlight exposure. In contrast to this, by artificially excluding light from selected clusters of 40 red and black varieties of *Vitis vinifera*, Weaver and McCune (1960) were unable to detected significant differences in titratable acidity, soluble solids or visual fruit coloration. Berry temperature in the field is largely regulated by the flux density of absorbed radiation and convective heat loss and has been shown to increase linearly with incident radiation. Kliewer and Lider (1968) reported that the temperature of sunlight exposed Thompson Seedless berries was 3-8$^0$C greater compared to berries in shade. Shaded clusters accumulated more potassium from veraison through harvest in Cabernet Sauvignon grapes than exposed clusters (Morrison and Noble, 1990). Increased shade markedly reduced ripening causing reduced sugar, phenol and anthocyanin concentration, and increased levels of titratable acidity, malic and tartaric acids.

UV radiations play a relevant role in grape vines in the production of certain important chemical compounds directly responsible for yield and wine quality. Grifoni et al. (2008) reported that row orientation of the vines had a pronounced effect on the global photosynthetically active radiation (PAR) received by the two sides of the rows and to a lesser extent UV-A and UV-B. UV-B/PAR and UV-A/PAR ratios were also affected with potential consequences on physiological process.

Thus, the titratable acidity, pH, malic acid, and potassium content of Norton juice may potentially be improved through wise selection of row orientation and use of optimal canopy management practices.

***Project Approach***

The 2010 season activity in the four experiments funded by this project commenced in January with pruning of the experiments near Purdy and Boone County. Pruning of the two experiments near Gasconade County was completed in March. The three canopy management experiments near Barry County, Boone County, and Gasconade County were shoot thinned once per location in early May, followed by four rounds of shoot positioning and leaf removal in May through August to maintain the experimental treatments. Cluster exposure treatments were initially imposed in June in the cluster exposure experiment near Gasconade County, and weekly maintenance was performed to maintain the integrity of these treatments through harvest.

Three measurements of cluster light exposure were made in the Gasconade County cluster exposure experiment, beginning on August 13 (shortly before veraison) and ending on September 13 approximately one week before harvest. Cluster temperatures were measured on September 12 and 21.

Assessments of canopy architecture and fruit microclimate in the canopy management experiments were made in mid-September near Barry County, late September near Gasconade County, and concluded on October 4 near Boone County. These data were collected shortly before commercial harvest in all three locations to assure presence of a full leaf canopy and fair representation of the entire growing season.

Sampling and harvest data collection in the four experiments was completed on the following dates:

- Barry County canopy management experiment: September 19
- Gasconade County cluster exposure experiment: September 22
- Gasconade County canopy management experiment: September 27
- Boone County canopy management experiment: October 6

Basic fruit composition was determined within 48 hours after sampling for all four experiments. A second sample from each treatment was also frozen immediately after sampling to facilitate subsequent determination of anthocyanins, phenols, and tannins through spectrophotometric means and organic acids and carbohydrates by high performance liquid chromatography (HPLC). Spectrophotometric measurements were completed on December 8. Review and summarization of the HPLC and mineral analysis data was completed by January 15, 2011. Pruning data was collected prior to March 2011 for all four plots. Data were analyzed using SAS statistical software (version 9.1 and 9.2; SAS Institute, Cary, NC). Tukey's studentized range test was used to separate means between different treatments.

***Goals and Outcomes Achieved***

***a. Assessment of canopy architecture and microclimate of Norton grapevines grown in different regions of Missouri:***

The proposed projects were initiated to achieve the following objectives:

1. Examine the relationship between training system, row orientation and canopy management practices
2. Assess the impact(s) of this relationship on the canopy architecture of Norton grapevines
3. Determine the effect of canopy architecture via modified fruit microclimate on vine metabolism, fruit maturation and berry composition of Norton grapevines.

*Location: Barry County, MO*

Results from 2009 and 2010 seasons of the study are given below:
Overall, vine size at this site was low and in decline since the Easter Freeze of 2007. Treatment effects on yield were inconsistent (Tables 1 & 7). Shoot positioning reduced vine size (2 & 8). Leaf removal, and to a lesser extent shoot positioning, resulted in greater cluster exposure (Tables 5, 6, 11 & 12). Canopy asymmetry occurred but did not influence fruit composition or yield (Tables 1, 3, 4, 7, 9 & 10). Minor but significant canopy assessment effects on fruit composition were generally observed on full treatment vines.

*Location: Boone County, MO*

Results from 2009 and 2010 seasons of the study are given below:
Vine size at this site was generally high. There were no consistent treatment effects on yield (Tables 13 & 19). Consistent with the Barry County site, shoot positioning reduced vine size (Tables 14 & 20). Leaf removal enhanced cluster exposure (Tables 17, 18, 23 & 24). Canopy asymmetry occurred but didn't consistently affect fruit composition or yield (Tables 13, 15, 16, 19, 21 & 22). Significant canopy management effects on fruit composition were generally observed on full treatment, leaf removal, and shoot positioning + leaf removal vines (Tables 15, 16, 21 & 22).

***b. Influence of cluster exposure to the sun on fruit composition of Norton grapes:***

*Location: Gasconade County, MO*

The proposed project was initiated to achieve following objectives:

1. Understanding the importance of light and temperature (canopy microclimate) on fruit composition of Norton grapes
2. Manipulating canopy for optimization of light exposure to bunches
3. To improve fruit composition of Norton in terms of soluble solids, pH, titratable acidity and nutraceutical properties
4. Maximizing the net returns to growers and wine makers by improving fruit quality

Results from the both seasons of the study are given below:
The 2009 and 2010 were seasons were distinctly different. The 2009 season was generally much cooler with 3,313 growing degree days (GDD50). Conversely, 4,133 GDD were accumulated during the 2010 season. In addition, the ripening period of 2010 was warmer resulting in an earlier harvest date of September 24 when compared to the October 13 harvest date in 2009. Cluster exposure status had a greater impact on fruit composition than canopy side. For North-South oriented row, fully exposed clusters had higher soluble solids and lower titratable acidity, malic acid, and juice potassium content than fully shaded clusters in 2009 (Tables 25 & 26). The 2010 season produced slightly different results. Percent soluble solids and tannins were higher while pH, titratable acidity, malic acid content, and juice potassium content were lower in fully exposed than fully shaded fruit (Tables 27 & 28). Anthocyanin content was highest for partly exposed fruit for 2010 (Table 3). For East-West oriented rows, fully exposed clusters had higher soluble solids and lower titratable acidity, malic acid, and juice potassium content than fully shaded clusters in 2009 (Tables 29 & 30). Slightly

different results were obtained for the 2010 season. Fully exposed clusters displayed higher soluble solids, lower pH, titratable acidity, malic acid content, and juice potassium content than fully shaded clusters (Tables 31 & 32). Anthocyanin content was highest for partly exposed fruit for 2010 (Table 31). Fruit grown in the warmer 2010 season tended to exhibit a greater response to cluster exposure that fruit from the cooler 2009 season (Tables 33 & 34). Full or partial exposure of Norton clusters contributed to improved Norton fruit composition except for anthocyanin content. Anthocyanin content of fruit was increased by partial exposure in the warmer 2010 season.

***Beneficiaries***

Norton is the state grape of Missouri and also widely planted in many Midwestern states. There are approximately 300 acres of Norton planted in Missouri. Improved fruit and wine quality would increase the competitiveness of Norton wines for the 98 wineries currently licensed in Missouri, half of which offer at least one wine based upon Norton and are now competing in the competitive global wine market. Increased sales of Norton wine will likely to drive more sales of all Missouri wines due to the high profile of this wine based upon it being the flagship wine grape of Missouri. The results of the present project can be disseminated to all the Norton grape growers to improve the fruit quality of Norton in terms of balancing the acidity and pH by various canopy management practices to optimize the quantity of sunlight recorded by clusters. The results have been disseminated at the 2010 Viticulture Field Day in Hermann, Missouri and the 2011 Midwest Grape and wine conference in St. Charles, Missouri. The results will also be published in scientific journals for the benefit of colleagues involved in Norton research. Furthermore, this project will support the marketing efforts of the Norton Says campaign currently underway by the Missouri Wine and Grape Board. Concurrently, this would enable Missouri wineries to offer higher fruit price to growers, thereby improving the entire wine industry's financial position.

***Lessons Learned***

Results from this study clearly indicate the significant influence of sunlight intensity on fruit composition of Norton grapes. The row orientation in which vines are planted plays a large role in determining the amount of sunlight intercepted by the vine canopy. It is clearly established from this study that light intensity and berry temperature are two interdependent factors. Though no significant difference was observed for cluster zone air temperature, a significant difference was observed for berry temperature at different exposure levels. The influence of light and temperature were clearly reflected in several berry composition parameters such as soluble solids, titratable acidity, potassium content, juice sugars and organic acids, tannins etc. Furthermore, the results obtained in this study indicated that optimizing canopy management practices such as shoot thinning, shoot positioning and leaf removal to attain good exposure of clusters to sunlight can lessen the problems associated with Norton grapes such as high TA, high juice pH with respect to increased accumulation of malic acid and juice potassium. The 2009 season was characterized by cool and wet conditions with few days having high light intensity or temperature. The extremely high titratable acidity in fruit during 2009 is a good indicator of the environmental conditions this season. The 2010 season was much warmer and shorter due to higher temperatures during ripening. The comparison of these two different years helped to get a better understating of how Norton reacts to different climatic conditions.

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***Additional Information-*** *See Tables below*

**Table 1. Effect of canopy management treatments on yield and yield components of Norton grapevines by canopy side and treatment. Barry County, MO. 2009**

| | Yield (lbs/vine) | | Yield (tons/A) | | Yield/ ft | | Clusters /vine | | Cluster/ ft | | Cluster wt (lbs) | | Berry no./ cluster | | Berry wt (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | | | | | | |
| East | 6.89 | a[y] | 1.87 | a | 0.78 | a | 56 | a | 6.4 | a | 0.12 | | 57 | | 0.99 |
| West | 5.53 | b | 1.50 | b | 0.62 | b | 44 | b | 4.9 | b | 0.13 | | 58 | | 1.00 |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.0553* | | *0.2180* | | *0.8909* |
| **Treatments** | | | | | | | | | | | | | | | |
| Control | 7.52 | ab | 2.05 | ab | 0.86 | a | 62 | a | 7.0 | a | 0.123 | abc | 57 | ab | 0.98 |
| LR | 6.75 | abc | 1.84 | abc | 0.78 | abc | 57 | ab | 6.6 | ab | 0.118 | bc | 55 | ab | 1.00 |
| SP | 7.68 | a | 2.09 | a | 0.84 | ab | 61 | a | 6.7 | ab | 0.127 | abc | 57 | ab | 1.04 |
| ST | 5.91 | abc | 1.61 | abc | 0.65 | bcd | 48 | abc | 5.2 | bc | 0.124 | abc | 59 | ab | 0.95 |
| SP+LR | 5.41 | c | 1.47 | c | 0.65 | bcd | 48 | abc | 5.7 | abc | 0.113 | c | 53 | b | 0.99 |
| ST+LR | 5.65 | bc | 1.54 | bc | 0.62 | cd | 44 | bc | 4.8 | c | 0.129 | ab | 61 | a | 0.96 |
| ST+SP | 5.62 | c | 1.53 | c | 0.65 | bcd | 41 | c | 4.7 | c | 0.136 | a | 61 | a | 1.02 |
| ST+SP+LR | 5.14 | c | 1.40 | c | 0.57 | d | 40 | c | 4.4 | c | 0.127 | abc | 57 | ab | 1.02 |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.0005* | | *0.0044* | | *0.0907* |
| ***Side*Treatment*** | *0.7558* | | *0.7558* | | *0.7441* | | *0.4773* | | *0.4536* | | *0.9017* | | *0.8763* | | *0.9979* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 2. Effect of canopy management treatments on vegetative growth of Norton grapevines by canopy side and treatment. Barry County, MO. 2009**

| | Pruning wt/ vine (lbs) | | Pruning wt (lbs)/ft | | Canes/ vine | | Canes/ ft | | Ravaz index | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 1.06 | a[y] | 0.12 | a | 30 | a | 3.40 | a | 7.5 | b |
| West | 0.74 | b | 0.09 | b | 19 | b | 2.21 | b | 9.5 | a |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0102* | |
| **Treatments** | | | | | | | | | | |
| Control | 0.94 | bc | 0.11 | abc | 24 | | 2.8 | | 8.2 | bc |
| LR | 0.94 | bc | 0.11 | abc | 24 | | 2.8 | | 7.8 | bc |
| SP | 0.56 | c | 0.06 | c | 26 | | 3.0 | | 15.5 | a |
| ST | 1.24 | ab | 0.13 | ab | 24 | | 2.6 | | 5.5 | bc |
| SP+LR | 0.76 | c | 0.09 | bc | 27 | | 3.3 | | 8.9 | bc |
| ST+LR | 1.39 | a | 0.15 | a | 23 | | 2.5 | | 4.6 | c |
| ST+SP | 0.65 | c | 0.07 | c | 24 | | 2.8 | | 9.9 | b |
| ST+SP+LR | 0.70 | c | 0.08 | c | 25 | | 2.7 | | 7.7 | bc |
| *P=* | *<.0001* | | *<.0001* | | *0.1660* | | *0.1660* | | *<.0001* | |
| ***Side*Treatment*** | *0.7963* | | *0.7270* | | *0.0763* | | *0.0763* | | *0.7614* | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 3. Effect of canopy management treatments on fruit composition and color of Norton grapevines by canopy side and treatment. Barry County, MO. 2009**

| | %SS (brix) | Juice pH | TA (g/L) | Anthocyanins (mg/g) | Phenols (AU/g berry) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Side** | | | | | | |
| East | 21.9 | 3.39 | 15.63 | 3.27 | 2.83 | 2.67 |
| West | 22.3 | 3.40 | 15.62 | 3.27 | 2.75 | 2.46 |
| *P=* | *0.1095* | *0.8465* | *0.9623* | *0.9828* | *0.4395* | *0.1734* |
| **Treatments** | | | | | | |
| Control | 22.8 | 3.44 a[y] | 15.44 | 2.95 b | 2.74 | 2.47 |
| LR | 22.5 | 3.41 ab | 15.27 | 3.45 ab | 2.76 | 2.69 |
| SP | 21.9 | 3.37 b | 15.90 | 3.07 ab | 2.73 | 2.67 |
| SP+LR | 21.6 | 3.39 b | 15.83 | 3.50 ab | 2.71 | 2.56 |
| ST | 22.0 | 3.43 a | 15.85 | 3.10 ab | 2.78 | 2.31 |
| ST+LR | 21.9 | 3.40 ab | 15.73 | 3.60 a | 2.94 | 2.84 |
| ST+SP | 21.6 | 3.36 b | 15.68 | 3.19 ab | 2.77 | 2.22 |
| ST+SP+LR | 22.1 | 3.36 b | 15.31 | 3.28 ab | 2.85 | 2.73 |
| *P=* | *0.1855* | *0.0066* | *0.7325* | *0.0178*[z] | *0.9521* | *0.4270* |
| ***Side*Treatment*** | *0.9997* | *0.6036* | *0.6026* | *0.8328* | *0.7121* | *0.9825* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 4. Effect of canopy management treatments on organic acids and sugars of Norton grapevines by canopy side and treatment. Barry County, MO. 2009**

| | Citric (g/L) | Tartaric (g/L) | | Malic (g/L) | Glucose (g/L) | | Fructose (g/L) | | Juice K (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | |
| East | 0.56 | 10.14 | b[y] | 3.97 | 75.76 | b | 117.63 | b | 2773 |
| West | 0.57 | 10.44 | a | 3.93 | 105.74 | a | 143.68 | a | 2568 |
| *P=* | *0.2191* | *0.0026*[z] | | *0.8997* | *<.0001* | | *<.0001* | | *0.0001* |
| **Treatments** | | | | | | | | | |
| Control | 0.55 | 10.01 | b | 3.81 | 94.65 | | 135.15 | | 2811 |
| LR | 0.54 | 10.26 | ab | 3.54 | 92.36 | | 132.85 | | 2713 |
| SP | 0.53 | 10.09 | ab | 3.81 | 90.27 | | 130.95 | | 2619 |
| ST | 0.59 | 10.28 | ab | 4.02 | 88.19 | | 128.92 | | 2795 |
| SP+LR | 0.56 | 10.66 | a | 3.71 | 88.79 | | 128.22 | | 2599 |
| ST+LR | 0.60 | 10.53 | ab | 4.88 | 89.43 | | 128.92 | | 2709 |
| ST+SP | 0.58 | 10.19 | ab | 4.53 | 90.26 | | 129.59 | | 2600 |
| ST+SP+LR | 0.55 | 10.27 | ab | 3.29 | 92.05 | | 130.65 | | 2517 |
| *P=* | *0.0254* | *0.0239* | | *0.2320* | *0.5636* | | *0.6685* | | *0.0525* |
| ***Side*Treatment*** | *0.9929* | *0.6875* | | *0.9984* | *0.9501* | | *0.9805* | | *0.6617* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 5. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side and treatment. Barry County, MO. 2009**

| | % Ambient light | | % Gap | | LLN | | PIC | | PIL | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 33.16 | a[y] | 20.35 | a | 1.14 | b | 56.35 | b | 31.30 | b |
| West | 7.24 | b | 3.61 | b | 1.75 | a | 91.05 | a | 45.04 | a |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| **Treatment** | | | | | | | | | | |
| Control | 3.47 | c | 1.39 | c | 2.12 | a | 95.37 | a | 52.87 | a |
| LR | 25.48 | b | 19.44 | b | 0.96 | c | 54.10 | b | 29.65 | b |
| SP | 8.66 | c | 0.83 | c | 1.87 | b | 96.10 | a | 46.82 | a |
| ST | 7.75 | c | 0.83 | c | 2.19 | a | 98.56 | a | 53.84 | a |
| SP+LR | 36.21 | a | 20.83 | ab | 0.93 | cd | 52.84 | b | 27.38 | b |
| ST+LR | 26.44 | b | 21.94 | ab | 1.05 | c | 56.45 | b | 31.63 | b |
| ST+SP | 12.30 | c | 4.44 | c | 1.76 | b | 91.32 | b | 46.46 | a |
| ST+SP+LR | 41.26 | a | 23.11 | a | 0.69 | d | 44.84 | b | 16.70 | c |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| ***Side*Treatment*** | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |

LLN; Leaf layer number; PIC: percent interior cluster; PIL: Percent interior leaf

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 6. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side by treatments. Barry County, MO. 2009**

| Treatment | Side | Control | LR | SP | ST | SP+LR | ST+LR | ST+SP | ST+SP+LR |
|---|---|---|---|---|---|---|---|---|---|
| % Ambient light | East | 3.36 | 44.53 | 1.11 | 8.33 | 61.50 | 49.89 | 15.54 | 69.68 |
| | West | 3.59 | 6.43 | 0.56 | 7.18 | 10.91 | 2.99 | 9.06 | 12.84 |
| | *Significance* | *0.8859* | *<.0001* [z] | *0.0145* | *0.8045* | *<.0001* | *<.0001* | *0.1462* | *<.0001* |
| % Gap | East | 0.56 | 35.00 | 12.42 | 0.00 | 38.89 | 40.00 | 1.67 | 45.56 |
| | West | 2.22 | 3.89 | 4.90 | 1.67 | 2.78 | 3.89 | 7.22 | 6.67 |
| | *Significance* | *0.3605* | *<.0001* | *0.5490* | *0.3409* | *<.0001* | *<.0001* | *0.0101* | *<.0001* |
| LLN | East | 2.36 | 0.17 | 1.91 | 2.28 | 0.24 | 0.19 | 1.87 | 0.13 |
| | West | 1.88 | 1.76 | 1.82 | 2.09 | 1.61 | 1.92 | 1.65 | 1.24 |
| | *Significance* | *0.0024* | *<.0001* | *0.5559* | *0.2828* | *<.0001* | *<.0001* | *0.0148* | *<.0001* |
| PIC | East | 100.0 | 16.21 | 97.92 | 99.24 | 11.86 | 16.66 | 100.00 | 8.95 |
| | West | 90.7 | 92.0 | 94.29 | 97.88 | 93.82 | 96.30 | 82.64 | 80.73 |
| | *Significance* | *0.1692* | *<.0001* | *0.3800* | *0.4017* | *<.0001* | *<.0001* | *0.0347* | *<.0001* |
| PIL | East | 57.4 | 12.8 | 47.81 | 55.86 | 13.69 | 13.10 | 46.95 | 2.78 |
| | West | 48.4 | 46.5 | 45.83 | 51.82 | 41.06 | 50.16 | 45.97 | 30.62 |
| | *Significance* | *0.0053* | *<.0001* | *0.6323* | *0.2656* | *<.0001* | *0.0013* | *0.6731* | *<.0001* |

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 7. Effect of canopy management treatments on yield and yield components of Norton grapevines by canopy side and treatment. Barry County, MO. 2010**

| | Yield (lbs/vine) | Yield (tons/A) | Yield/ ft | Clusters/ vine | Cluster/ ft | Cluster wt (lbs) | Berry no./ cluster | Berry wt (g) |
|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | |
| East | 5.71 | 1.55 | 0.63 | 51 | 5.6 | 0.114 | 57 | 0.90 |
| West | 5.67 | 1.54 | 0.63 | 49 | 5.4 | 0.115 | 57 | 0.92 |
| *P=* | *0.8813* | *0.8813* | *0.9010* | *0.5262* | *0.5649* | *0.5813* | *0.9687* | *0.3928* |
| **Treatments** | | | | | | | | |
| Control | 6.06 | 1.65 | 0.67 | 55 ab[y] | 6.1 | 0.110 ab | 54 | 0.92 |
| LR | 5.87 | 1.60 | 0.65 | 53 ab | 5.9 | 0.111 ab | 55 | 0.91 |
| SP | 5.96 | 1.62 | 0.64 | 58 a | 6.2 | 0.105 b | 55 | 0.88 |
| ST | 5.46 | 1.48 | 0.58 | 46 ab | 4.9 | 0.116 ab | 57 | 0.92 |
| SP+LR | 5.82 | 1.58 | 0.67 | 52 ab | 6.0 | 0.112 ab | 55 | 0.94 |
| ST+LR | 5.06 | 1.38 | 0.58 | 43 b | 4.9 | 0.119 ab | 59 | 0.91 |
| ST+SP | 5.74 | 1.56 | 0.65 | 44 ab | 5.0 | 0.127 a | 62 | 0.92 |
| ST+SP+LR | 5.55 | 1.51 | 0.61 | 48 ab | 5.2 | 0.115 ab | 60 | 0.87 |
| *P=* | *0.8217* | *0.8217* | *0.7696* | *0.0247*[z] | *0.0473* | *0.0178* | *0.0754* | *0.3195* |
| ***Side*Treatment*** | *0.2674* | *0.2674* | *0.2223* | *0.3675* | *0.3999* | *0.4273* | *0.3621* | *0.9896* |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 8. Effect of canopy management treatments on vegetative growth of Norton grapevines by canopy side and treatment. Barry County, MO. 2010**

| | Pruning wt/ vine (lbs) | | Pruning wt (lbs)/ft | | Canes/ vine | | Canes/ ft | | Ravaz index | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 1.00 | a[y] | 0.11 | a | 5.58 | a | 0.62 | a | 7.46 | |
| West | 0.83 | b | 0.09 | b | 4.26 | b | 0.47 | b | 8.15 | |
| *P=* | *0.0301*[z] | | *0.0202* | | *0.0215* | | *0.0225* | | *0.4632* | |
| **Treatments** | | | | | | | | | | |
| Control | 0.98 | abc | 0.105 | abc | 4.3 | | 0.47 | | 7.12 | ab |
| LR | 0.92 | abc | 0.102 | bc | 5.3 | | 0.59 | | 6.91 | ab |
| SP | 0.60 | c | 0.067 | c | 4.8 | | 0.52 | | 10.69 | a |
| ST | 1.14 | ab | 0.123 | ab | 5.2 | | 0.55 | | 7.22 | ab |
| SP+LR | 0.65 | c | 0.073 | bc | 4.3 | | 0.48 | | 9.45 | ab |
| ST+LR | 1.37 | a | 0.156 | a | 5.7 | | 0.65 | | 4.41 | b |
| ST+SP | 0.80 | bc | 0.089 | bc | 5.3 | | 0.59 | | 8.33 | ab |
| ST+SP+LR | 0.84 | bc | 0.092 | bc | 4.7 | | 0.51 | | 8.45 | ab |
| *P=* | *<.0001* | | *<.0001* | | *0.8742* | | *0.8403* | | *0.0864* | |
| ***Side*Treatment*** | *0.2881* | | *0.2581* | | *0.9606* | | *0.9510* | | *0.4142* | |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 9. Effect of canopy management treatments on fruit composition and color of Norton grapevines by canopy side and treatment. Barry County, MO. 2010**

| | %SS (brix) | Juice pH | TA (g/L) | Anthocyanins (mg/g) | Phenols (AU/g berry) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Side** | | | | | | |
| East | 20.9 | 3.84 | 6.47 | 1.95 | 1.03 | 1.02 |
| West | 20.8 | 3.97 | 6.39 | 1.91 | 1.02 | 1.11 |
| *P=* | *0.8064* | *0.2195* | *0.3554* | *0.5651* | *0.7834* | *0.4376* |
| **Treatments** | | | | | | |
| Control | 20.8 | 3.88 | 6.68 | 1.92 | 1.01 | 0.97 |
| LR | 21.3 | 3.86 | 6.39 | 1.97 | 1.02 | 1.21 |
| SP | 20.8 | 3.86 | 6.43 | 2.02 | 1.06 | 0.97 |
| ST | 20.5 | 3.89 | 6.53 | 1.82 | 1.05 | 0.98 |
| SP+LR | 20.5 | 3.79 | 6.39 | 1.99 | 1.00 | 1.02 |
| ST+LR | 21.0 | 3.87 | 6.48 | 1.99 | 1.06 | 1.08 |
| ST+SP | 21.1 | 3.84 | 6.47 | 1.76 | 0.99 | 1.24 |
| ST+SP+LR | 20.8 | 4.23 | 6.13 | 1.96 | 1.05 | 1.06 |
| *P=* | *0.2250* | *0.5880* | *0.1481* | *0.6382* | *0.8939* | *0.8692* |
| ***Side*Treatment*** | *0.9785* | *0.4814* | *0.5868* | *0.8056* | *0.6643* | *0.8001* |

Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 10. Effect of canopy management treatments on organic acids and sugars of Norton grapevines by canopy side and treatment. Barry County, MO. 2010**

| | Citric (g/L) | Tartaric (g/L) | | Malic (g/L) | | Glucose (g/L) | Fructose (g/L) | Juice K (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | |
| East | 1.40 | 11.45 | a[y] | 3.68 | | 83.46 | 100.25 | 3051 | |
| West | 1.45 | 10.48 | b | 3.76 | | 83.83 | 100.11 | 3027 | |
| *P=* | *0.1772* | *<.0001*[z] | | *0.4329* | | *0.7232* | *0.8858* | *0.5953* | |
| | | | | | | | | | |
| Control | 1.42 | 11.04 | | 4.17 | A | 82.93 | 88.62 | 3199 | a |
| LR | 1.42 | 10.93 | | 3.48 | bcd | 85.79 | 101.69 | 3033 | ab |
| SP | 1.42 | 10.49 | | 3.79 | abc | 83.56 | 100.27 | 3069 | ab |
| ST | 1.46 | 10.77 | | 4.11 | ab | 82.09 | 98.32 | 3173 | a |
| SP+LR | 1.43 | 10.84 | | 3.41 | cd | 82.16 | 99.14 | 2863 | b |
| ST+LR | 1.40 | 10.93 | | 4.11 | ab | 83.86 | 99.80 | 3171 | a |
| ST+SP | 1.45 | 11.01 | | 3.65 | abcd | 86.12 | 102.33 | 2998 | ab |
| ST+SP+LR | 1.41 | 11.67 | | 3.02 | d | 82.63 | 100.25 | 2807 | b |
| *P=* | *0.9874* | *0.3309* | | *<.0001* | | *0.3560* | *0.5249* | *<.0001* | |
| ***Side*Treatment*** | *0.9399* | *0.7985* | | *0.3923* | | *0.9198* | *0.8405* | *0.7306* | |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 11. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side and treatment. Barry County, MO. 2010**

| | % Ambient light | | % Gap | | LLN | | PIC | | PIL | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 31.51 | a[y] | 40.47 | a | 1.83 | a | 48.60 | b | 50.49 | A |
| West | 11.14 | b | 10.98 | b | 1.11 | b | 78.44 | a | 31.19 | B |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| **Treatment** | | | | | | | | | | |
| Control | 10.19 | c | 8.03 | b | 2.18 | a | 97.22 | a | 57.72 | a |
| LR | 25.39 | ab | 40.60 | a | 0.95 | b | 37.10 | b | 26.52 | c |
| SP | 18.88 | bc | 10.03 | b | 1.73 | a | 91.32 | a | 46.51 | ab |
| ST | 6.72 | c | 12.89 | b | 1.91 | a | 71.11 | ab | 51.78 | a |
| SP+LR | 38.31 | a | 42.18 | a | 0.95 | b | 50.99 | b | 30.41 | c |
| ST+LR | 27.72 | ab | 46.27 | a | 0.95 | b | 51.39 | b | 26.30 | c |
| ST+SP | 6.32 | c | 4.15 | b | 2.26 | a | 69.44 | ab | 56.07 | a |
| ST+SP+LR | 37.05 | a | 41.65 | a | 0.83 | b | 39.58 | b | 31.44 | bc |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| ***Side*Treatment*** | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |

LLN; Leaf layer number; PIC: percent interior cluster; PIL: Percent interior leaf

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 12. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side by treatments. Barry County, MO. 2010**

| Treatment | Side | Control | LR | SP | ST | SP+LR | ST+LR | ST+SP | ST+SP+LR |
|---|---|---|---|---|---|---|---|---|---|
| % Ambient light | East | 10.25 | 43.13 | 24.18 | 5.99 | 57.52 | 46.07 | 3.56 | 61.40 |
| | West | 10.13 | 7.66 | 13.58 | 7.46 | 19.11 | 9.37 | 9.08 | 12.71 |
| | *Significance* | *0.9798* | *<.0001* [z] | *0.2883* | *0.6181* | *0.0002* | *0.0036* | *0.1153* | *0.0003* |
| % Gap | East | 9.14 | 70.51 | 6.76 | 14.16 | 69.76 | 80.08 | 1.28 | 72.08 |
| | West | 6.92 | 10.70 | 13.30 | 11.61 | 14.60 | 12.46 | 7.02 | 11.21 |
| | *Significance* | *0.5124* | *<.0001* | *0.2424* | *0.6338* | *<.0001* | *<.0001* | *0.0791* | *<.0001* |
| LLN | East | 2.17 | 0.03 | 1.74 | 2.16 | 0.56 | 0.06 | 2.59 | 0.10 |
| | West | 2.19 | 1.88 | 1.73 | 1.66 | 1.85 | 1.85 | 1.93 | 1.56 |
| | *Significance* | *0.9178* | *<.0001* | *0.9798* | *0.2842* | *<.0001* | *<.0001* | *0.0789* | *<.0001* |
| PIC | East | 94.44 | 13.10 | 82.64 | 85.56 | 10.32 | 19.44 | 83.33 | 0.00 |
| | West | 100.00 | 61.11 | 100.00 | 56.67 | 91.67 | 83.33 | 55.56 | 79.17 |
| | *Significance* | *0.3409* | *0.0527* | *0.0499* | *0.2384* | *<.0001* | *0.0071* | *0.2229* | *<.0001* |
| PIL | East | 58.61 | 0.00 | 45.80 | 56.73 | 8.33 | 0.00 | 60.62 | 19.44 |
| | West | 56.84 | 53.03 | 47.21 | 46.84 | 52.48 | 52.60 | 51.52 | 43.44 |
| | *Significance* | *0.6720* | *<.0001* | *0.8621* | *0.1779* | *0.0007* | *<.0001* | *0.1071* | *0.0981* |

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences Tukey's studentized range test.

**Table 13. Effect of canopy management treatments on yield and yield components of Norton grapevines by canopy side and treatment. Boone, MO. 2009**

| | Yield (lbs/vine) | | Yield (tons/A) | | Yield/ ft | | Clusters/ vine | | Cluster/ ft | | Cluster wt (lbs) | | Berry no./ cluster | Berry wt (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | | | | | |
| East | 9.07 | | 2.00 | | 1.14 | | 66 | b[y] | 8.3 | b | 0.14 | a | 74 | 0.88 |
| West | 9.53 | | 2.10 | | 1.20 | | 73 | a | 9.1 | a | 0.13 | b | 69 | 0.87 |
| *P=* | *0.3666* | | *0.3666* | | *0.3251* | | *0.0347*[z] | | *0.0323* | | *0.0497* | | *0.0867* | *0.8488* |
| **Treatments** | | | | | | | | | | | | | | |
| Control | 10.86 | ab | 2.39 | ab | 1.38 | ab | 77 | ab | 9.8 | ab | 0.14 | | 78 | 0.83 |
| LR | 10.60 | abc | 2.33 | abc | 1.31 | ab | 78 | a | 9.7 | abc | 0.14 | | 71 | 0.96 |
| SP | 11.50 | a | 2.53 | a | 1.45 | a | 85 | a | 10.8 | a | 0.14 | | 73 | 0.85 |
| ST | 7.94 | bcd | 1.75 | bcd | 0.98 | bc | 55 | c | 6.8 | d | 0.15 | | 75 | 0.89 |
| SP+LR | 11.47 | a | 2.52 | a | 1.42 | a | 88 | a | 10.9 | a | 0.13 | | 73 | 0.84 |
| ST+LR | 7.44 | d | 1.64 | d | 0.92 | c | 55 | c | 6.8 | d | 0.14 | | 72 | 0.88 |
| ST+SP | 7.08 | d | 1.64 | d | 0.91 | c | 57 | c | 7.3 | cd | 0.12 | | 65 | 0.89 |
| ST+SP+LR | 7.51 | cd | 1.65 | cd | 0.96 | bc | 59 | bc | 7.5 | bcd | 0.13 | | 67 | 0.86 |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.1293* | | *0.4125* | *0.5768* |
| ***Side*Treatment*** | *0.6039* | | *0.6039* | | *0.5389* | | *0.4448* | | *0.4221* | | *0.9790* | | *0.9917* | *0.8057* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 14. Effect of canopy management treatments on vegetative growth of Norton grapevines by canopy side and treatment. Boone County, MO. 2009**

| | Pruning wt/ vine (lbs) | | Pruning wt (lbs)/ft | | Canes/ vine | | Canes/ ft | | Ravaz index | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 2.01 | a[y] | 0.25 | a | 37 | a | 4.6 | a | 5.30 | b |
| West | 1.50 | b | 0.19 | b | 30 | b | 3.8 | b | 6.96 | a |
| *P=* | *0.0002*[z] | | *0.0002* | | *<.0001* | | *<.0001* | | *0.0003* | |
| **Treatments** | | | | | | | | | | |
| Control | 2.28 | a | 0.29 | a | 34 | ab | 4.4 | ab | 6.14 | bc |
| LR | 2.19 | a | 0.27 | ab | 36 | ab | 4.5 | ab | 5.44 | c |
| SP | 1.26 | b | 0.16 | c | 38 | a | 4.7 | a | 9.45 | a |
| ST | 2.31 | a | 0.29 | a | 32 | ab | 4.0 | ab | 3.93 | c |
| SP+LR | 1.36 | b | 0.17 | bc | 39 | a | 4.9 | a | 8.65 | ab |
| ST+LR | 1.97 | ab | 0.25 | abc | 27 | b | 3.3 | b | 4.23 | c |
| ST+SP | 1.34 | b | 0.17 | bc | 30 | ab | 3.8 | ab | 5.51 | c |
| ST+SP+LR | 1.34 | b | 0.14 | bc | 32 | ab | 4.4 | ab | 5.69 | c |
| *P=* | *<.0001* | | *<.0001* | | *0.0022* | | *<.0001* | | *<.0001* | |
| ***Side*Treatment*** | *0.1150* | | *0.1412* | | *0.2820* | | *0.3059* | | *0.7471* | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 15. Effect of canopy management treatments on fruit composition and color of Norton grapevines by canopy side and treatment. Boone County, MO. 2009**

| | %SS (brix) | Juice pH | TA (g/L) | Anthocyanins (mg/g) | Phenols (AU/g berry) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Side** | | | | | | |
| East | 21.9 | 3.45 a[y] | 15.07 b | 3.46 a | 3.25 a | 2.59 |
| West | 22.2 | 3.43 b | 15.60 a | 3.14 b | 2.25 b | 2.81 |
| *P=* | *0.1298* | *0.0444*[z] | *0.0815* | *0.0009* | *<.0001* | *0.1288* |
| **Treatments** | | | | | | |
| Control | 21.6 | 3.45 | 15.98 a | 2.97 c | 2.71 | 2.67 |
| LR | 22.6 | 3.47 | 14.39 b | 3.66 a | 2.68 | 2.47 |
| SP | 22.3 | 3.44 | 15.84 a | 3.39 abc | 2.88 | 2.76 |
| SP+LR | 22.4 | 3.46 | 14.90 ab | 3.56 ab | 2.76 | 2.85 |
| ST | 21.7 | 3.45 | 15.57 ab | 3.01 bc | 2.53 | 2.79 |
| ST+LR | 22.0 | 3.44 | 14.93 ab | 3.43 abc | 2.94 | 2.54 |
| ST+SP | 21.7 | 3.41 | 16.12 a | 3.34 abc | 2.85 | 2.64 |
| ST+SP+LR | 21.9 | 3.41 | 14.93 ab | 3.00 c | 2.67 | 2.87 |
| *P=* | *0.0914* | *0.0763* | *0.0007* | *0.0005* | *0.7070* | *0.8014* |
| ***Side*Treatment*** | *0.9521* | *0.3543* | *0.2151* | *0.4816* | *0.0308* | *0.4016* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 16. Effect of canopy management treatments on organic acids and sugars of Norton grapevines by canopy side and treatment. Boone County, MO. 2009**

| | Citric (g/L) | Tartaric (g/L) | Malic (g/L) | Glucose (g/L) | Fructose (g/L) | Juice K (mg/L) |
|---|---|---|---|---|---|---|
| **Side** | | | | | | |
| East | 0.52 | 9.33 | 5.36 | 73.3 | 114.4 | 2902 |
| West | 0.49 | 9.22 | 4.82 | 75.1 | 116.2 | 3000 |
| *P=* | *0.0122* [z] | *0.1607* | *0.1130* | *0.0904* | *0.2265* | *0.0760* |
| **Treatments** | | | | | | |
| Control | 0.52 | 9.31 ab[y] | 7.83 a | 70.2 b | 112.7 ab | 3018 |
| LR | 0.49 | 9.44 a | 3.92 c | 77.5 a | 120.1 a | 2888 |
| SP | 0.49 | 8.85 b | 5.48 bc | 75.1 ab | 116.7 ab | 3108 |
| ST | 0.52 | 9.37 ab | 4.91 bc | 72.9 ab | 110.6 b | 3054 |
| SP+LR | 0.49 | 9.10 ab | 3.99 c | 76.0 ab | 117.2 ab | 2918 |
| ST+LR | 0.49 | 9.35 ab | 4.13 c | 74.3 ab | 114.9 ab | 2908 |
| ST+SP | 0.53 | 9.43 a | 6.30 ab | 71.9 ab | 113.3 ab | 2914 |
| ST+SP+LR | 0.52 | 9.34 ab | 4.18 c | 75.6 ab | 117.1 ab | 2798 |
| *P=* | *<.0001* | *0.0098* | *<.0001* | *0.0160* | *0.0493* | *0.1112* |
| ***Side*Treatment*** | *0.9542* | *0.6923* | *0.0631* | *0.5737* | *0.3646* | *0.6977* |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 17. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side and treatment. Boone County, MO. 2009**

| | % Ambient light | | % Gap | | LLN | | PIC | | PIL | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 32.7 | a[y] | 16.3 | a | 1.31 | b | 64.3 | b | 49.5 | |
| West | 6.2 | b | 6.5 | b | 1.83 | a | 90.1 | a | 48.8 | |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *0.8074* | |
| **Treatment** | | | | | | | | | | |
| Control | 0.8 | c | 0.8 | e | 2.81 | a | 99.0 | a | 64.4 | a |
| LR | 27.9 | b | 17.8 | ab | 0.93 | d | 62.5 | b | 44.7 | bc |
| SP | 6.2 | c | 1.9 | de | 2.01 | bc | 94.2 | a | 52.5 | ab |
| ST | 4.5 | c | 4.2 | de | 2.16 | b | 95.8 | a | 55.6 | ab |
| SP+LR | 23.3 | b | 14.2 | | 0.99 | d | 63.5 | b | 48.1 | abc |
| ST+LR | 33.7 | ab | 19.4 | ab | 1.04 | d | 56.9 | b | 46.1 | bc |
| ST+SP | 11.3 | c | 8.1 | cd | 1.75 | c | 92.3 | a | 48.1 | abc |
| ST+SP+LR | 42.9 | a | 24.7 | a | 0.86 | d | 53.4 | b | 33.8 | c |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| ***Side*Treatment*** | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.4832* | |

LLN; Leaf layer number; PIC: percent interior cluster; PIL: Percent interior leaf

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 18. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side by treatments. Boone County, MO. 2009**

| Treatment | Side | Control | LR | SP | ST | SP+LR | ST+LR | ST+SP | ST+SP+LR |
|---|---|---|---|---|---|---|---|---|---|
| % Ambient light | East | 0.98 | 49.06 | 10.57 | 1.67 | 50.53 | 61.14 | 16.78 | 68.40 |
| | West | 0.64 | 6.75 | 1.86 | 6.67 | 6.03 | 6.27 | 5.86 | 17.30 |
| | *Significance* | *0.4118* | *0.0041* [z] | *0.0094* | *0.8258* | *<.0001* | *<.0001* | *0.0319* | |
| % Gap | East | 1.11 | 25.56 | 2.78 | 4.15 | 25.56 | 30.56 | 8.89 | 33.89 |
| | West | 0.56 | 10.00 | 1.11 | 4.90 | 2.78 | 8.33 | 7.22 | 15.56 |
| | *Significance* | *0.6643* | *0.0188* | *0.0924* | *0.0237* | *<.0001* | *0.0003* | *0.6495* | *<.0001* |
| LLN | East | 2.94 | 0.40 | 1.96 | 2.29 | 0.34 | 0.47 | 1.78 | 1.39 |
| | West | 2.68 | 1.47 | 2.05 | 2.02 | 1.64 | 1.62 | 1.73 | 0.32 |
| | *Significance* | *0.2478* | *<.0001* | *0.6395* | *0.1750* | *<.0001* | *0.0002* | *0.8133* | *<.0001* |
| PIC | East | 100.00 | 35.72 | 90.77 | 96.25 | 36.89 | 30.07 | 95.49 | 29.55 |
| | West | 98.02 | 89.25 | 97.58 | 95.34 | 90.16 | 83.81 | 89.06 | 77.22 |
| | *Significance* | *0.2147* | *<.0001* | *0.0590* | *0.8213* | *<.0001* | *<.0001* | *0.1361* | *0.0005* |
| PIL | East | 66.22 | 46.68 | 53.46 | 57.41 | 52.34 | 46.57 | 47.67 | 25.56 |
| | West | 62.57 | 42.77 | 51.56 | 53.71 | 43.82 | 45.68 | 48.51 | 41.98 |
| | *Significance* | *0.1830* | *0.7402* | *0.6565* | *0.2112* | *0.3982* | *0.9208* | *0.8860* | *0.1427* |

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences using Tukey's studentized range test.

**Table 19. Effect of canopy management treatments on yield and yield components of Norton grapevines by canopy side and treatment. Boone, MO. 2010**

| | Yield (lbs/vine) | | Yield (tons/A) | | Yield/ ft | | Clusters/ vine | | Cluster/ ft | | Cluster wt (lbs) | Berry no./ cluster | | Berry wt (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | | | | | | |
| East | 10.76 | | 2.37 | | 1.42 | | 81 | | 10.8 | | 0.13 | 59 | | 1.03 | |
| West | 10.71 | | 2.36 | | 1.42 | | 81 | | 10.8 | | 0.13 | 58 | | 1.03 | |
| *P=* | *0.9140* | | *0.9140* | | *0.9313* | | *0.9664* | | *0.9467* | | *0.4944* | *0.4478* | | *0.8031* | |
| **Treatments** | | | | | | | | | | | | | | | |
| Control | 10.66 | ab[y] | 2.35 | ab | 1.44 | ab | 82 | ab | 11.0 | abc | 0.13 | 55 | b | 1.10 | a |
| LR | 10.57 | ab | 2.33 | ab | 1.45 | ab | 86 | ab | 11.8 | ab | 0.12 | 56 | b | 0.99 | ab |
| SP | 12.63 | a | 2.78 | a | 1.66 | a | 97 | a | 12.8 | a | 0.13 | 56 | b | 1.05 | ab |
| ST | 9.67 | b | 2.13 | b | 1.22 | b | 69 | bc | 8.7 | cd | 0.14 | 61 | ab | 1.04 | ab |
| SP+LR | 12.31 | a | 2.71 | a | 1.64 | a | 97 | a | 13.0 | a | 0.13 | 56 | b | 1.03 | ab |
| ST+LR | 8.69 | b | 1.91 | b | 1.16 | b | 62 | c | 8.4 | d | 0.14 | 64 | a | 0.98 | b |
| ST+SP | 11.19 | ab | 2.46 | ab | 1.47 | ab | 83 | ab | 10.8 | abcd | 0.14 | 60 | ab | 1.03 | ab |
| ST+SP+LR | 10.13 | ab | 2.23 | ab | 1.33 | ab | 73 | bc | 9.6 | bcd | 0.14 | 63 | ab | 1.00 | ab |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.0344* | *0.0015* | | *0.0318* | |
| ***Side*Treatment*** | *0.7875* | | *0.7875* | | *0.7560* | | *0.3786* | | *0.3908* | | *0.2545* | *0.3059* | | *0.9628* | |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 20. Effect of canopy management treatments on vegetative growth of Norton grapevines by canopy side and treatment. Boone County, MO. 2010**

| | Pruning wt/ vine (lbs) | | Pruning wt (lbs)/ft | | Canes/ vine | | Canes/ ft | | Ravaz index | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 1.96 | a[y] | 0.26 | a | 41 | a | 5.4 | a | 6.25 | b |
| West | 1.61 | b | 0.21 | b | 34 | b | 4.5 | b | 7.36 | a |
| *P=* | *0.0006*[z] | | *0.0004* | | *<.0001* | | *0.0002* | | *0.0153* | |
| **Treatments** | | | | | | | | | | |
| Control | 2.05 | abc | 0.28 | ab | 37 | | 5.0 | ab | 5.60 | cd |
| LR | 2.03 | abcd | 0.28 | ab | 39 | | 5.3 | ab | 5.49 | cd |
| SP | 1.34 | e | 0.18 | c | 42 | | 5.5 | ab | 10.07 | a |
| ST | 2.31 | a | 0.29 | a | 32 | | 4.0 | b | 5.12 | d |
| SP+LR | 1.42 | de | 0.19 | c | 44 | | 5.9 | a | 9.09 | ab |
| ST+LR | 2.13 | ab | 0.29 | a | 31 | | 4.2 | b | 4.37 | d |
| ST+SP | 1.44 | cde | 0.19 | c | 38 | | 4.9 | ab | 7.92 | abc |
| ST+SP+LR | 1.53 | bcde | 0.20 | bc | 36 | | 4.8 | ab | 6.80 | bcd |
| *P=* | *<.0001* | | *<.0001* | | *0.0065* | | *0.0028* | | *<.0001* | |
| ***Side*Treatment*** | *0.0562* | | *0.0464* | | *0.0004* | | *0.0004* | | *0.7839* | |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 21. Effect of canopy management treatments on fruit composition and color of Norton grapevines by canopy side and treatment. Boone County, MO. 2010**

| | %SS (brix) | | Juice pH | | TA (g/L) | | Anthocyanins (mg/g) | Phenols (AU/g berry) | Tannins (mg/g) |
|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | |
| East | 22.0 | | 3.71 | | 8.82 | b[y] | 3.39 | 1.62 | 1.82 |
| West | 22.1 | | 3.69 | | 9.30 | a | 3.34 | 1.59 | 1.74 |
| *P=* | *0.4204* | | *0.4522* | | *0.0008*[z] | | *0.5639* | *0.2388* | *0.5114* |
| **Treatments** | | | | | | | | | |
| Control | 21.5 | b | 3.75 | a | 9.68 | a | 3.21 | 1.55 | 1.89 |
| LR | 22.2 | ab | 3.71 | abc | 8.88 | ab | 3.55 | 1.67 | 1.73 |
| SP | 22.1 | ab | 3.70 | abc | 8.85 | ab | 3.35 | 1.58 | 1.66 |
| ST | 21.7 | ab | 3.74 | ab | 9.40 | ab | 3.34 | 1.60 | 1.61 |
| SP+LR | 22.4 | a | 3.69 | abc | 8.61 | b | 3.25 | 1.57 | 1.84 |
| ST+LR | 21.9 | ab | 3.67 | c | 9.21 | ab | 3.52 | 1.67 | 1.89 |
| ST+SP | 22.4 | a | 3.68 | bc | 9.09 | ab | 3.35 | 1.59 | 1.89 |
| ST+SP+LR | 22.0 | ab | 3.65 | c | 8.75 | b | 3.36 | 1.61 | 1.70 |
| *P=* | *0.0105* | | *0.0002* | | *0.0036* | | *0.2288* | *0.1646* | *0.8841* |
| ***Side*Treatment*** | *0.8259* | | *0.4127* | | *0.4210* | | *0.9872* | *0.9789* | *0.9129* |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 22. Effect of canopy management treatments on organic acids and sugars of Norton grapevines by canopy side and treatment. Boone County, MO. 2010**

| | Citric (g/L) | Tartaric (g/L) | | Malic (g/L) | | Glucose (g/L) | Fructose (g/L) | Juice K (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | |
| East | 1.24 | 10.27 | a[y] | 4.82 | b | 89.10 | 105.0 | 3328 | b |
| West | 1.23 | 9.38 | b | 5.41 | a | 90.67 | 105.5 | 3574 | a |
| *P=* | *0.8424* | *0.0002*[z] | | *0.0003* | | *0.1454* | *0.6077* | *<.0001* | |
| **Treatments** | | | | | | | | | |
| Control | 1.33 | 9.47 | | 5.89 | a | 87.65 | 102.6 | 3848 | a |
| LR | 1.24 | 9.77 | | 4.69 | bc | 90.72 | 106.4 | 3404 | b |
| SP | 1.22 | 9.68 | | 5.48 | ab | 90.76 | 105.6 | 3370 | b |
| ST | 1.28 | 9.60 | | 5.47 | ab | 89.68 | 105.0 | 3846 | a |
| SP+LR | 1.21 | 9.45 | | 5.08 | abc | 90.18 | 104.5 | 3350 | b |
| ST+LR | 1.21 | 10.15 | | 5.02 | abc | 89.55 | 105.5 | 3330 | b |
| ST+SP | 1.24 | 9.87 | | 5.09 | abc | 91.37 | 106.6 | 3388 | b |
| ST+SP+LR | 1.17 | 10.60 | | 4.19 | c | 89.58 | 105.6 | 3066 | b |
| *P=* | *0.1190* | *0.2240* | | *<.0001* | | *0.7393* | *0.6612* | *<.0001* | |
| ***Side*Treatment*** | *0.4560* | *0.9261* | | *0.1096* | | *0.9925* | *0.9457* | *0.2872* | |

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.
[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 23. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side and treatment. Boone County, MO. 2010**

| | % Ambient light | | % Gap | | LLN | | PIC | | PIL | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Side** | | | | | | | | | | |
| East | 30.68 | a[y] | 27.74 | a | 1.60 | b | 46.68 | b | 37.31 | b |
| West | 2.03 | b | 1.39 | b | 2.75 | a | 84.26 | a | 63.68 | a |
| *P=* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| **Treatment** | | | | | | | | | | |
| Control | 1.95 | b | 0.00 | b | 3.13 | ab | 68.57 | abc | 67.01 | a |
| LR | 26.52 | a | 36.11 | a | 1.35 | d | 31.25 | c | 40.58 | bc |
| SP | 2.66 | b | 0.00 | b | 2.72 | ab | 97.92 | a | 62.83 | a |
| ST | 2.46 | b | 0.00 | b | 3.38 | a | 90.00 | ab | 66.32 | a |
| SP+LR | 30.31 | a | 22.22 | a | 1.43 | cd | 62.13 | abc | 36.45 | c |
| ST+LR | 30.91 | a | 27.08 | a | 1.49 | d | 49.58 | bc | 37.93 | c |
| ST+SP | 5.29 | b | 2.78 | b | 2.40 | bcd | 74.31 | ab | 60.24 | ab |
| ST+SP+LR | 30.74 | a | 28.33 | a | 1.50 | cd | 50.00 | bc | 32.61 | c |
| *P=* | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | |
| ***Side*Treatment*** | *<.0001* | | *<.0001* | | *<.0001* | | *<.0001* | | *0.0545* | |

LLN; Leaf layer number; PIC: percent interior cluster; PIL: Percent interior leaf

[y]: Least Square Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test.

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences

**Table 24. Effect of canopy management treatments on point quadrat analysis of Norton grapevines by canopy side by Treatments. Boone County, MO. 2010**

| Treatment | Side | Control | LR | SP | ST | SP+LR | ST+LR | ST+SP | ST+SP+LR |
|---|---|---|---|---|---|---|---|---|---|
| % Ambient light | East | 2.59 | 51.54 | 2.64 | 3.87 | 41.67 | 2.33 | 6.22 | 59.78 |
| | West | 1.32 | 1.50 | 2.68 | 1.05 | 2.78 | 59.50 | 4.35 | 1.71 |
| | *Significance* | *0.3599* | *<.0001* [z] | *0.9795* | *0.3987* | *<.0001* | *<.0001* | *0.5787* | *0.0010* |
| % Gap | East | 0 | 66.67 | 0 | 0 | 59.28 | 54.17 | 2.78 | 56.67 |
| | West | 0 | 5.56 | 0 | 0 | 1.33 | 0.00 | 2.78 | 0.00 |
| | *Significance* | | *<.0001* | | | *0.0045* | *0.0010* | *1.0000* | *<.0001* |
| LLN | East | 3.47 | 0.06 | 2.86 | 3.87 | 0.06 | 0.15 | 2.25 | 0.07 |
| | West | 2.80 | 2.64 | 2.58 | 2.90 | 2.81 | 2.82 | 2.56 | 2.93 |
| | *Significance* | *0.2558* | *<.0001* | *0.3645* | *0.2723* | *<.0001* | *<.0001* | *0.5108* | *<.0001* |
| PIC | East | 60.00 | 41.70 | 100.00 | 80.00 | 40.93 | 7.50 | 54.17 | 26.67 |
| | West | 77.14 | 58.33 | 95.83 | 100.00 | 83.33 | 91.67 | 94.44 | 73.33 |
| | *Significance* | *0.5988* | *0.0246* | *0.3409* | *0.3466* | *0.0328* | *<.0001* | *0.0662* | *0.0739* |
| PIL | East | 70.98 | 16.67 | 63.62 | 68.17 | 8.33 | 12.50 | 58.25 | 0.00 |
| | West | 63.04 | 64.49 | 62.05 | 64.47 | 64.57 | 63.36 | 62.24 | 65.21 |
| | *Significance* | *0.1840* | *0.0172* | *0.6712* | *0.6727* | *<.0001* | *0.0033* | *0.4228* | *<.0001* |

[z]: Values below 0.05 indicate significant differences, while values above indicate non significant differences using Tukey's studentized range

**Table 25. Influence of cluster exposure and canopy side of N-S oriented rows on fruit composition and polyphenolics of Norton grapes. Gasconade County, MO. 2009.**

| Treatments | SS (%) | pH | TA (g/L) | Phenols (AU/g berry wt) | Anthocyanins (mg/g) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 22.6 a[y] | 3.35 | 13.83 b | 3.11 | 2.67 | 2.99 |
| Partly Exposed | 21.8 ab | 3.29 | 16.16 a | 3.22 | 2.90 | 2.83 |
| Fully Shaded | 20.9 b | 3.30 | 17.10 a | 3.06 | 2.74 | 2.76 |
| *Significance* | *0.0005*[z] | *0.2842* | *0.003* | *0.5451* | *0.4534* | *0.7117* |
| **Canopy Side** | | | | | | |
| West | 21.8 | 3.35 | 15.54 | 3.10 | 2.70 | 2.73 |
| East | 21.7 | 3.29 | 15.85 | 3.08 | 2.85 | 2.99 |
| *Significance* | *0.8621* | *0.0726* | *0.6149* | *0.4812* | *0.3333* | *0.2581* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.9600 | 0.4511 | 0.8978 | 0.5906 | 0.7592 | 0.6401 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 26. Influence of cluster exposure and canopy side of N-S oriented rows on juice organic acids, sugars and K of Norton grapes. Gasconade County, MO. 2009.**

| Treatments | Tartaric (mg/mL) | Citric (mg/mL) | Malic (mg/mL) | Glucose (mg/mL) | Fructose (mg/mL) | Juice K (mg/L) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 9.46 | 0.58 | 3.58 b[y] | 81.77 a | 123.0 ab | 2446 b |
| Partly Exposed | 9.97 | 0.57 | 5.45 ab | 82.86 a | 126.3 a | 2394 b |
| Fully Shaded | 9.74 | 0.58 | 7.13 a | 74.00 b | 116.5 b | 2822 a |
| *Significance* | *0.1257* | *0.9381* | *0.0016*[z] | *0.0137* | *0.0265* | *0.0058* |
| **Canopy Side** | | | | | | |
| West | 9.72 | 0.58 | 4.97 | 81.46 | 124.2 | 2577 |
| East | 9.72 | 0.57 | 5.80 | 77.63 | 119.6 | 2531 |
| *Significance* | *0.9970* | *0.4975* | *0.2637* | *0.1387* | *0.1239* | *0.6824* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.4524 | 0.8887 | 0.8338 | 0.6915 | 0.4657 | 0.7841 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 27. Influence of cluster exposure and canopy side of N-S oriented rows on fruit composition and polyphenolics of Norton grapes. Gasconade County, MO. 2010.**

| Treatments | SS (%) | | pH | | TA (g/L) | | Phenols (AU/g berry wt) | | Anthocyanins (mg/g) | | Tannins (mg/g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | | | | | | | |
| Fully Exposed | 21.2 | a[y] | 3.51 | b | 7.70 | b | 1.35 | ab | 2.36 | b | 2.26 | a |
| Partly Exposed | 20.7 | ab | 3.53 | ab | 8.26 | ab | 1.42 | a | 2.68 | a | 2.00 | ab |
| Fully Shaded | 20.0 | b | 3.58 | a | 8.61 | a | 1.25 | b | 2.36 | b | 1.65 | b |
| *Significance* | *0.0249* | | *0.0180*[z] | | *0.0374* | | *0.0054* | | *0.0114* | | *0.0331* | |
| **Canopy Side** | | | | | | | | | | | | |
| West | 20.8 | | 3.56 | a | 7.87 | b | 1.33 | | 2.46 | | 1.88 | |
| East | 20.5 | | 3.51 | b | 8.51 | a | 1.35 | | 2.47 | | 2.06 | |
| *Significance* | *0.3017* | | *0.0147* | | *0.0280* | | *0.6927* | | *0.9575* | | *0.3363* | |
| **Interaction Effects** | | | | | | | | | | | | |
| Side * Exposure | 0.5751 | | 0.3915 | | 0.6603 | | 0.6307 | | 0.8822 | | 0.2443 | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 28. Influence of cluster exposure and canopy side of N-S oriented rows on juice organic acids, sugars, and K of Norton grapes. Gasconade County, MO. 2010.**

| Treatments | Tartaric (mg/mL) | Citric (mg/mL) | Malic (mg/mL) | | Glucose (mg/mL) | | Fructose (mg/mL) | | Juice K (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | | | | | |
| Fully Exposed | 10.90 | 1.15 | 3.09 | c[y] | 88.18 | a | 104.6 | a | 2132 | c |
| Partly Exposed | 10.39 | 1.10 | 4.16 | b | 86.60 | a | 100.3 | a | 2296 | b |
| Fully Shaded | 10.07 | 1.16 | 5.60 | a | 79.17 | b | 92.8 | b | 2547 | a |
| *Significance* | *0.1663* | *0.3090* | *<.0001*[z] | | *0.0002* | | *<.0001* | | *<.0001* | |
| **Canopy Side** | | | | | | | | | | |
| West | 10.29 | 1.14 | 4.18 | | 85.61 | | 100.1 | | 2349 | |
| East | 10.61 | 1.14 | 4.39 | | 83.69 | | 98.3 | | 2300 | |
| *Significance* | *0.3727* | *0.9080* | *0.3757* | | *0.2614* | | *0.3361* | | *0.2797* | |
| **Interaction Effects** | | | | | | | | | | |
| Side * Exposure | 0.5315 | 0.1620 | 0.3684 | | 0.1841 | | 0.1300 | | 0.2528 | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 29. Influence of cluster exposure and canopy side of E-W oriented rows on fruit composition and polyphenolics of Norton grapes. Gasconade County, MO. 2009.**

| Treatments | SS (%) | pH | TA (g/L) | Phenols (AU/g berry wt) | Anthocyanins (mg/g) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 24.1 a[y] | 3.32 | 13.4 b | 2.70 | 3.25 | 3.26 |
| Partly Exposed | 23.7 ab | 3.30 | 15.1 a | 2.64 | 3.57 | 3.59 |
| Fully Shaded | 23.0 b | 3.35 | 15.2 a | 2.66 | 3.24 | 3.04 |
| *Significance* | *0.0158*[z] | *0.3390* | *0.0002* | *0.8970* | *0.1030* | *0.1681* |
| **Canopy Side** | | | | | | |
| South | 23.7 | 3.35 | 14.1 b | 2.62 | 3.30 | 3.41 |
| North | 23.5 | 3.30 | 15.0 a | 2.72 | 3.41 | 3.19 |
| *Significance* | *0.4983* | *0.0820* | *0.0226* | *0.3474* | *0.4049* | *0.3436* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.0782 | 0.4398 | 0.0945 | 0.5068 | 0.9539 | 0.1317 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 30. Influence of cluster exposure and canopy side of E-W oriented rows on juice organic acids, sugars and K of Norton grapes. Gasconade County, MO. 2009.**

| Treatments | Tartaric (mg/mL) | Citric (mg/mL) | Malic (mg/mL) | Glucose (mg/mL) | Fructose (mg/mL) | Juice K (mg/L) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 10.05 | 0.55 | 2.77 b[y] | 95.8 a | 140.1 a | 2041 b |
| Partly Exposed | 9.99 | 0.53 | 3.68 a | 92.5 ab | 136.8 ab | 2213 ab |
| Fully Shaded | 9.99 | 0.53 | 4.45 a | 87.6 b | 131.6 b | 2430 a |
| *Significance* | *0.9359* | *0.5532* | *<.0001*[z] | *0.0053* | *0.0139* | *0.0005* |
| **Canopy Side** | | | | | | |
| South | 9.94 | 0.56 a | 3.54 | 93.6 | 137.8 | 2217 |
| North | 10.08 | 0.51 b | 3.73 | 90.3 | 134.5 | 2239 |
| *Significance* | *0.3963* | *0.0010* | *0.5036* | *0.0952* | *0.1458* | *0.7741* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.4150 | 0.7862 | 0.9045 | 0.9259 | 0.9908 | 0.3155 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 31. Influence of cluster exposure and canopy side of E-W oriented rows on fruit composition and polyphenolics of Norton grapes. Gasconade County, MO. 2010.**

| Treatments | SS (%) | pH | TA (g/L) | Phenols (AU/g berry wt) | Anthocyanins (mg/g) | Tannins (mg/g) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 22.5 a[y] | 3.54 b | 6.54 b | 1.39 ab | 2.66 b | 1.93 |
| Partly Exposed | 22.7 a | 3.58 b | 7.39 a | 1.48 a | 3.05 a | 1.83 |
| Fully Shaded | 12.6 b | 3.66 a | 7.77 a | 1.35 b | 2.77 b | 1.53 |
| *Significance* | *0.0034*[z] | *<.0001* | *<.0001* | *0.0185* | *0.0024* | *0.1291* |
| **Canopy Side** | | | | | | |
| South | 22.3 | 3.58 | 7.28 | 1.41 | 2.84 | 1.83 |
| North | 22.3 | 3.61 | 7.18 | 1.41 | 2.81 | 1.70 |
| *Significance* | *0.9859* | *0.1107* | *0.6365* | *0.8348* | *0.7411* | *0.4380* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.1732 | 0.9838 | 0.7074 | 0.8615 | 0.5143 | 0.4664 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 32. Influence of cluster exposure and canopy side of E-W oriented rows on juice organic acids, sugars, and K of Norton grapes. Gasconade County, MO. 2010.**

| Treatments | Tartaric (mg/mL) | Citric (mg/mL) | Malic (mg/mL) | Glucose (mg/mL) | Fructose (mg/mL) | Juice K (mg/L) |
|---|---|---|---|---|---|---|
| **Exposure Level** | | | | | | |
| Fully Exposed | 10.82 | 1.05 | 2.53 b[y] | 95.2 a | 111.1 a | 2086 c |
| Partly Exposed | 10.78 | 1.03 | 3.47 a | 95.9 a | 110.5 a | 2303 b |
| Fully Shaded | 10.56 | 1.10 | 4.10 a | 89.3 b | 104.1 b | 2541 a |
| *Significance* | *0.6842* | *0.2815* | *<.0001*[z] | *0.0021* | *0.0025* | *<.0001* |
| **Canopy Side** | | | | | | |
| South | 10.85 | 1.06 | 3.24 | 92.8 | 108.3 | 115 |
| North | 10.58 | 1.06 | 3.49 | 94.1 | 108.9 | 116 |
| *Significance* | *0.3178* | *0.9111* | *0.2597* | *0.4371* | *0.7081* | *0.7512* |
| **Interaction Effects** | | | | | | |
| Side * Exposure | 0.3741 | 0.1612 | 0.8567 | 0.2654 | 0.3192 | 0.7804 |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 33. Influence cluster exposure and canopy side of N-S oriented rows on percent of ambient photosynthetically active radiation (PAR) at the base of Norton grape clusters. Gasconade County, MO. 2009-2010.**

| | 2009 | | | | 2010 | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | **8/14/09** | | **9/18/09** | | **8/24/10** | | **9/13/10** | |
| | **% Ambient** | | | | | | | |
| **Exposure Level** | | | | | | | | |
| Fully Exposed | 80.25 | a[y] | 69.96 | a | 90.58 | a | 96.64 | a |
| Partly Exposed | 4.37 | b | 3.86 | b | 8.42 | b | 6.48 | b |
| Fully Shaded | 0.44 | b | 0.55 | b | 0.74 | c | 0.70 | c |
| *Significance* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | |
| **Canopy Side** | | | | | | | | |
| West | 34.43 | a | 28.70 | a | 33.74 | | 35.35 | |
| East | 22.28 | b | 20.88 | b | 32.75 | | 33.86 | |
| *Significance* | *0.0040* | | *0.0004* | | *0.4779* | | *0.2691* | |
| **Interaction Effects** | | | | | | | | |
| Side * Exposure | 0.0011 | | <.0001 | | 0.1076 | | 0.5836 | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

**Table 34. Influence cluster exposure and canopy side of E-W oriented rows on percent of ambient photosynthetically active radiation (PAR) at the base of Norton grape clusters. Gasconade County, MO. 2009-2010.**

| | 2009 | | | | 2010 | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | **8/14/09** | | **9/18/09** | | **8/24/10** | | **9/13/10** | |
| | **% Ambient** | | | | | | | |
| **Exposure Level** | | | | | | | | |
| Fully Exposed | 110.13 | a[y] | 76.39 | a | 89.52 | a | 94.55 | a |
| Partly Exposed | 5.45 | b | 6.30 | b | 5.44 | b | 5.41 | b |
| Fully Shaded | 0.63 | c | 0.83 | c | 0.43 | c | 0.53 | c |
| *Significance* | *<.0001*[z] | | *<.0001* | | *<.0001* | | *<.0001* | |
| **Canopy Side** | | | | | | | | |
| South | 39.28 | | 28.18 | | 31.28 | | 34.70 | |
| North | 38.19 | | 27.49 | | 32.31 | | 32.29 | |
| *Significance* | *0.2548* | | *0.6332* | | *0.4982* | | *0.1340* | |
| **Interaction Effects** | | | | | | | | |
| Side * Exposure | 0.7149 | | 0.8748 | | 0.5543 | | 0.4804 | |

[y]: Means followed by one or more identical letters do not differ significantly at ά = 0.05 by Tukey's studentized range test

[z]: values below 0.05 indicate significant differences, while values above 0.05 indicate non significant differences

*Appendix*

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**Project 4: Introducing High Tunnel Technology and Enhancing Food Safety Practices**
**Webb City Farmers' Market**
**Final Performance Report**
**Eileen Nichols-Webb City Farmers' Market Manager**

***Project Summary***

The purpose of this project was to introduce high tunnel technology in the contiguous areas of Missouri, Arkansas, Oklahoma and Kansas, to provide analytical tools to area farmers to evaluate the risks and benefits of adding a high tunnel to a farm operation, to provide area farmers with training and information to increase the likelihood of success in high tunnel farming by participating farmers, and to enhance food safety knowledge among area farmers. Due to a large population of immigrant Hmong farmers, special measures were taken to ensure their complete understanding through translation.

High tunnel farming is a relatively new technique for Southwest Missouri and there is strong interest among farmers in adopting this practice to extend their season as well as allow them to participate in the increasing number of winter markets in the area. Food safety is of paramount concern to the farmers, the consumers and the farmers markets.

This project was not previously funded by Specialty Crop Block Grant Program.

***Project Approach***

The following workshops were held with attendance and survey results:

1. Is a High Tunnel Right for My Operation – 12/7/09 – Mount Vernon, Misouri – Attendance – 16 including 5 Hmong families

2. Introduction to High Tunnels, the EQUIP high tunnel program and backpack sprayers – 2/8/10 – Lamar, Missouri – Attendance – 70 including 4 Hmong families

3. Food Safety: from field to market – 2/27/10 – Joplin, Missouri – Attendance – 96 including 14 Hmong families (morning English-only session repeated in afternoon with full Hmong translation)

4. High Tunnel Spring Management – 4/5/10 – Galena, Kansas – Attendance – 12 including 1 Hmong family

5. Fall High Tunnel Management – 10/26/10 – Pierce City, Missouri - Attendance – 19 including 4 Hmong families

6. Food Safety: from field to market – 12/6/10 – Springfield, Missouri – Attendance – 46 including 11 Hmong families (morning English-only session repeated in afternoon with full Hmong translation

7. 1/21/11 – production problems in 2010 and how to address them in 2011 – held at Mid-Missouri Bank in Webb City – Attendance 25 including 5 Hmong families.

8. 3/24/11 & 3/25/11 – hands-on high tunnel installation workshop held on the Xiong Farm in Exeter, Missouri. Hmong translation provided. Approx attendance – 10 including 5 Hmong families

9. 3/2/11 – Identifying Common Insects and Diseases on Your Produce Farm – held at the Neosho Chamber. Hmong translation provided. Approx attendance – 12 including 8 Hmong families

10. 3/31/11 – Peach Culture Workshop – held on the Ge Lor Lee Farm in Seneca, Missouri. Hmong translation provided. Approx attendance – 7 including 3 Hmong families

11. 4/6/11 – Sustainable Use of Pesticides and Integrated Pest Management – held at the Neosho Chamber. Hmong translation provided – Approx attendance – 10 including 5 Hmong families

12. 5/18/11 & 5/19/11 – hands-on high tunnel installation – held at the Leverich Family Farm in Exeter, Missouri. Approx attendance - 15

13. 6/9/11 & 6/10/11 – hands-on high tunnel installation workshop held at Sunshine Valley Farm in Rogersville, Missouri. Approx attendance - 14

14. Food Safety: from field to market – 2/18/12 – Webb City, Missouri – Attendance – 49 including 9 Hmong families (morning English-only session repeated in afternoon with full Hmong translation)

Depending on the setting, formal or informal (show of hands) pre- and post surveys were conducted. The results from the 2/8/10 high tunnel workshop are fairly typical:

I understand how to select a high tunnel that is right for my operation:

| | | | | |
|---|---|---|---|---|
| Pre | Completely – 10% | Some – 15% | A little – 35% | Not at all – 40% |
| Post | Completely – 45% | Some – 50% | A little – 5% | Not at all – 0% |

I understand how to select a site and install a high tunnel:

| | | | | |
|---|---|---|---|---|
| Pre | Completely – 5% | Some – 45% | A little – 5% | Not at all – 45% |
| Post | Complete – 45% | Some – 50% | A little – 5% | Not at all – 0% |

I understand the options for supplemental heat in high tunnels:

| | | | | |
|---|---|---|---|---|
| Pre | Completely – 0% | Some - 40% | A little – 15% | Not at all – 45% |
| Post | Completely – 35% | Some – 60% | A little – 5% | Not at all – 0% |

I have the information I need to participate in the EQUIP program for high tunnels

| | | |
|---|---|---|
| Pre | Yes – 30% | No – 70% |
| Post | Yes – 90% | No – 10% |

I understand how to adapt and use a backpack sprayer:

| | | | | |
|---|---|---|---|---|
| Pre | Completely – 5% | Some – 25% | A little – 50% | Not at all – 20% |
| Post | Completely – 55% | Some – 40% | A little – 5% | Not at all – 0% |

Some of the comments:

- Variety of information with good speakers
- Opportunity to see live operation
- Lots of good information
- Appreciated the passive heat ideas

Both University of Missouri Extension and Lincoln University Extension personnel provided essential support in both planning and execution of the workshops/field days. Market growers more than fulfilled their commitment to support the program both in terms of leadership and participation. Area markets cooperated with the market in promoting the educational activities to their growers.

***Goals and Outcomes Achieved***

The original proposal included 5 workshops and/or field days. Thanks to our close partnership with Extension and considerable donated time, we were able to do 14 workshops and/or field days, including three 2-day hands-on high tunnel installations. The tools purchased for these installations are now being used in a lending program to area farmers putting up high tunnels. The tools will also be available for any additional workshops put on by the market or Extension. We far exceeded our target goals of 50 farmers attending one of the workshops or field days.

Outcome measures were not long term (as they were educational workshops) and actual accomplishments exceeded the goals established. All outcomes achieved with the exception of the high tunnel guide (see information under “Lessons Learned”)

Our surveys used a scale of 1 to 10 with 1 being the least knowledgeable and 10 being the most knowledgeable. On average our attendees classified themselves at a 3 (which translates to not very knowledgeable) on the workshop topic in the pre-surveys. On the post survey, on average, 77% of them classified themselves at an 8 (knowledgeable). It is impossible to match each pre and post response form to an individual (we didn't want them to do both on the same page because we didn't want their post response influenced by their pre response), but taking the responses as a whole, it is typical that the workshop responses showed an increase point-wise of 3 or more. While the 80%, was not achieved to the level of 8 (knowledgeable), the increase of three point-wise was achieved across the board for respondents.

***Beneficiaries***
Participants include groups from socially disadvantaged farmers such as immigrant farmers, the Amish and women. It also included white male farmers as well. Most seemed to be farmers interested in farming full time and in selling produce direct to the public or through the Amish public auctions.

Some 210 farmers participated in at least one of the workshops/field days, not including the almost 200 who attended a food safety workshop - eight times the number of farmers stated in the initial goal. During the process of the workshops it was determined that the Hmong farmers needed additional information on such topics as pest identification and pest management. The main cost for these additional training was translating.

***Lessons Learned***
Location and timing seemed to play an important part. There seems to be more interest in food safety in the Joplin area as opposed to the Springfield area. This may be in part due to the fact that the Webb City Farmers Market requires food safety training of all vendors selling edible produce prior to securing a spot in the market, however at least 50% of those attending the Joplin classes do not sell at the Webb City market.
The best attended high tunnel workshop was on a snowy day in February (we were afraid the weather would keep people away but it seemed to cut down on outdoor farm projects competing for the farmers' time). It was held on an Amish farm in an area of many Amish farms. More than half those attending were Amish (good thing the Hershbergers were well equipped to handle buggy parking!). At most other high tunnel workshops there were only a few Amish attending – distance is an issue for the Amish.

The high tunnel guide that was to provide tips via print and internet because in the interim time several such guides were developed suitable for our region by others.
The time and money was approved for use for additional workshops.

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***Additional Information***

Food Safety
Workshop

Clockwise from top left –

Pruning tomatoes in a high tunnel.

Installing a high tunnel.

Dr. Gu presents power point Amish style.

Translating during an on-site workshop.

**Project 5: Dent County Garden n' Grow Program**
**University of Missouri Cooperative Extension**
**Final Performance Report**
**Sarah Hultine**

***Project Summary***
a) This project enhances the competitiveness of Missouri-grown specialty crops through education and training of youth in gardening skills and food entrepreneurship techniques, introduction to healthy cooking, nutrition, and volunteer service. The project was be led by MU Extension-Dent County Healthy Lifestyle Initiative, and supported by the Bonebrake Center of Nature & History and the Dent County Master Gardeners.
b) In 2007, Dent County was selected as a Healthy Lifestyle Initiative Pilot community. The Healthy Lifestyle Initiative is working to create communities that support the availability of healthy, affordable, locally-produced food and safe, accessible physical activity. As the interest and demand for healthy, locally-grown food has increased in Missouri, the need to begin training a new generation of gardeners and farmers is growing. This program trained youth in gardening techniques, encourage market gardens, and emphasize the benefits of buying and eating locally-grown food, encouraging new consumers for local food markets. An emphasis was placed on connecting youth gardeners to volunteer and training opportunities with local market gardeners, community gardens, and local farmers' markets.

***Project Approach***
February 2010 – Sarah Hultine hosted a meeting with Bonebrake Center Board of Trustees, regional extension specialists and local partners to determine Garden 'n Grow Program Coordinator duties and application process, and develop an advisory committee to guide the project. Advisory Committee will conduct interviews and hire coordinator. Completed on schedule.

March 2010 – Coordinator began planning summer school program, advertising, and scheduling volunteer workdays with local partners. Completed on schedule.

May 2010 through September 2010 – Coordinator conducted registration for program, and volunteer corps. Worked with local master gardeners to coordinate volunteer hours for program and workdays. Coordinator and volunteers conducted Garden 'n Grow summer school program for 20 participants. Conduct volunteer corps workdays and events at Salem Community Garden, Salem Farmers' Market, the Bonebrake Center, and with other local garden organizations. Program was conducted with 5 participants in 2010. The volunteer corps project was combined with existing volunteer workdays and opportunities already scheduled to reduce duplication. As reported in the 2010 end of year report, the following volunteer events occurred:

June 12, 2010-Workday at Bonebrake Center, 10 participants.

August 7, 2010-Workday at Bonebrake Center, 8 participants.

Weekly volunteer hours from community members at Garden during program: 6 hours.

Community Garden volunteer workshop and composting demonstration, August 5, 2010: 15 adults, 3 youth.

Winter 2010 – Advisory committee and coordinator conducted review of summer 2010 program.

Successes included donations and support from local businesses and individuals. Biggest challenge was transportation for students which decreased our participation. Our strategy was to connect with 4-H in 2011 to collaborate to recruit 4-H students in Garden n Grow.

May 2011– Advisory Committee and Coordinator conducted second year of Garden 'n Grow summer school program and volunteer corps. Three first year graduates participated again in 2011. Program was held beginning in April 2011 as part of the 4-H gardening project, which increased participation and adult volunteer support for Garden n Grow.

October 2011- With input from Advisory Committee, Sarah Hultine will turn in final report. Completed December 2011.

1st Annual Report

February 2011 – Garden and Grow Coordinator and MU Extension worked with Dent County 4-H program to schedule gardening project meetings and recruit 4-H participants. Completed as scheduled.

March –May 2011 – Monthly project meetings with participants included activities such as seed starting, planning a garden, composting and other early season gardening activities. Recruit 15 4-H and other local students to join the Garden n Grow project. Eleven students participated in the 2011 project, and have indicated interest to continue gardening with 4-H next year. Meetings included seed starting, developing a composting program, planning the garden, etc.

May 2011 through September 2011 – Coordinator conducted summer gardening program and project meetings for 20 students. Coordinator worked with local master gardeners and other volunteers to coordinate volunteer hours for program and workdays. Coordinator conducted volunteer corps workdays and events at Salem Community Garden, Salem Farmers' Market, the Bonebrake Center, and with other local garden organizations.

In 2011, 16 Community Garden volunteer workdays engaged 15 volunteers donating over 480 volunteer hours to the Community Garden. Additionally, three new parent volunteers for the GNG program in 2011 donated 60 hours of time to assist with the program.

Fall 2011 – Advisory committee and coordinator conducted a review of 2011 program and identified long-term 4-H project opportunities to continue program into the future. The project will continue through 4-H, with interested 4-Hers signing up in late fall and participating throughout the year. Additionally, a local Master Gardener will utilize the curriculum and materials we've collected to start a Garden n Grow program with students with disabilities at the Salem Upper Elementary during the spring and fall school semesters.

October 2011- With input from Advisory Committee, Sarah Hultine turned in final report to Missouri Department of Agriculture. Completed December 2011.

a) Bonebrake Center for Nature and History board member Jamin Bray coordinated the 2010-2011 GNG program with assistance from 8 volunteers, three of whom are also 4-H volunteers. In 2011 the program was offered as a 4-H project, so that participating students could also submit a project book for the 4-H Achievement Day, and enter vegetables and flower arrangements in the Fair. This increased recruitment for the program. 16 students participated in the program over the two years, which was held as a summer school program. Program participants ranged from age 5-14. Participants had healthy snacks from the garden at each session and learned about the basic needs of a garden, using the Garden n Grow student workbooks.

The participants harvested vegetables and flowers from their gardens, and sold 1/3 of their harvest at the Salem Farmers' Market, donated 1/3 to the Salem Senior Center, and took 1/3 home for their personal use.

For 2012, the program will transfer from Bonebrake to be used at Salem Upper Elementary School. A local Master Gardener, trained in 2011, will work with special needs students at the school to garden during the spring and fall. This will also fulfill her required volunteer hours. Additionally, a new school garden is being developed at North Wood R-IV elementary school, and the GNG materials will be utilized in that program with students as well. While we may not have a specific summer school program as we have done this past two years, we feel these new opportunities will reach a broader section of students and introduce new opportunities to use the program in different settings. Bonebrake Center continues to have volunteer workdays throughout the growing season that relate to gardening and nature, and we will encourage students in the other GNG programs to volunteer their time at these workdays to continue the relationship with Bonebrake.
*b)* Cahill Family Greenhouse, a local family owned business, sponsored the program both years by providing the participant registration fees and all the vegetable plants, flowers, and seeds needed for the participants' gardens. A Master Gardener donated $20 for program supplies, and several other Master Gardeners donated their time to watering the garden between sessions. Two local farmers donated their time and equipment to plow and till the garden spot both years. The Bonebrake Center provided the space for the garden, organizational support for the program, and storage space for the garden tools. Dent County Extension provided organizational, advertising and administrative support for the program, along with assistance from the Nutrition Program Associate for healthy cooking and nutrition resources.

***Goals and Outcomes Achieved***
*Activities completed:*
Developed the Garden n Grow summer school program which was hosted by Bonebrake Center of Nature & History in 2010 and 2011.

Organized multiple volunteer events for adults and youth at Bonebrake Center of Nature & History, Salem Community Garden, and Salem Farmers' Market.

Worked with MU Extension Nutrition Program Associate to increase awareness of healthy eating and cooking using fresh produce.

Created mentorship opportunities between adult and youth gardeners by recruiting local farmers and Master Gardeners to assist with the GNG program.

*Comparison of accomplishments with stated goals*

*Goal 1:* Develop a Garden 'n Grow summer school program beginning in June 2011 for 20 participants age 9-13.
*Target*: Enroll 20 youth in Garden 'n Grow program by program start.
*Overall Progress:* 16 youth participated in the program over the 2 year period, along with 8 adult volunteers who assisted with implementing the program.

*Goal 2:* Create a Dent County Youth Gardeners Volunteer Corps by July 2011.
*Target*: Plan 10 volunteer events in partnership with Bonebrake Center and other local organizations by October 1, 2011, and engage more than 50 youth and adults as volunteers.
*Overall Progress:* In 2010, volunteer workdays engaged 36 volunteers, in addition to the weekly hours volunteered by the 2 GNG program assistants. In 2011, 16 Community Garden volunteer workdays engaged 15 volunteers donating over 480 volunteer hours to the Community Garden. Additionally, the

three new parent volunteers for the GNG program in 2011 donated 60 hours of time to assist with the program.

*Goal 3:* Increase participants' awareness of and knowledge about gardening skills, nutrition, healthy cooking, and local food marketing.
*Target*: By the end of the program, students will have a collection of recipes for several healthy meals, describe at least one specific gardening technique, and identify at least one successful marketing technique for local food businesses.
*Overall Progress:* Students created posters and flyers to advertise their products at the Salem Farmers' Market, discussed appropriate pricing strategies as a group to determine sale prices as well as quantity, discussed with customers about their growing techniques, and shared recipes with customers for their products.

*Goal 4:* Introduce participants to volunteer opportunities related to community gardening, beautification, farmers' markets, and food pantries.
*Target*: By October 30, 2011, plan and implement 8 volunteer workdays/events at above organizations, with at least 40 youth and adult volunteers participating.
*Overall Progress:* This goal was combined with Goal 2 in 2011, as the Volunteer Corps evolved to recruit existing volunteers such as Master Gardeners and Master Naturalists, as well as Community Garden volunteers. 2010 and 2011 GNG participants experienced volunteering at the Salem Farmers' Market, Senior Center, and Bonebrake Center gardens.

*Goal 5:* Create mentorship opportunities between youth program participants and local master gardeners, farmers, and area garden club members.
*Target*: 10 adult mentors (farmers, garden club mentors, Master Gardeners, etc) involved in program by Sept. 1, 2011.
*Overall Progress:* In 2010, eight adult volunteers representing different organizations assisted with the Garden n Grow program. Donations from community members and a local business demonstrated support and enthusiasm for the program. In 2011, an additional 3 parents volunteered to assist with the program, and a newly trained Master Gardener will be using the program in 2012 with special needs students at Salem Upper Elementary.

On the final program survey, all participants reported that they like to grow vegetables that they can eat. All participants reported that they can choose healthy vegetables to eat. In response to the question: How did Garden N' Grow help you become a better gardener? Participants responded: "I didn't know how to garden at all – now I do." "I learned more about pests." "I know when to pick cucumbers." Participants also responded to a survey question: "What did you enjoy most about Garden N' Grow? "Watching the vegetables grow and eating the food." "Getting produce out of a garden." "I liked going to the Farmer's Market and seeing all the different vegetables I didn't know about." "Eating the cucumbers!"

***Beneficiaries***
a) 16 youth participated directly in the program; Bonebrake Center of Nature & History; Dent County Extension 4-H programs; Master Gardeners; Salem Community Garden
b) Bonebrake Center recruited new volunteers who are actively involved in their programs and also built a composter that will reduce costs for the Center by composting yard waste into usable compost. Master Gardeners gained volunteer hours towards their certification through participation in this program. Dent County 4-H gained a new project for participants to complete, expanding the opportunities available for 4-Hers.

***Lessons Learned***

a) The tools provided in the GNG curriculum materials are adaptable to a variety of settings beyond the summer school programming. We learned that while summer school programs are limited in Dent County and there is a strong need for these programs, the challenges presented in implementing a summer school program in rural, limited resource communities are difficult to overcome. We will continue to pursue opportunities to use the GNG curriculum for summer school programs, but our new approach is to increase the usage of the curriculum into regular school settings, which should reach a broader number of students on a more regular basis, within an institutionalized setting. The increase in school gardens and interest in using locally grown food for school lunches will open new opportunities for incorporating the GNG curriculum.

Master Gardener volunteers are a critical resource for youth gardening programs because of their knowledge of gardening and experience. Working with the 4-H program also opened additional volunteer resources for our program, and will sustain the main goals of teaching youth about gardening, healthy eating, and food entrepreneurship through the incorporation of gardening as a new 4-H project in Dent County.

b) Recruitment of students for the summer school program was a challenge because of the rural nature of Dent County which limits transportation for students. A recommendation for the future would be to tie the program into existing school summer programs where bus transportation is provided. Our future plans are to utilize the program at schools directly during the school year in conjunction with school gardening efforts. The Volunteer Corps was also a challenge because many of the volunteers for this project are also Master Gardeners, and didn't feel they needed another "title" for volunteering since their hours were already counted towards Master Gardener certification, so they were willing to volunteer without an additional program encouragement. So utilizing and supporting existing volunteer bases was a much more feasible option for this program.

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***Additional Information***

**Project 6: Economic Analysis of a Paddock Vacuum for Mechanical Harvest of Chestnut Trees**
**University of Missouri**
**Final Performance Report**
**Michele R. Warmund**

***Project Summary***

It is estimated that up to 50% of the cost of production in a bearing chestnut orchard is for harvest labor. Currently, 90% of all producers hire part-time workers to pick up chestnuts by hand. In many regions of the United States, part-time seasonal labor is scarce due to the physical nature of the work and it is difficult to hire young workers after schools are in session during September and October. Because of the high labor requirements for harvest, alternative low-cost equipment is needed that hastens the pick-up time for chestnuts. Commercially-available pasture vacuum systems, initially developed to collect horse manure, may also provide an efficient method to pick up chestnuts and burs. Thus, this study was conducted to compare the time required to harvest chestnuts with paddock vacuums and with a Nut Wizard, as well as evaluate the economic feasibility of using this equipment.

***Project Approach***

In 2009, a Paddock Vac (Greystone Vacuums Paddock Vac, Zephyrhills, FL) (Fig. 1A) and a medium-sized Nut Wizard (Fig. 1C) were used to harvest chestnuts. The Paddock Vac was equipped with a 397 L collection tank, a 12.7cm-diameter and 3.7 m-long reinforced hose, and a small gas-fueled engine and was towed with a utility vehicle. A second hose was attached to the original one to increase the harvestable area without moving the equipment.

Twelve, 14-year-old 'Qing' Chinese chestnut trees at the Horticulture and Agroforestry Research Center (HARC) near New Franklin, MO were used for this study. Cultivars had been grafted onto Miller 72-138 seedling rootstock and were spaced 4 x 8 m apart. A cross-over split plot experimental design was used in which two rows of six trees were divided into 24 plots with 12 replications of each harvest method. The 4 m x 8 m-area below the tree canopy was divided in half and designated as either the east or west sector. Harvest equipment used on each tree sector was randomly assigned and the same sectors were harvested on 15, 16, 22, and 25 Sept. 2009. For the Nut Wizard, the time to pick up the chestnuts, empty them into a container, and then pick up burs and dump them into another bin for disposal was recorded. For the Paddock Vac, the time to pick up chestnuts and burs, sort them, move the equipment, and dump the burs and other debris was recorded. Nut numbers and their fresh weights were also recorded to calculate the time to harvest chestnuts on a per kg basis. Total pick-up times, harvest times (which included sorting nuts and collecting and disposing of burs), nut weight, and harvest efficiency (harvest time/kg of chestnuts) data were subjected to an analysis of variance (ANOVA) using the PROC MIXED procedure of SAS and means were separated by Fisher's least significant difference (LSD) test, $P \leq 0.05$.

After using the harvest equipment in 2009, a larger Maxi Vac with similar features as the Paddock Vac, except for a 799 L collection tank was purchased. In an attempt to improve harvest efficiency, this vacuum was modified for the 2010 harvest. The collection tank was raised to a 1 m height and a 1.2 x 1.5 m open-weave expanded metal shelf was mounted near the end of the compartment to facilitate chestnut removal and sorting (Fig. 1B). Open spaces in the woven wire of the shelf were 8 mm x 25 mm. For the 2010 study, 18 'Qing' trees in the planting described above were used in a cross-over experimental design. The area below the canopy of two adjacent trees in a row was divided in half, resulting in nine replications of each 8 x 8 m plot. Experimental methods, data collection, and analyses were similar to those used in 2009. Harvest time per nut was also calculated. Harvest dates were 21, 23, 27, and 30 Sept. and 4 Oct. 2010. To compare the harvest efficiency of the Maxi Vac and the Nut Wizard, time required to harvest chestnuts at varying production levels was calculated. Labor costs at varying wage rates and chestnut production levels (i.e., yields) for the Maxi Vac and Nut Wizard were calculated and then added to the cost of equipment to compare total costs for sensitivity analysis.

Equipment costs were based on the sum of the purchase price and the shipping cost for the Nut Wizard ($65) and the Maxi Vac ($4,505). Modifications to the Maxi Vac were $405 and the towing equipment

was estimated to cost $400. The cost of the Maxi Vac was amortized over a five year period at 7%. The Nut Wizard equipment cost was also spread out over a 4 year period to reflect depreciation and replacement. Because estimated fuel usage was minimal (< 38 ml/hr), this cost was not included in the economic analysis for the Maxi Vac.

***Goals and Outcomes Achieved***

The time required to harvest and field sort Chinese chestnuts with two types of paddock vacuums and with a Nut Wizard were compared. Pick-up time for harvesting Chinese chestnuts was faster with a Paddock Vac than with a Nut Wizard, but field sorting plant material and soil, as well as movement of the Paddock Vac was time-consuming. With minor equipment modifications to facilitate sorting, harvest time for the Maxi Vac was 2 sec faster per nut than the Nut Wizard. Economic analyses revealed that the Maxi Vac also reduced labor costs by $237 when the wage rate was low ($8/h) and with production at 1,000 kg. However, with the lower equipment cost, the Nut Wizard was more economical to use than the Maxi Vac with $8/h labor costs and < 6,000 kg of harvested chestnuts. As labor costs and production increased, it was more economically efficient to use the modified Maxi Vac as compared to a Nut Wizard. At $10, $12, and $15/h labor, the Maxi Vac was the lowest cost method of harvesting chestnuts at yields > 4,500, 4,000, and 3,000 kg, respectively. Thus, the modified Maxi Vac provides a relatively inexpensive method for new, small producers to mechanize chestnut harvest. Information gained from this study gained was communicated through various University of Missouri media outlets and outreach activities. Knowledge gained from this project was presented at the Chestnut Growers of America, the Northern Nut Growers Association, and the North American Agroforestry annual meetings, and at chestnut grower's workshops conducted at HARC.

***Beneficiaries***

All current and future chestnut producers will benefit from an improvement in production efficiency. There are currently more than 150 chestnut producers in the United States, and 100 of these growers are members of the Chestnut Growers of America (CGA) and/or the Northern Nut Growers Association (NNGA). Also, 40 potential producers (not members of CGA or NNGA in Missouri and surrounding states) participated in the 2010 UMCA-sponsored chestnut grower workshops. With the results of this study presented at multiple annual meetings (see above), growers are beneficiaries of this work as enhanced profitability will be obtained with lower costs of production.

For many growers, the labor requirement is the limiting factor to the size of the chestnut production operation. This study identified the costs associated with a paddock vacuum used as a chestnut mechanical harvester, including estimates on payback periods, labor reduction savings, operational costs, and returns to investment. With this economic data on a mechanical harvester, growers can make an informed decision regarding the expansion or establishment of chestnut production operations. Based on the equipment costs used in this study and an $8/h wage for harvest labor, 2.7 ha of chestnut trees with a typical nut yield are needed to cover the additional cost of the modified Maxi-Vac as compared to the Nut Wizard. At the highest wage ($15/h), labor and equipment costs for the vacuum were recovered with1.3 ha of chestnut trees with typical nut production.

***Lessons Learned***

Pick-up and harvest times, nut weights, and harvest efficiency for trees and side (east versus west) of the tree canopy were similar for each type of equipment in 2009 (Table 1). The Paddock Vac pick-up time was faster than the Nut Wizard across all harvest dates. However, total harvest time was faster using the Nut Wizard as compared to the Paddock Vac. Sorting chestnuts from burs, soil particles, and other plant debris (grass clippings, twigs, etc.), as well as moving the equipment to adjacent trees, were time-consuming with the Paddock Vac. Additionally, sorting and emptying the material from the Paddock Vac required considerable operator bending, which was uncomfortable. Nut weights harvested with each type of equipment were similar, but the Paddock Vac was less efficient that the Nut Wizard across all dates.

Climatic conditions during the harvest period affected the performance of the equipment in 2009 (Table 1). Pick-up and harvest times for both types of equipment were longer on 22 Sept. than on all other dates. The only rainfall that occurred in September before the first two harvest dates (15 and 16 Sept.) was 14 mm on 5 Sept. so soil conditions were relative dry. However, 42 mm of precipitation occurred during a 53 h-period before the third harvest and an additional 25 mm of rainfall was recorded about 8 h before the final harvest. On 22 Sept., wet soil clods were picked up with the Paddock Vac along with plant material. However, clods did not always fall through the open-weave shelf, resulting in long harvest times. Also, most chestnuts were harvested on 22 Sept., followed by those on 16 Sept., and the fewest nuts were collected on 15 and 25 Sept. Harvest efficiency for both types of equipment was the lowest on 25 Sept. due to the time required to locate the few nuts in plots and sort out soil clods.

In 2010, climatic conditions did not affect harvesting chestnuts. By replacing the Paddock Vac with the larger Maxi Vac, nuts of two trees were harvested before moving the equipment. With the addition of the raised shelf on the Maxi Vac, soil particles easily sifted through the open-weave material, which facilitated sorting and reduced the harvest times per nut by about 2 sec as compared to the Nut Wizard (Table 2). Also, the modified Maxi Vac had greater harvest efficiency than the Nut Wizard and eliminated operator fatigue associated with bending over to remove chestnuts from the vacuum tank. The amount of time saved using the Maxi Vac rather than the Nut Wizard when harvesting 1,000 to 3,000 kg of chestnuts ranged from nearly 30 to 89 h (Table 3). This represents a considerable savings in labor costs. For example, when wages range from $8 to $15/h, $237 to $445 are saved when harvesting 1,000 kg of chestnuts (Table 4). When 3,000 kg of nuts are harvested at $8 to $15/h wages, the Maxi Vac reduced labor costs by $712 to $1,336, respectively. However, the critical economic analysis is determining the level of production where the total cost of labor and equipment is lowest for each harvest method. As expected, lower levels of production favor the low cost Nut Wizard (Fig. 2). However, with higher levels of production and higher wage rates, the Maxi Vac becomes the more economically efficient harvest method. At $8, 10, 12, and 15/h wages, the Maxi Vac was the lowest cost method of harvesting at > 6,000, 4,500, 4,000, and 3,000 kg, respectively.

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***Additional Information***

Fig. 1. Harvest equipment evaluated for harvesting Chinese chestnuts: (A) Paddock Vac, (B) modified Maxi Vac with raised collection tank and open weave metal shelf, and (C) Nut Wizard.



Fig. 2. Sensitivity analysis and comparison of labor, equipment, and total costs for the Maxi-Vac (MV) and the Nut Wizard (NW) at various chestnut production levels and wage rates of (A) $8/h, (B) $10/h, (C) $12/h, and (D) $15/h.

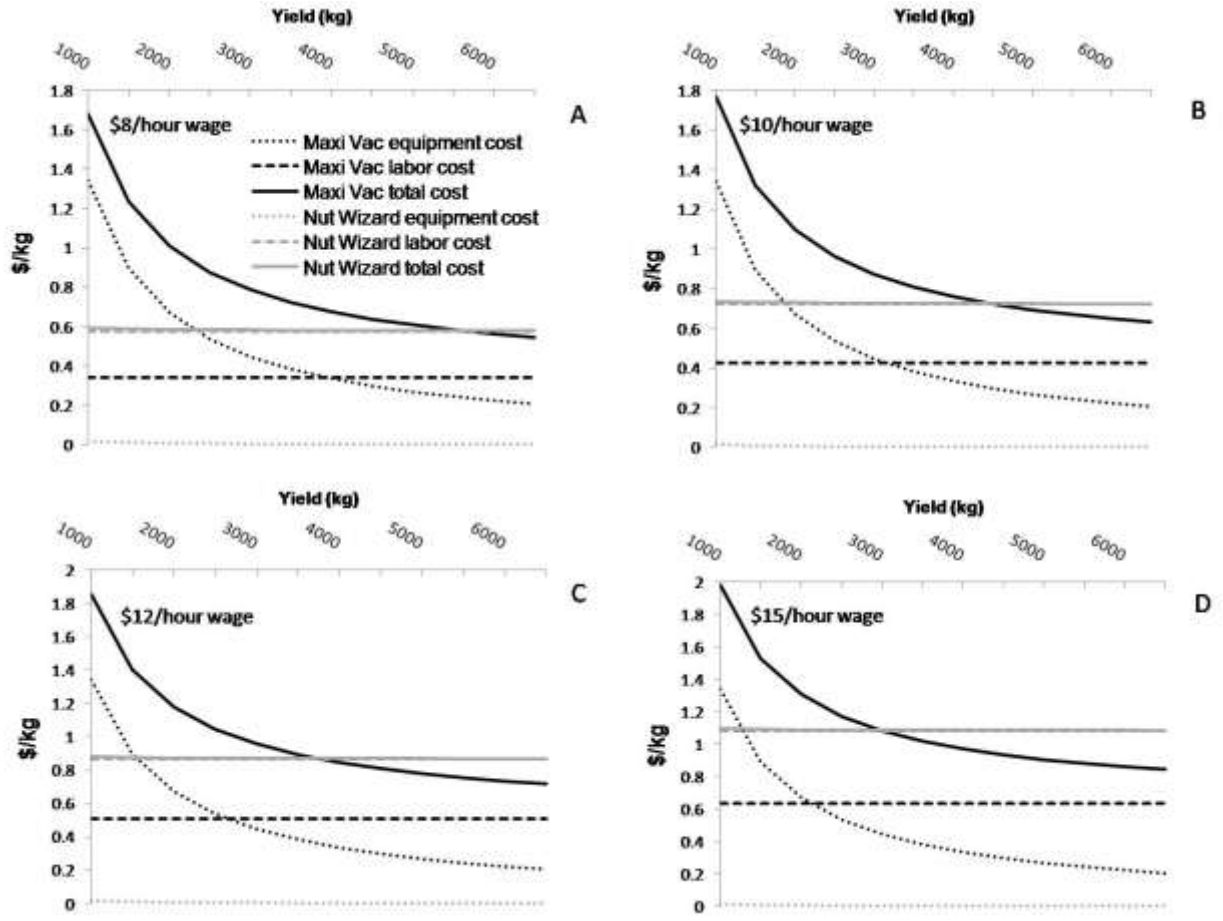


Fig. 2. Sensitivity analysis and comparison of labor, equipment, and total costs for the Maxi-Vac (MV) and the Nut Wizard (NW) at various chestnut production levels and wage rates of (A) $8/h, (B) $10/h, (C) $12/h, and (D) $15/h.

Table 1. Average time to harvest and sort chestnuts from burs with the Paddock Vac or the Nut Wizard in 2009.

| Harvest Date | Harvest method | Pick-up time/tree (sec) | Total harvest time/tree tree (sec) [z] | Nut wt/ (g) | efficiency (sec/kg) [y] |
|---|---|---|---|---|---|
| Sept. 15 | Paddock Vac | 68 | 144 | 559 | 257 |
| | Nut Wizard | 99 | 99 | 567 | 175 |
| Sept. 16 | Paddock Vac | 79 | 167 | 894 | 186 |
| | Nut Wizard | 140 | 140 | 1137 | 123 |
| Sept. 22 | Paddock Vac | 236 | 653 | 3001 | 218 |
| | Nut Wizard | 475 | 475 | 2757 | 172 |
| Sept. 25 | Paddock Vac | 52 | 105 | 250 | 419 |
| | Nut Wizard | 140 | 140 | 406 | 344 |
| Significance[w] | | | | | |
| Harvest method | | *** | ** | NS | * |
| Date | | *** | *** | *** | *** |
| Tree | | NS | NS | NS | NS |
| Side of tree | | NS | NS | NS | NS |
| Date x harvest method | | NS | NS | NS | NS |

[z] Total harvest time for the Paddock Vac is the sum of the time for picking up chestnuts and burs, sorting nuts from burs, movement of equipment, and dumping burs. Total harvest time for the Nut Wizard is the sum of the time for picking up and dumping chestnuts, then picking up burs and dumping burs.

[y] Harvest efficiency is the total time divided by the weight of the harvested chestnuts.

[w] ANOVA included side of tree (east versus west), tree, harvest method, and date of harvest. [NS], *, **, *** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 2. Average time to harvest and sort chestnuts with the modified Maxi Vac or the Nut Wizard in 2010.[z]

| Harvest method | Harvest time/plot (sec) | Nut wt/plot (kg) | Nut no. | Harvest time (sec/nut) [y] | Harvest efficiency (sec/kg) [y] |
|---|---|---|---|---|---|
| Maxi Vac | 973 | 6.4 | 350 | 2.78 a | 153.06 a |
| Nut Wizard | 1209 | 4.7 | 254 | 4.76 b | 259.97 b |

[z] Values represent means of 9 replications of 2-tree plots (8 m x 8 m) for each type of equipment. Harvest time for the Maxi Vac is the sum of the time for picking up chestnuts and burs, sorting nuts from burs, movement of equipment, and dumping burs. Harvest time for Nut Wizard is the sum of the time for picking up and dumping chestnuts, then picking up burs and dumping burs.

[y] Means within each column followed by different letters are significantly different ($P \leq 0.05$).

Table 3. Harvest time for the Maxi Vac and Nut Wizard calculated at several levels of nut yield using data collected in 2010.

| Yield (kg) | Harvest time (h) Maxi Vac | Nut Wizard | Difference (h) [z] |
|---|---|---|---|
| 1000 | 42.51 | 72.21 | 29.70 |
| 1500 | 63.77 | 108.32 | 44.55 |
| 2000 | 85.03 | 144.43 | 59.40 |
| 2500 | 106.29 | 180.54 | 74.25 |
| 3000 | 127.54 | 216.64 | 89.10 |

[z] Difference represents the time saved by using the Maxi Vac to harvest chestnuts.

Table 4. Potential dollars saved using the Maxi Vac instead of the Nut Wizard at varying wage rates and nut yields calculated from 2010 data.

| Wage rate ($/h) | Yield (kg) 1000 | 1500 | 2000 | 2500 | 3000 |
|---|---|---|---|---|---|
| 8 | 237.60 | 356.39 | 475.19 | 593.99 | 712.79 |
| 10 | 296.99 | 445.49 | 593.99 | 742.49 | 890.98 |
| 12 | 356.39 | 534.59 | 712.79 | 890.98 | 1069.18 |
| 15 | 445.49 | 668.24 | 890.98 | 1113.73 | 1336.48 |

***Additional Information***

A presentation was delivered entitled, "A preliminary economic analysis of small-scale mechanized chestnut harvesting" at the 12th North American Agroforestry Conference., Athens, GA on June 6, 2011. An abstract with the same title was also published in the proceedings of the 12th North American Agroforestry Conference p. 427. (http://www.centerforagroforestry.org/pubs/proceedings.pdf).

Another presentation entitled, "Low Cost Harvest Equipment for Chestnuts" was delivered at the Chestnut Growers of America annual meeting in Elsberry, Missouri, June 25, 2011 . (http://www.centerforagroforestry.org/pubs/action/1107action.pdf) and at the Northern Nut Growers Association meeting in Logan, Utah on July 19, 2011.

An abstract entitled, "Time and Motion Comparison of Harvest Equipment for Small-Scale Chestnut Production" was published in HortScience 46(9): 343 and presentation was delivered at the American Society for Horticultural Science meeting in Waikoloa, Hawaii, Sept. 27, 2011. (http://ashs.org/downloads/2011ASHS_Conference_abstracts.pdf)

Warmund, M. Horticultural Improvement of Black Walnut and Chestnut. Low-Cost Mechanical Harvest Equipment for Chestnut. University of Missouri Center for Agroforestry 13th Annual Project Summary. Dec. 2011. Pp. 11.

**Project 7: Extension Series to Increase Local Fruit and Vegetable Production in the Kansas City Region**
**Final Performance Report**
**University of Missouri Extension**
**Marlin Bates**

***Project Summary***

In November, 2008, Missouri tobacco producers were informed that their long-time buyer would no longer be writing contracts to buy Missouri tobacco. With the bulk of Missouri tobacco being produced in the Kansas City region, many impacted parties understood the potential of transitioning these producers into the local foods market. Working with tobacco producers, project managers applied for and received Specialty Crop Block Grant-Farm Bill funding to help them organize a comprehensive project to educate interested tobacco producers and other interested parties about the various skills needed to successfully transition into specialty crop production.

***Project Approach***

The first leg of the project was a series of three workshops that focused on three areas of particular importance. All three hour workshops were held free of charge. All participants received a 3-ring binder filled with MU Extension Guides and presentations.

· Nov 30 - Vegetable Production & Profitability This workshop provided an overview of techniques from transplant production to harvest, including crop management, nutrient management, and pest control.

· Dec 7 - An Overview of Specialty Crop Marketing Options. An in-depth exploration of marketing opportunities for fruits/vegetables.

· Dec 14 - An Exploration of Alternatives and High Tunnel Production A study in high tunnel production and alternative products. A host of industry, university, and state agency speakers were lined up providing valuable information.

All participants in the workshops received complimentary registration for the 2010 Great Plains Vegetable Growers Conference. This is one of the premier vegetable production conferences in the Midwest, featuring day-long workshops on high tunnel production, community supported agriculture (CSA) operations, and new this year, a day looking at growing the profitability of the farm. The conference also includes two days of concurrent sessions focusing on all aspects of vegetable production including transplant production, marketing, pollination, and good agricultural practices, to name a few.

Finally, participants took part in three field trips highlighting production and marketing techniques and tours of existing farms to see full-scale, successful production in action. These events were in May and June 2010.

· Destination Jamesport was held on May 28th and provided a charter bus to the North Missouri Produce Auction and visits to four Jamesport area farms.

· Growing Growers Equipment Workshop was held on June 14 at the KSU Horticulture Research and Extension Center outside of Olathe, KS. This project teamed with the Growing Growers program to expose project participants to scale-specific tools and equipment. The $15 per participant fee was covered by the grant.

· Farmers Market Tour held on June 26th was the final event in the series. Participants had the opportunity to speak with the City Market manager on a walking tour of the area during a high consumer volume time period. This included explanation of how the Market is set-up and the importance of market organization. We observed direct marketing of fruits and vegetables by vendors as well as their interactions with customers.

***Goals and Outcomes Achieved***

This project contained both short-term and longer-term expected measurable outcomes. In order to assess progress toward these goals, project managers collected data at the following points throughout the life of the project: At the conclusion of each of the three workshops, approximately 6 weeks after the workshop series, at the conclusion of each of the three field trips/farm tours, and approximately 6 weeks after the conclusion of the field trips/farm tours.

Short-Term Outcomes:

As outlined in the project proposal, participants were expected to become more knowledgeable about production practices of various specialty crops, and become more aware of marketing options available for these crops.

For production practices, participants assessed their knowledge prior to participating in the series at 2.91 on a five-point scale and 4.64 after the series. This reflects an increase of 1.73 on a 5-point scale.

For marketing options, participants assessed their knowledge prior to participating in the series at 2.73 on a five-point scale and 4.36 after the series. This reflects an increase of 1.63 on a 5-point scale.

Additional short-term outcomes can be assessed by viewing participant comments. Included here is a sampling of those comments:

· “The series was very helpful in learning about available markets & practices.”

· “The series provides a solid introduction to many significant aspects of specialty crop production.”

· The high tunnel information was fascinating.”

Long-Term Outcomes:

As outlined in the project proposal, long-term outcomes include an increase in the number of regional specialty crop producers and/or an increase in the quantity of land dedicated to specialty crop production in the region. As you can imagine, project managers have not been able to assess the true impact of the project on these variables. However, we did attempt to get a feel for how the project might affect the amount of land in specialty crop production throughout the evaluation process.

Eighty-seven percent of participants responding indicated that their participation in the project has encouraged them to expand the amount of land they currently have in specialty crop production. Additionally, 90% of respondents indicated

that they were more confident about the demand for their products as a direct result of the project. At least one participant has already planted twice as much of his crop after his participation in the project led him to discover a better marketing opportunity.

***Beneficiaries***
Direct beneficiaries of the project activities were farmers and potential producers who participated in some or all of the various activities of the project. Attendance numbers for each of the events are listed below:
· November 30, 2009 Workshop – 36
· December 7, 2009 Workshop – 26
· December 14, 2009 Workshop – 41
· May 28, 2010 Field Trip/Farm Tour – 19
· June 14, 2010 Field Trip/Workshop – 24
· June 26, 2010 Field Trip - 9

***Lessons Learned***
Fulfilling the activities of this project has lead to a lot of lessons learned. The incentive of free registration at the Great Plains Vegetable Growers Conference helped to attract participants to the free workshops. Additionally, the myriad presenters at the workshops helped to facilitate more group discussion which helped to unite the otherwise hesitant participants. Evaluation data indicated that participants' knowledge of the subject matter and their social connection to like-minded individuals increased as a direct result of the project.

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***Additional Information***
1) Project Promotional Flyer
2) Event Report for "Destination Jamesport"
3) Event Report for Growing Growers "Equipment Workshop"

***1) Project Promotional Flyer***

# EXTENSION SERIES TO INCREASE LOCAL FOOD PRODUCTION IN THE KANSAS CITY AREA

University of Missouri Extension encourages you to participate in a comprehensive program designed to help current and potential farmers learn about the opportunities that specialty crops offer as high value products with increasing demand. This project is supported by the Specialty Crop Block Grant Program administered by the Missouri Department of Agriculture and USDA. This funding provides the following:

## 3 Free Workshops

**Platte County Resource Center**
**11724 NW Plaza Circle**
**Kansas City, MO 64153**

**Workshop Schedule** (dinner provided)

**Nov 30 - Vegetable Production & Profitablility**
**Dec 7 - An Overview of Specialty Crop Marketing Options**
**Dec 14 - An Exploration of Alternatives and High Tunnel Production**

**Space is Limited! Sign-up Today**

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**Bonus**

**Free Admission to the 2010 Great Plains Vegetable Growers Conference**
**On the Campus of Missouri Western State University**
**In St. Joseph, MO**
**January 7, 8, 9**

**Contact**
Marlin Bates
Horticulture Specialist
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A series of field trips and farm tours to highlight best management practices in production and alternative marketing approaches. These events will be held in May and June, 2010

# More Information

## Opportunities abound for those interested in fruit/vegetable production

A local specialist with University of Missouri Extension has been awarded grant funds from the Specialty Crop Block Grant Program through the Missouri Department of Agriculture. The project, titled "Extension series to increase local food production in the Kansas City area," has been designed to assist interested farmers in their transition into specialty crop production.

The first leg of the project will be a series of three workshops, set for Nov. 30, Dec. 7, and Dec. 14, 2009. These workshops will focus on three areas of particular importance. The first workshop will be an overview of techniques from transplant production to harvest, including crop management, nutrient management, and pest control. The second workshop will be an in-depth exploration of marketing opportunities for fruits/vegetables. Finally, the third workshop will be a study in high tunnel production and alternative products. A host of industry, university, and state agency speakers have been lined up to provide this valuable information. All workshops will be held, free of charge, at the Platte County University of Missouri Extension office at 11724 NW Plaza Circle from 5-8 pm. Workshops may go later, depending on the topic. Dinner will be provided at each workshop.

All participants in the workshops will receive complimentary registration for the 2010 Great Plains Vegetable Growers Conference. This is the premier vegetable production conference in the Midwest, featuring day-long workshops on high tunnel production, community supported agriculture (CSA) operations, and new this year, a day looking at growing the profitability of the farm. The conference also includes two days of concurrent sessions focusing on all aspects of vegetable production including transplant production, marketing, pollination, and good agricultural practices, to name a few.

To round out the project, participants will take part in two field trips highlighting production and marketing techniques and two tours of existing farms to see full-scale, successful production in action. For more information about the project or to register, contact Marlin Bates at 816-270-2141 or batesma@missouri.edu.

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"Equal opportunity is and shall be provided to all participants in Extension programs and activities, and for all employees and applicants for employment on the basis of their demonstrated ability and competence without discrimination on the basis of their race, color, religion, sex, sexual orientation, national origin, age, disability, or status as a Vietnam-era veteran. This policy shall not be interpreted in such a manner as to violate the legal rights of reli-

***2) Event Report for "Destination Jamesport"***

## EXTENSION SERIES TO INCREASE LOCAL FOOD PRODUCTION IN THE KANSAS CITY AREA

Event Report for:
May 28, 2010 Field Trip to North Missouri Produce Auction and Jamesport, MO Area Farms

Agenda:

8:30-10:00 : Travel from Liberty to Jamesport
10:00-12:00: Observe Produce Auction
12:00-2:30 : Visit 5 Jamesport Area Farms
2:30-3:30 : Travel from Jamesport to Liberty

We loaded a bus in Liberty to travel to Jamesport first thing in the morning. Many participants left the auction amazed at the volume of produce and flowers that were sold at the auction. Some even left with fresh strawberries, vegetables and flowers.

# TOUR OF JAMESPORT AREA FARMS

21 participants left the produce auction to tour five local farms. All of the farms that we visited were using some form of season extension (a topic that has consistently come up in this project). From strawberries, tomatoes, and flowers, we saw excellent examples of commercial horticulture production practices in the field and under plastic. Participants were very impressed with the size of the tomato plants inside the greenhouses.

This project is supported by the Specialty Crop Block Grant Program administered by the Missouri Department of Agriculture and USDA. Find out more about the MDA Specialty Crop Block Grant Program here.

Special thanks to Tim Baker, Horticulture Specialist for University of Missouri Extension in the NW Region for hosting us and to the many farmers who shared their knowledge and experiences with us.

***3) Event Report for Growing Growers "Equipment Workshop"***

## EXTENSION SERIES TO INCREASE LOCAL FOOD PRODUCTION IN THE KANSAS CITY AREA

Event Report for:
June 14, 2010 Growing Growers Equipment and Farm Safety Workshop

Agenda:
3:00-3:30 : Drip Irrigation Basics
3:30-4:15 : Intro to High Tunnels
4:30-5:30 : Tractor Safety
5:30-7:00 : Field Demonstration

Participants heard lots of information in the classroom on a number of topics, then received a great tutorial on how to put together a drip irrigation system, and were introduced to many ergonomic hand tools from Four Season Tools, Inc.

# IN THE FIELD EQUIPMENT DEMONSTRATION

More than 40 participants attended the workshop and all of them agreed that the hands-on equipment demonstration was the most valuable part of the workshop. From hand tools to power tools, participants were encouraged to observe and get their hands dirty. The audience was so intrigued that many of them stayed for an additional hour to learn even more.

This project is supported by the Specialty Crop Block Grant Program administered by the Missouri Department of Agriculture and USDA. Find out more about the MDA Specialty Crop Block Grant Program here.

The Growing Growers Kansas City program is a collaborative effort to train new and existing producers to be more successful in production and marketing. Find out more about the Growing Growers program here.

**Project 8: Optimizing an Inexpensive Trap and Lure for Monitoring Green June Beetle**
**Missouri State University**
**Final Performance Report**
**Dr. Maciej Pszczolkowski**

***Project Summary***

Green June beetle (GJB), Cotinis nitida, is an important pest of grapes, peaches, apples and all brambles. The beetles feed on the ripe fruit and inoculate it with fungi which cause fruit decay. As much as 80% of the fruit can be destroyed.

Mass GJB outbreaks occur when the fruit is ready for harvest, thus the growers cannot use insecticide sprays (Post harvest and re-entry intervals extends beyond the time of the harvest). Available control measures are exclusion nets, planting sacrificial plots, and timely harvesting and removing rotten fruit (which attracts this insect). Such control measures require planning ahead and forecasting dynamics of local GJB populations. Forecasting the time and the dynamics of GJB outbreaks has not been attempted because population monitoring tools for GJB do not exist. Lures are at the stage of development, traps are very expensive (up to $26 a piece). The Applicant has developed a prototype of GJB monitoring trap that costs $0.40 (forty cents), and was already successfully used in a study on GJB sexual dimorphism. All components of this trap (including the lure) are available in Wal-Mart or grocery stores.

In fall 2007, extension researchers from University of Arkansas surveyed county extension personnel and growers about the pest status of GJB in its geographic range including: Alabama, Arkansas, Georgia, Missouri, Mississippi, New Jersey, North Carolina, Oklahoma, South Carolina, Tennessee and Texas . GJB was reported to reduce yields annually in a total of about 13,100 ha of fruit and turf across these states with yield losses of at least $3.6 million, despite routine control practices that cost at least $260 per ha (Johnson et al. 2009).
In Missouri, the beetles occur in the field from mid-June into August (Iftner 1978), shortly after start feeding on the ripe fruit available and inoculate it with fungi which cause the fruit to decay. Rotten fruit coupled with beetle excrement create a blend that attracts even more GJB to the feeding place (Domek and Johnson 1988, 1990). Sometimes, in apple, grape, peach or pear orchards, total mass of feeding GJB may exceed 100 grams per fruit or cluster (Fig. 1A). Even if feeding damage is not severe, or the fruit do not rot, GJB odor and excrement ruin the odor and flavor of fruit (Fig. 1B,C). As much as 80% of the fruit can be fed on making it unmarketable. In Missouri, where most of the apples and peaches and some of the grapes are produced for fresh market, 80% loss translates to about $14.5 million annually. Unfortunately, there are not many insecticidal control options against GJB feeding on ripe fruit because most recommended insecticides have a 7d preharvest interval.

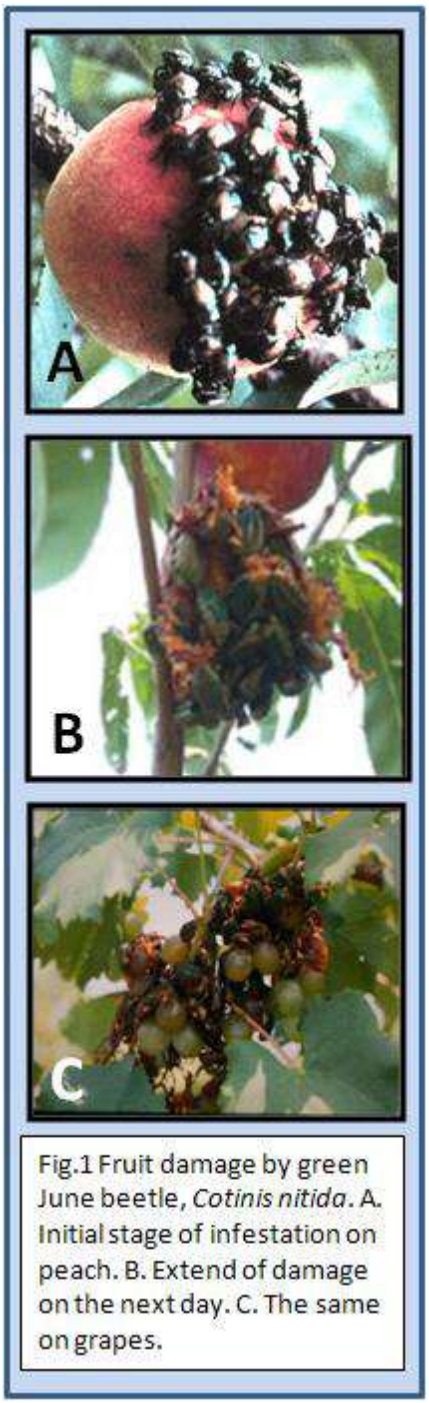


Fig.1 Fruit damage by green June beetle, *Cotinis nitida*. A. Initial stage of infestation on peach. B. Extend of damage on the next day. C. The same on grapes.

There are few other control measures available. Some small-scale producers use exclusion nets, wrapping particular bramble bushes in organza. This practice requires planning ahead in order to have the materials and

man power ready before the outbreak occurs. Vine growers in California set up sacrificial plots of early ripening grapes, which attract GJB before other, more valuable grapes ripen. The fruit in sacrificial plots may be than left to rot and attract more GJB, sprayed with insecticides, and then – disposed or composted. This strategy is not used in Missouri because phenology and population dynamics in Missourian GJB populations are unknown. The most commonly used remedy relies on timely harvesting and removing rotten fruit (which attracts this insect). Such control measures also require planning ahead and forecasting dynamics of local GJB populations. Finally, there are advocates of "attract and kill" strategy for controlling GJB. However, effective and inexpensive lure is needed here.

The most important problem with GJB is the fact that its early stages of the outbreak go unnoticed, even by experienced farmers. GJB look for food in dispersal, flying low over ruderal and segetal habitats such as abandoned pastures. When the grower sees larger congregations of GJB it is already too late to take effective control measures, and the fruit is usually destroyed at least in a part. Forecasting the time and the dynamics of GJB outbreaks or "attract and kill" strategy have not been attempted on a larger scale because population monitoring tools for GJB do not exist. Effective lures are only at the stage of development. Anecdotal evidence from the literature indicates that first attempts of creating GJB lure were made by Muma (1944), who used 100% caproic acid. Wylie (1969) proposed a very complex and difficult to standardize mixture of fermenting molasses, yeast and five aromatic compounds. More recent attempt of mixing phenylacetaldehyde, 2-phenylethanol, methyl-2-methoxybenzoate, limonene, and methyl salicylate (formulated by Trécé Inc., Adair, OK) was similar to a patented Mix-M blend for luring various scarab beetles (Lopez et al., 2002). This scarab lure could be obtained from several companies, however the price is very high (up to $53 per season-long lure) and the lure needs redesign to be attractive (Johnson, field observation in 2009). Additionally, the trap costs from $7 to $25 per trap per season. Clearly, monitoring traps available on the market are still in the stage of development and their availability is limited, particularly for smaller scale growers.

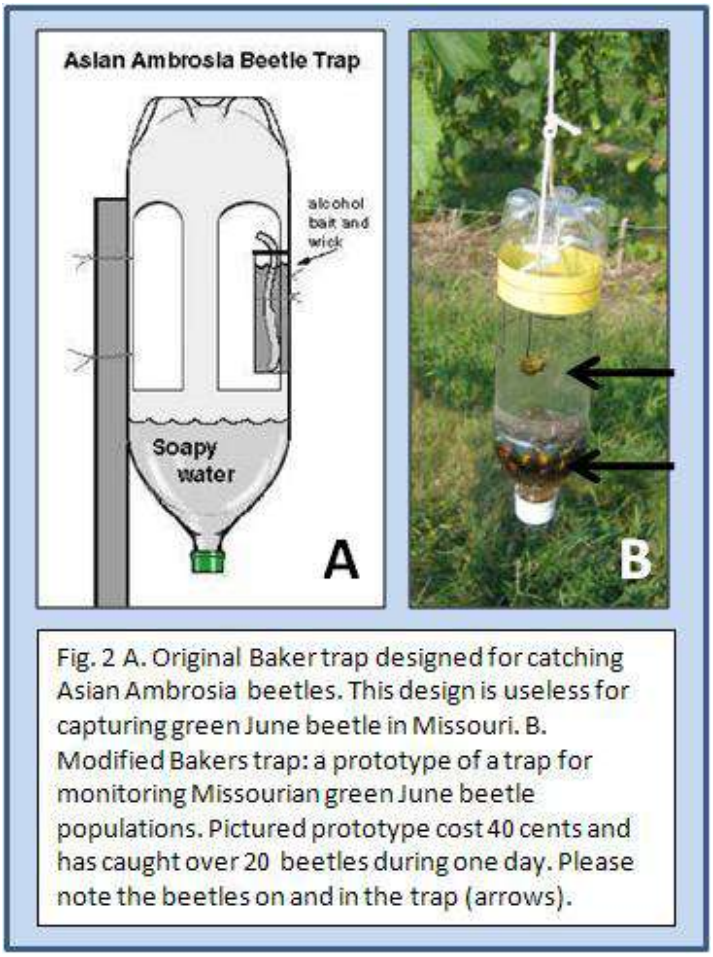


Fig. 2 A. Original Baker trap designed for catching Asian Ambrosia beetles. This design is useless for capturing green June beetle in Missouri. B. Modified Bakers trap: a prototype of a trap for monitoring Missourian green June beetle populations. Pictured prototype cost 40 cents and has caught over 20 beetles during one day. Please note the beetles on and in the trap (arrows).

More recently, Landolt (1990) reported that Floridian green June beetles and another beetles, the Flower scarab, (FS) Euphoria sepulchlaris, are attracted to isopropanol in combination bucket and vane traps. The Applicant hypothesized that rubbing alcohol manufactured by Cumberland Swan, Smyrna TN and marketed as 91% isopropyl alcohol in most of US supermarkets and grocery stores could also attract Missourian green June beetles and Flower scarabs. To test this hypothesis, he used 45% rubbing alcohol in modified Baker traps. Originally devised for collection of Asian Ambrosia beetles, Xylosandrus crassiusculus, Baker traps (Fig. 2A) were procured from two-liter PET bottles after Coca-cola and contained a volume of soapy water as killing agent and a small dispenser for the lure. Such traps proved to be useless for trapping GJB in Missouri. First, the amounts of rubbing alcohol released from the dispensers were too small to attract the beetles. For Missourian

GJB rubbing alcohol needed to be used in larger quantities and poured into the trap, as soapy water in the original. Next, the traps were too big to handle larger quantities of them and to use rubbing alcohol economically. The Applicant modified Baker trap by using a smaller 1 liter bottle, and using rubbing alcohol as lure and killing/preserving medium (Fig. 2B). Large openings on the sides of the trap contributed to losses of the lure and attracted beetles in windy Missouri, particularly on rainy days, when isopropanol and GJB were simply washed out off the original Baker traps. To prevent it, smaller openings were used providing greater collecting space. Yellow strip was added on the top of the trap, and the trap designed to hang from a branch or trellis wire by adding harness made of polypropylene rope.

The trap proved effective in 2007 allowing collecting almost 1,000 specimens for a study on sexual dimorphism in Missourian GJB populations (Pszczolkowski et al., 2008). Also, the trap lures the Flower scarabs (the flight of these beetles precedes the flight of GJB by approximately two weeks in Missouri). Dynamics of GJB catches shows one peak during the season and very likely mirrors the dynamic of population.

The prototype of the trap costs $0.40 (forty cents) apiece, and all its components (including the lure) are available in Wal-Mart or grocery stores. However, this prototype needed development and optimization. In particular, we needed to know whether 45% rubbing alcohol is optimal concentration of the lure. In Arkansas trials (commercial Xpando traps) the maximum concentration (91%) was better than 50%. In preliminary tests with our prototype, the concentration of 30% was already as effective as 50% and 91%.

We needed also to establish, moreover, the optimal height to hang the trap in the field and location. Johnson et al (2009) set traps between 2 to 3 ft height and located traps between pasture where GJBs emerge and fruit planting being attacked. During my experiments in Mountain Grove, the traps were hanged at the level of ca. 4 feet, but the literature suggests that placement the traps on a lower level may be more effective. We also need to establish whether yellow strip on the top of the trap is of optimal color and really attracts the beetles. Finally, we need more data on GJB and Flower scarab flight periods and respective behavior as these beetles approach and/or get captured in traps. These data verified efficacy of the trap design and lure.

Concurrently, a degree-day model to aid growers in predicting GJB emergence and peak flight and feeding activity could also be developed using trap catch data from this proposal and hourly records of local air (4 ft height) and soil (2 inch depth) temperatures. Past trap catch and temperature data for Arkansas and Missouri (Iftner 1978; Johnson et al. 2009; Johnson, unpublished data) was combined with GJB trap data collected during this 2-year proposed project. The temperature data was used to calculate cumulative degree-days (base developmental temperature of 50° F). Flower scarab adults appear to emerge slightly before GJBs and both are attracted to the same trap and lure of isopropanol. We proposed to set the date of first trap capture of the Flower scarab as the “biofix”, and then begin to accumulate daily DD after the biofix. (Degree-day = DD = average daily temperature – base developmental temperature for a specific insect.) We recorded the cumulative DD values on the dates we detect first GJB flight and peak GJB flight for the three seasons in this study. Once a DD model for GJBs is validated, it was posted and updated weekly on the webpage of State Fruit Experiment Station in Mountain Grove to aid in predicting GJB emergence.

This project focused on optimization of a GJB trap. Such a trap could be used by growers to monitor GJB flight and possibly to develop an “attract and kill” strategy to minimize GJB feeding damage to ripe fruit.

Simultaneously, a fact sheet was developed and will be distributed among Missourian growers, who would procure the traps for themselves, at a minimal cost. Using traps, a grower can set their own biofix date, and calculate cumulate DDs using either their own weather data or data from a local weather station available on the

Internet at www.wunderground.com. Thus, the grower will be able to use the GJB trap and DD model to predict and detect GJB emergence and adjust the timing of their preferred pest management strategy accordingly.

The project was to design an inexpensive trap and lure for monitoring green June beetle.

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***Project Approach***

1. The prototypical trap has been optimized. The improved version should be equipped with 125ml dispenser of 45.5% isopropanol (rubbing alcohol available in pharmacies and supermarkets) and blue strip, and should be hanged at the height of 1.3 m from the ground.
2. The trap allows accurately predicting the moment when the green June beetle first appears in the field and when this pest density reaches its peak. This could be done by using degree day model or by monitoring another beetle, Euphoria sepulcralis, with the same trap.
3. The project was the basis for one Master of Science dissertation at Missouri State University Graduate College.
4. Two presentations (one talk and one poster) of the research sponsored by the reported grant were given at Annual Meeting of Entomological Society of America. The results were presented in a form of a talk and a

poster. There were about 75 persons in the room during presentation and the room was full. There was standing room due to the lack of free seats. The poster was available to over 2,500 persons.
5. Cooperation with one private owned, US-based company (Alphascents Inc.) specialized in insect lure and trap technology was established within the framework of the reported grant.
6. On the basis of the reported research, one research paper was written, edited, revised and accepted for publication in Journal of Economic Entomology during realization of the reported grant. The paper has been published in Journal of Economic Entomology in December 2012 (Volume 105, No 6, pp.2076-2084. The link to the paper is http://esa.publisher.ingentaconnect.com/content/esa/jee/2012/00000105/00000006/art00026

***Goals and Outcomes Achieved***
The accomplishments related to this project have beneficial impact on small, medium and larger scale producers of peaches, apples, grapes, pears, and blueberries in the range of GJB occurrence. The number of potential beneficiaries may be estimated from data provided by U.S. Census Bureau. Missouri has about 1.2 million private farm employers (approximately 30% of employers in MO) and many of them will benefit from our research. Add to that number about 0.8 million of retirees who potentially maintain small scale home gardens and orchards and estimated number of residents below 18y of age in question, perhaps 0.5 million). In total, the results of our project will have positive impact on about 2.5 million MO residents, who currently have no effective tools to combat green June beetle damage to fruit.
The GJB DD model provides the commercial fruit growers with a potent tool to forecast GJB adult emergence and be ready with countermeasures. Smaller scale growers and the owners of household gardens will be able to procure exclusion nets or see assistance from local pest controlling agents on time, not while the outbreak is already at its top.
My estimate is that GJB can destroy as much as 80% of the apple, bramble, grape, and peach crops that ripen in July or early August. If one considers the market value of the most prevalent Missourian crops that GJB feeds on, this percentage translates to a significant portion of the $6 million in apples, $4 million in grapes, and $9 million in peaches, annually. About $14.5 million out of this amount reflects the value of fresh market production that cannot tolerate any damage. In summary, this proposal aimed to develop a trap that has potential to reduce the negative impact that feeding GJBs have on the fruit market worth in between $14.5 million and $19 million annually.

**Goal:** To provide an inexpensive trap and lure for green June beetle to Missouri growers and collect baseline data on seasonal changes in GJB trap catches and temperature that could be used toward developing degree-day model to predict GJB emergence.
**Performance measure:** This was a research proposal. The assistant(s) of the PI reported their results obtained from the field experiments to the PI on a weekly basis. Each week, the results were logged into the laboratory book. Each year, the PI reported the results to MDA.
**Benchmarking:** Productivity and quality of the research was compared with research standard and best practice by the means of discussing the results with top ranking national specialist in GJB biology, Dr. Donn Johnson from University of Arkansas was a consultant on the proposed project.

Further, a manuscript derived from this project was submitted to the peer reviewed Journal of Economic Entomology. (Peer reviewers and editors of this journal assured quality of the research and indicated the ways of its improvement).
**Target:** To optimize a GJB trap that can be further developed as an alternative strategy to insecticide control of GJBs.

**Outcomes**

Monitoring performance toward meeting the outcomes: The experiments were conducted in the orchards and vineyards of Missouri State Fruit Station in Mountain Grove, which is a part of Missouri State University of Agriculture. The source of the data was numbers of GJB attracted and caught in the traps baited with isopropanol. The number of GJBs captured in the traps were identified and counted weekly during the time of GJB activity in the field (in Missouri this is a period between the beginning of July and mid September). During the first year of the project, we performed the following experiments: (1) determination of optimal height at which the trap should be placed, (2) determination of optimal isopropanol concentration, (3) determination of optimal color of the strip topping the trap. Results from experiments (1), (2) and (3) suggested an optimal design for the GJB trap. During the second year, optimized traps were used for monitoring GJB flight in four locations in the Station experiment farm: a vineyard, an abandoned apple orchard, a commercial peach orchard, and arboretum. This experiment verified efficacy of the optimized traps and, additionally, provided additional knowledge about time/space distribution of GJB in different habitats during the outbreak.

Additionally, the proposed research created an opportunity of participation and acquiring hands-on research experience for MSU graduate students and undergraduates. The Applicant has a long lasting experience in mentoring graduates and undergraduates in Europe, Asia and the USA. All of these students contributed to his research and vast majority of them co-authored over twenty papers of the Applicant. The Applicant wants to enliven the spirit of optimism and urge for scientific adventure among local graduates and undergraduates, who often are deprived of opportunities of participating in scientific research. The Applicant began his work at the Station in late 2006, and has created a small but steady pool of assistants from the pool of local youth. One of them, at the time the proposal was funded, entered the Ph.D. program at the University of Arkansas. The second was looking for an opportunity to enter the MSU graduate program, advised by the Applicant. All assistants (four persons) co-authored two peer reviewed papers and three conference abstracts and presentations. One presented at the Entomological Society of America Annual Meeting that attracted over 2,000 participants.

***Lessons Learned***

**Year One (2010)**

***(1) Determination of optimal height at which the trap should be placed***

The height of 54 inches (1.3 m) was the most effective. The traps hung at this height attracted 18.3 ± 4.6 GJB per day, which was significantly more ($P<0.05$, $N=15$, Mann Whitney test) than in the case of the trap hung at 36 and 18 inches (16.4 ± 4.5 and 5.6 ± 2.5 GJB per day, respectively).

***(2) Determination of optimal isopropanol concentration***

Numerically, 33% isopropanol was the most effective (about 27 GJB per trap/day) followed by 50%, 66% and 10%. Pure isopropanol was less effective (about 10 GJB per trap/day). Differences among particular concentrations, examined with ANOVA followed by Bonferroni multiple comparison of means (a very conservative statistical method) were not significant due to large standard deviations. These results were counterintuitive and encouraged us to further research on lure optimization

***(3) Determination of optimal color of the strip topping the trap***

In initial experiments, the traps without color straps caught about 9 GJB per trap/day on average. The traps with orange, yellow and blue straps caught about 21, 16 and 13 GJB on average, respectively. The traps topped with violet, red, white, black or green straps caught 10 GJB per trap/day or less. Although, numerically, orange, yellow and blue straps were most effective, there were no statistically significant differences, which encouraged us to further research on color strap optimization

***(4) Further lure and trap optimization***

Puzzled by inconclusive results from the experiments with lure concentration and strap color we hypothesized that lure emission rates from our trap prototypes are too high and contribute to confusing results. To ascertain this, we measured lure emission rates in 24h intervals. The results indicated that in many cases more than a half of isopropanol evaporated within first 24h after trap setting, and after 48h less than 10% of isopropanol remained in the traps. This, we further hypothesized, may contribute to lower efficacy of the trap during the second half of the first day and during following hours of each experiment with color straps and different lure concentrations. To resolve this problem we used plastic lure dispensers kindly provided by AlphaScents Inc. Technically, the dispenser is a small, 100 ml bottle with a tightly closing cap and a 8 mm cotton wick protruding from the cap. The dispenser is filled with 100 ml of isopropanol at desired concentration, closed tightly with the cap. The wick collects isopropanol in the dispenser, and – due to viscosity – transmits the lure to the air at stable rates of about 7 ml a day. The dispenser is hung inside of the trap produced from PET bottle as usual, and the trap is additionally filled with water as GJB killing agent (see Fig.3). Such dispensers dramatically improved trap performance.

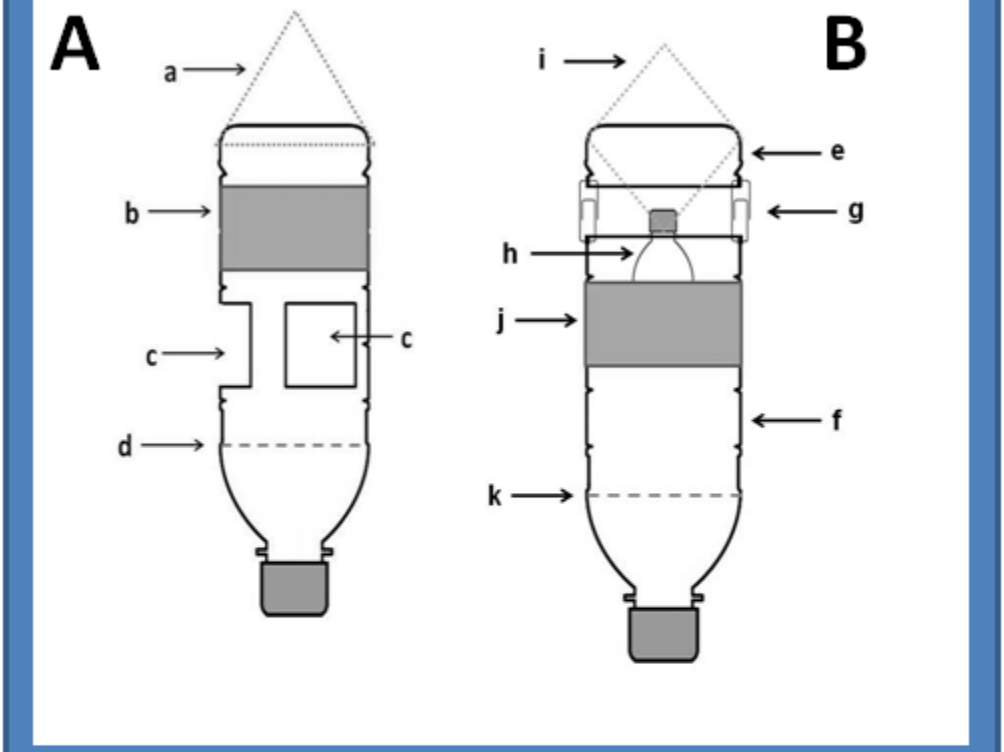


**Fig. 3** Trap design optimization. A) standard bottle trap; a = harness, b = yellow band, c = three square openings(the third opening is placed on the opposite side of the bottle), d = maximum level of the lure; B) improved bottle trap; the bottom of the bottle (e) is cut off from the upper portion (f) and these two parts are reattached with paper clips (g). The isopropanol dispenser (h) is hung by a rope or wire harness (i), j=color band, k= maximum level of the killing agent (aqueous 0.02% Triton X).

***(5) Determination of optimal isopropanol concentration in improved traps***

We found that the traps equipped with lure dispensers baited with various concentrations of isopropanol (10%, 33%, 50%, 66% and 99%) caught GJB in expected concentration-dependent manner; 9.5 ± 1.4, 22.6 ± 2.5, 32.9 ± 2.5, 36.5 ± 3.7, 51.5 ± 5.1 respectively. Statistical analysis (N=15-17, Mann Whitney test) indicated that 50% and 66% isopropanol baited traps caught significantly more GJB than the traps baited with 10% and 33% isopropanol, and the traps with 99% isopropanol dispensers caught significantly more than any other traps.

***(6) Determination of optimal color of the strip topping the trap***

The use of the dispensers also improved the experiments with color straps (Table 1). Here, the traps equipped with 50% isopropanol dispenser and white, blue or orange strap caught significantly more (40.3 ± 4.6, 68.7 ±

18.8, and 47.1 ± 7.9, respectively) GJB than the traps without straps (18.9 ± 3.1). Mann Whitney test indicated differences between the traps without straps and those with orange, white or blue straps at $P<0.05$ or $P<0.01$).

**Table 1.** Effect of band color on number of green June beetles caught in improved bottle traps in Mountain Grove, MO in 2010.

| Color of the band | Pantone color reference | Number of green June beetles caught within 48 h |
|---|---|---|
| Clear | | 18.9 ± 3.1 |
| Blue | 2935C | 68.7 ± 18.8** |
| Orange | 165C | 47.1 ± 7.9** |
| White | 11-0602TPX | 40.3 ± 4.6* |
| Yellow | 109C | 32.0 ± 4.2 |
| Black | 433C | 31.3 ± 3.5 |
| Green | 354C | 28.4 ± 5.8 |
| Violet | 226C | 28.0 ± 2.4 |
| Red | 199C | 19.2 ± 1.3 |

***(7) GJB population dynamics and habitat preference***

Initially we planned to monitor 2010 GJB population dynamics using standard bottle traps only (Fig. 3A). However, our preliminary observations done in the previous season (2009) suggested that improved trap design (Fig. 3B) may be necessary to obtain good results. Thus, during the first three weeks of GJB population monitoring, we used both types of traps. Because improved traps proved their superiority over prototypical standard traps, we abandoned data collection using standard traps after three weeks, and resorted to improved traps solely. The results shown in this report were obtained using improved traps. First GJB were caught on June 21 and population dynamics peaked on July 13. The results collected in 2010 indicate that GJB prefer habitats with edible fruit. Peach orchard attracted 586 GJB per season, abandoned apple plot 233 GJB per season, Norton grape plot (Norton grapes are inedible during GJB occurrence) 106 GJB per season and maintained lawn in the arboretum 55 GJB per season.

**Year Two (2011)**

***Verification of the efficacy of the optimized design***

Fourteen 6-foot property fence poles were proposed for supporting optimized traps. On each pole, three fixing points for the traps were supposed to be arranged by tightly wrapping cable ties at the most effective height, seven traps (experimental traps) filled with 125 ml of the most attractive concentration of rubbing alcohol and seven traps with water (control traps). We planned to randomly assign a particular trap (either experimental or control) to each pole and place this experimental setting in each of four locations in the Station experiment farm: a vineyard, an apple orchard, a peach orchard, and arboretum. The content of the traps was supposed to be collected after 48 hours, transferred to the laboratory and the insects stored in 91% isopropanol for further identification and quantification. Traps would be then washed in soapy water, water, alcohol and dried before being returned to the field. We wanted to repeat this experiment every week throughout the duration of the experiment, and produce four sets of data, each representing different GJB habitat, and reflecting GJB population dynamics throughout duration of the season. Each data point in each population dynamics curve would correspond to a mean of 7 independent samples.

Verification of the efficacy of the optimized design was assessed in a manner different from planned. Since we established in 2010 season that traps with water instead of isopropanol do not attract any green June beetles, and that blue traps are most effective, we used only isopropanol baited traps. Seven prototypical standard bottle traps (each with 125 ml of 45.5% isopropanol, topped with yellow band) and seven improved bottle traps (8mm wick dispensers, 45.5% isopropanol) topped with blue band, were randomly placed in the commercial Catawba vineyard in Missouri State University experiment farm in Mountain Grove, MO. This experimental plot, located in the neighborhood of the aforementioned peach orchard, received routine management by weekly mowing and sprays with insecticides, fungicides and herbicides. The traps were hung at the height of 1.3 m above the ground level. The insects were collected after 48 hours and identified. This experiment was repeated twice in August, 2011.

Population dynamics and habitat preference of the beetles were monitored with improved bottle traps with lure dispensers and with standard, prototypical traps. The traps were randomly placed in peach orchard, unmanaged apple orchard, Norton vineyard and arboretum. After 48 hours the beetles were counted, the traps taken to the laboratory, mended if necessary, washed, and dried.

We also performed chromametric analysis of the color trap toppings in order to provide objective reference to the color (reflectance of a given light wavelength). Additionally, the shade and color of each trap was visually approximated to the closest matching color in Pantone ® solid color formula guide (see Table 1).

***(1) Chromametric analysis of the bands***.

During experimenting we realized that a more objective definition of attractive colors than visual comparison with Pantone ® solid color formula guide is needed. To better define the color of attractive bands, the dominant wavelength, percentage reflected spectrum and CIE L*a*b* values for each plastic color band was determined by a Jaz spectrometer (Ocean Optics, Dunedin, FL), where L*= 0 (black) to 100 (white); a* = negative (green) to positive (red); and b* = negative (blue) to positive (yellow). The results are given in (Table 2) and Fig. 4.

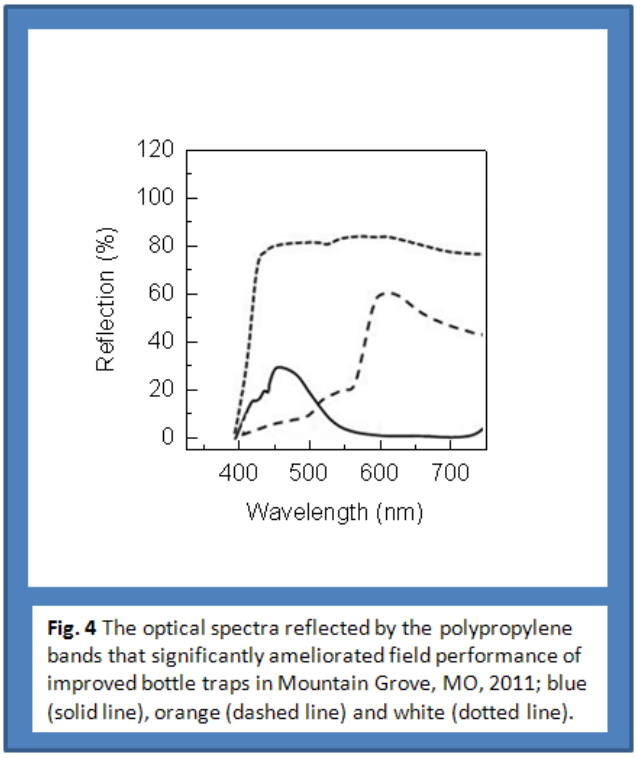


**Fig. 4** The optical spectra reflected by the polypropylene bands that significantly ameliorated field performance of improved bottle traps in Mountain Grove, MO, 2011; blue (solid line), orange (dashed line) and white (dotted line).

**Table 2**. Jaz Spectrometer (Ocean Optics, Dunedin, FL) measurements of the dominant color wavelength, percentage reflectance and CIE *L*a*b** values for each plastic color band used in traps.

| Color band | Dominant wavelength (nm) | % Reflectance | *L** | *a** | *b** |
|---|---|---|---|---|---|
| Blue | 475.6 | 30.0 | 31.8 | 5.8 | -45.9 |
| Orange | 587.0 | 53.0 | 61.0 | 26.6 | 55.0 |
| White | Reflect all | 88.0 | 95.7 | -0.7 | 2.2 |
| Yellow | 577.1 | 79.0 | 85.2 | 2.9 | 82.0 |

Spectrometer analysis of the colored bands (Table 2; Fig. 4) suggested that the beetles were attracted either to one or combination of two light wavelength spectra; one covering the range between 450 and 475 nm (blue) and one corresponding to a combination of yellow and orange (570 – 620 nm).

**Field Performance of the Improved Trap in Comparison to the Standard Trap.**
Blue bands and lure dispensers increased field efficacy of the trap by a factor of ten (Fig. 5).

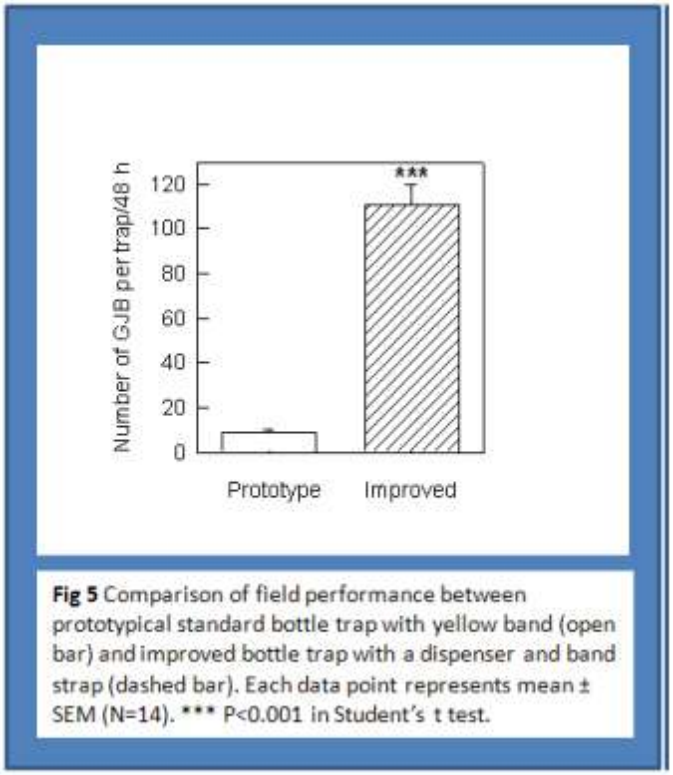


**Fig 5** Comparison of field performance between prototypical standard bottle trap with yellow band (open bar) and improved bottle trap with a dispenser and band strap (dashed bar). Each data point represents mean ± SEM (N=14). *** P<0.001 in Student's t test.

***(2) Population dynamics and habitat preference in green June beetle (2011***)
In 2011 the green June beetle (GJB) was monitored with and improved traps only (Fig. 3B). First GJB were caught on July 7 and population dynamics peaked on July 20.
The results collected in 2011 indicate that GJB prefer habitats with edible fruit. Peach orchard attracted 544 GJB per season, abandoned apple plot 1140 GJB per season, Norton grape plot (Norton grapes are inedible during GJB occurrence) 280 GJB per season and maintained lawn in the arboretum 228 GJB per season.
***(3) Preparation of a manuscript for Journal of Economic Entomology.***
At the end of 2011 the paper was in the process of copyediting by the authors.

**Year Three (no cost extension, 2012)**
***(1) Population dynamics and habitat preference in green June beetle***
In 2012 the green June beetle (GJB) was monitored with improved traps only (Fig. 3B). First GJB were caught on June 13 and population dynamics peaked on July 11.
The results collected in 2012 also indicate that GJB prefer habitats with edible fruit. Peach orchard attracted 825 GJB per season, abandoned apple plot 599 GJB per season. Interestingly, Norton grape plot attracted 918 GJB season, despite there was no edible fruit there. Maintained lawn in the arboretum attracted 46 GJB per season.
Table 3 summarizes the data on GJB habitat preference for the duration of entire project. In 2010 and 2012 the beetles strongly preferred peach orchard. In 2012 Norton vines were attractive in addition to peach plot. Abandoned apples were the most attractive in 2011. Arboretum lawn was consistently less attractive habitat.

**Table 3.** Habitat preference by green June beetles in three consecutive years. Total numbers of the beetles caught in particular habitats are given. Seven traps were set up in each of the habitats located in Mountain Grove, MO. In parentheses are given numbers of green June beetles expected if the beetles had no habitat preference (null hypothesis).

| Year | Habitat | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Peaches* | *Norton vines* | *Abandoned apple plot* | *Arboretum lawn* | $\chi^2$ *value* | *dF* | *P* |
| 2010 | 586 (245) | 106 (245) | 233 (245) | 55 (245) | 315.61 | 3 | <0.0001 |
| 2011 | 544 (548) | 280 (548) | 1140 (548) | 228 (548) | 426.34 | 3 | <0.0001 |
| 2012 | 825 (597) | 918 (597) | 599 (597) | 46 (597) | 576.74 | 3 | <0.0001 |

***(2) Degree-day model for predicting green June beetle outbreaks.***

Degree day model was constructed as follows: Cumulative degree days were calculated based on maximum and minimum daily temperatures recorded by computerized weather station located on Mountain Grove experiment farm. The weather station, MMOA15, is located in a distance of about 50 m from the peach orchard that was monitored with our traps in three consecutive years (2010, 2011 and 2012). Cumulative degree days between April 1st (this date has been used in constructing degree day models for other insects in Mountain Grove Station) and monitored event in GJB populations were calculated according to the formula:

Degree-days = [(max temperature + min temperature) / 2] – base temperature

where base temperature was 10 degrees C. Two events in GJB population dynamics were monitored using our traps and lures: GJB first catch and the peak of GJB population density. Cumulative precipitation was also calculated for the same periods of time (between April 1st and a given event in GJB population dynamics). Also cumulative days from biofix (first catch of Euphoria sepulcralis) (Fig. 6) to first GJB catch and the peak in GJB population density were calculated. Data on cumulative degree days and cumulative precipitation are given in Table 4.

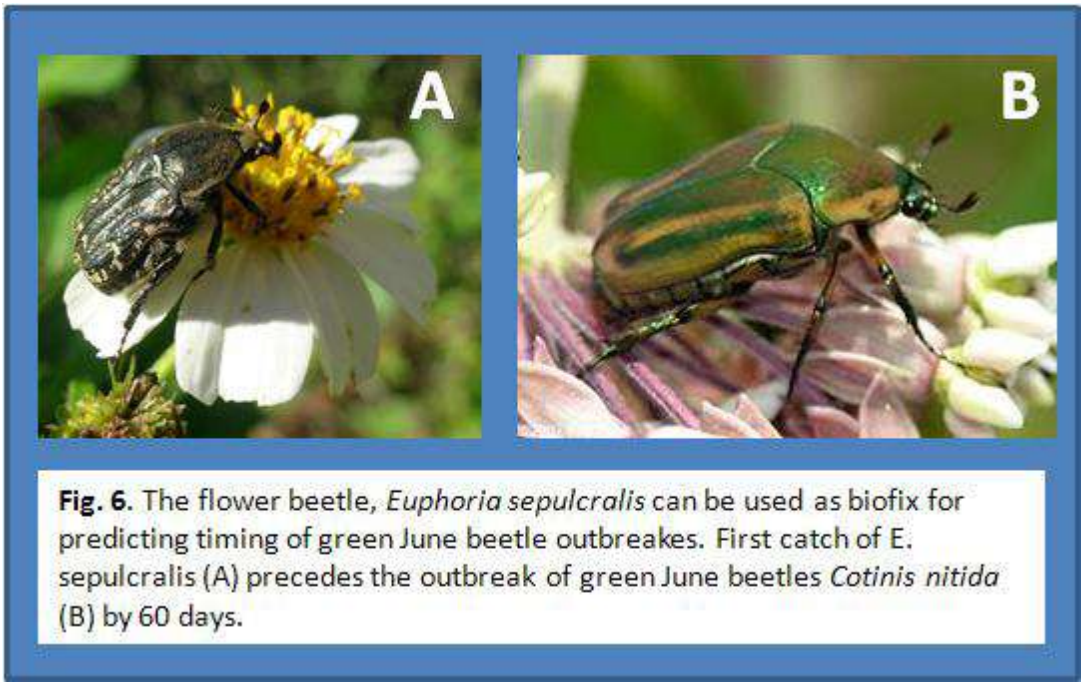


**Fig. 6.** The flower beetle, *Euphoria sepulcralis* can be used as biofix for predicting timing of green June beetle outbreakes. First catch of E. sepulcralis (A) precedes the outbreak of green June beetles *Cotinis nitida* (B) by 60 days.

**Table 4** Cumulative degree days, precipitation and number of days elapsed from biofix for the green June beetle in peach orchard in Mountain Grove. Data are presented for three consecutive years. DD = cumulative degree days, CP = cumulative precipitation calculated beginning from April 1st of the given year. DFB = number of days that elapsed from first catch of *Euphoria sepulcralis* to GJB first catch or the peak of GJB population dynamics.

| Year | GJB first catch | GJB population density peak |
|---|---|---|
| 2010 | June 21<br><br>DD=733 °C<br>CP=308 mm<br>DFB=39 days | July 13<br><br>DD=1077 °C<br>CP=395 mm<br>DFB=61 days |
| 2011 | July 07<br><br>DD=849 °C<br>CP=591 mm<br>DFB=38 days | July 20<br><br>DD=1119 °C<br>CP=598 mm<br>DFB= 51 days |
| 2012 | June 13<br><br>DD=609 °C<br>CP=130 mm<br>DFB=39 days | July 11<br><br>DD=1091 °C<br>CP=176 mm<br>DFB= 67 days |

Average DD for GJB first catch equaled 730.3 ± 69.3 degrees C and for GJB peak of density it equaled 1095 ± 12.4. Average number of days elapsed from biofix was 38.7 ± 0.3 for GJB first catch and 59.7 ± 4.7 for GJB peak density. Contrary to popular belief, green June beetles occurred in the field later in very wet year of 2011 than in very dry year of 2012. Average cumulative precipitation equaled 308.0 ± 134.2 mm at the time of GJB first catch and 395.0 ± 121.9 mm at the time of peak GJB population density.

The general objective of this project has been met. An inexpensive trap for monitoring green June beetle populations has been optimized and evaluated. Consequently, we have provided knowledge that will allow peach, apple, grape, and bramble growers plan their IPM strategies against green June beetle.
Historically, green June beetles were caught using baited JB Expando traps originally designed for the smaller Japanese beetle (Popillia japonica Newman). However, that trap cost $19 each and is the only commercial beetle trap with a funnel opening large enough to allow green June beetle adults to drop into the capture container. A mixture of phenylacetaldehyde, 2-phenylethanol, methyl-2-methoxybenzoate, limonene, and methyl salicylate (formulated by Trécé Inc., Adair, OK), similar to a patented Mix-M blend (Lopez et al. 2002) that attracts various scarab beetles and green June beetle, was reported to be attractive to GJB adults (Johnson et al. 2009). This lure could be obtained from several companies, but it costs as much as $7 US/lure/week ($77-86 US a season) to keep a trap baited to monitor GJB seasonal flight.

Our traps are much less expensive and are easy to procure; all components can be acquired from beverage bottle recycling centers or purchased in grocery stores or supermarkets. One trap could be made at a cost of less than $7.20 US the first season and $4.70 US each following season. Our traps are also reusable (we have used some traps for three years in succession); they can be stored over winter in non-heated storage without loss of integrity.

**Trap Design and Use**

Made of beverage polyethylene terephthalate bottle (710-ml; 24 oz) the trap should be equipped with 125ml dispenser of 45.5% isopropanol (rubbing alcohol available in pharmacies and supermarkets) and blue strip, and should be hanged at the height of 1.3 m from the ground. Water with small addition of dishwashing liquid is used as killing agent. Our experiments showed that such a trap is ten times more effective than the prototype (Fig. 5).

**Predicting of GJB Population Dynamics**

The trap allows accurately predicting the moment when the green June beetle first appears in the field and when this pest density reaches its peak. This could be done by using a degree day (DD) model or by monitoring another beetle, Euphoria sepulcralis, with the same trap. The peak of GJB population density occurs at DD equaling 1095 ± 12.4 (mean ± SEM) or 59.7 ± 4.7 (mean ± SEM) after biofix i.e. first catch of Euphoria sepulcralis (Fig. 6, Table 4). Both methods seem to be reliable for predicting of GJB outbreak, since relative standard error is low here (1.1% for DD method and 7.8% for biofix method). Cumulative precipitation cannot be used as estimator of population dynamics. Average cumulative precipitation equaled 308.0 ± 134.2 mm at the time of GJB first catch and 395.0 ± 121.9 mm at the time of peak GJB population density. In both cases relative standard error exceeds 30% which is regarded as indication of poor reliability of the method by National Center for Health Statistics, Hyattsville, Maryland (Klein et al.2002).
Interestingly, excessively dry weather in 2012 did not delay GJB outbreak in comparison to moderately dry 2010 (Table 4), whereas in humid 2011 the outbreak was delayed both in terms of DD counts and Julian date. This finding is contradictory to popular belief that in humid years the beetles appear in the field earlier, and in dry years the outbreaks are postponed.

**Habitat Preference**

Our results on habitat preference in green June beetle indicate that in moderately humid and dry years (2010 and 2012) the beetles strongly prefer habitats with abundance of edible fruit (Tables 3 and 4). In humid years (2011) GJB may also be numerous in habitats which are less abundant in food, but provide quieter environment without disturbance from agricultural workers.

**References**

Johnson, D.T., B.A. Lewis, R.J. Bryant, R. Liyanage, J.O. Lay, and M.A. Pszczolkowski. (2009) Attractants for the green June beetle, Cotinis nitida (Coleoptera: Scarabaeidae). J. Econ. Entomol. 102:2224-32.

Klein RJ, Proctor SE, Boudreault MA, Turczyn KM. (2002) Healthy People 2010 criteria for data s uppression. Statistical Notes, no 24. Hyattsville, Maryland: National Center for Health Statistics.

Lopez, Crocker and Shaver (2002) Attractant for monitoring and control of adult scarabs. United States Patent 6,440,406.

**Dissemination of the Results**

The results from this project have been presented at one international conference, 2010 Annual Meeting of Entomological Society of America in a form of a poster and a talk:

Cowell, B., Reut, M., Snodgrass, L., Johnson, D.T., Czokajlo, D., Lewis, B., Pszczolkowski, M.A. (2010). Prospects of isopropanol use in controlling green June beetle, Cotinis nitida. Annual Meeting of Entomological Society of America, San Diego, CA. (poster, Attachment A-Additional Information)

Cowell, B., Johnson, D.T., Czokajlo, D., Lewis, B., Pszczolkowski, M.A. (2010). Inexpensive trap for monitoring green June beetle, Cotinis nitida. Annual Meeting of Entomological Society of America, San Diego, CA. (10-minute talk, Attachment B-Additional Information)

A paper entitled "Inexpensive trap for monitoring the green June beetle Cotinis nitida (L.)" by Cowell, B., Reut, M., Johnson, D.T., Czokajlo, D., Kim S-H, Lewis, B., and M.A. Pszczolkowski was submitted to Journal of Economic Entomology. This paper (38 pages, 6 tables and 6 figures) summarizes the process of trap optimization and was accepted for publication on August 30, 2012 (Attachment C).
We are in a process of drafting another paper that will partially base of the data amassed during funded project (degree day model and habitat use).

**The Role of the Project in Student's Career**
Mr. Brian Cowell was the Graduate Assistant during the study supported by the grant reported. His presentations at 2010 Annual ESA Meeting attracted attention of entomologists from Arkansas and robotics specialists from California based private company. As a result, Mr. Cowell has been offered a PhD program at University of Arkansas with tuition and stipend funded by U. of Arkansas.

**Cooperation with Industry and Further Funding Secured in a Consequence of the Project Reported**
Funding of the reported grant enabled establishing of two professional connections. Dr, Donn Johnson from University of Arkansas, who served as a consultant on the reported project has established closer mutual co-operation with the PI, Dr. Pszczolkowski, which so far resulted in four presentations at international meetings and three publications.

Moreover, the reported project resulted in more effective professional networking and allowed generating more funds. While carrying on the reported project, Dr. Pszczolkowski and Dr. Johnson approached Dr. Darek Czokajlo, the president of trap and lure company from Oregon, Alphascens Inc., and proposed co-operation. This resulted in writing a proposal by Pszczolkowski M.A, Johnson, D.T. and Czokajlo, D. "Optimizing an inexpensive trap and lure and developing killing station for green June beetle" and in consequence Dr. Czokajlo was awarded federal assistance through USDA Small Business

Research Initiative, Phase I for research on trap, lure and killing station for green June beetle. Dr. Czokajlo subcontracted Dr. Pszczolkowski funding his research on green June beetle with $10,000. Dr. Johnson was awarded similar amount of money.

**Contact Person**
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## Additional Information

### Attachment 1

*Abstract of the presentation at ESA Annual Meeting in 2010 (poster)*

ENTOMOLOGY 2010

ESA 58TH ANNUAL MEETING
DECEMBER 12-15, SAN DIEGO, CA

Start | Browse by Day | Author Index

Prospects of isopropanol use in controlling green June beetle, *Cotinis nitida*

*Wednesday, December 15, 2010*
*Grand Exhibit Hall (Town and Country Hotel and Convention Center)*

***Brian Cowell*** *, Missouri State University, Mountain Grove, MO*
*Michal Reut , Horticulture and Landscape Architecture, Warsaw University of Life Sciences, Warsaw, Warsaw, Poland*
*Lucas Snodgrass , Agriculture, Missouri State University, Mountain Grove, MO*
*DT. Johnson , Department of Entomology, University of Arkansas, Fayetteville, AR*
*Darek Czokajlo , Alphascents Inc, West Linn, OR*
*Barbara Lewis , Entomology, University of Arkansas, Fayetteville, AR*
*Maciej A. Pszczolkowski , Missouri State University, Mountain Grove, MO*

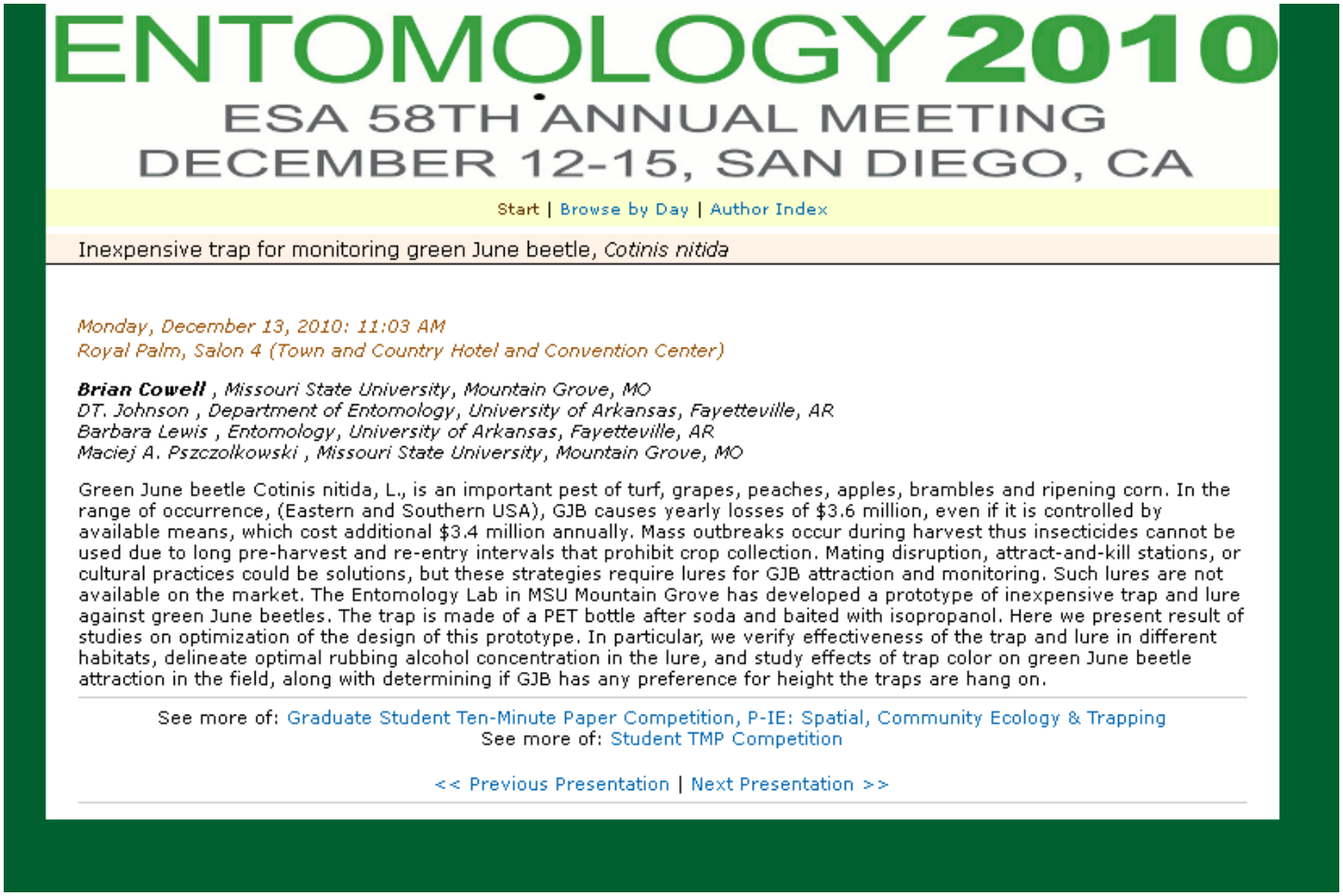
Green June beetle Cotinis nitida, L., is an important pest of turf, grapes, peaches, apples, brambles and ripening corn. Controlling this insect on crops is difficult because no lures or monitoring traps are available, commercially. For several years we have been investigating potential of isopropanol as a lure against green June beetle. Here we present results of field studies on prototypes of improved monitoring trap and attract-and-kill station baited with this chemical.

See more of: Poster Display Presentations, P-IE: Session 2
See more of: Poster

<< Previous Abstract | Next Abstract >>

**Attachment 2**

*Abstract of the presentation at ESA Annual Meeting in 2010 (talk)*



ENTOMOLOGY 2010

ESA 58TH ANNUAL MEETING

DECEMBER 12-15, SAN DIEGO, CA

Start | Browse by Day | Author Index

Inexpensive trap for monitoring green June beetle, *Cotinis nitida*

*Monday, December 13, 2010: 11:03 AM*
*Royal Palm, Salon 4 (Town and Country Hotel and Convention Center)*

***Brian Cowell** , Missouri State University, Mountain Grove, MO*
*DT. Johnson , Department of Entomology, University of Arkansas, Fayetteville, AR*
*Barbara Lewis , Entomology, University of Arkansas, Fayetteville, AR*
*Maciej A. Pszczolkowski , Missouri State University, Mountain Grove, MO*

Green June beetle Cotinis nitida, L., is an important pest of turf, grapes, peaches, apples, brambles and ripening corn. In the range of occurrence, (Eastern and Southern USA), GJB causes yearly losses of $3.6 million, even if it is controlled by available means, which cost additional $3.4 million annually. Mass outbreaks occur during harvest thus insecticides cannot be used due to long pre-harvest and re-entry intervals that prohibit crop collection. Mating disruption, attract-and-kill stations, or cultural practices could be solutions, but these strategies require lures for GJB attraction and monitoring. Such lures are not available on the market. The Entomology Lab in MSU Mountain Grove has developed a prototype of inexpensive trap and lure against green June beetles. The trap is made of a PET bottle after soda and baited with isopropanol. Here we present result of studies on optimization of the design of this prototype. In particular, we verify effectiveness of the trap and lure in different habitats, delineate optimal rubbing alcohol concentration in the lure, and study effects of trap color on green June beetle attraction in the field, along with determining if GJB has any preference for height the traps are hang on.

See more of: Graduate Student Ten-Minute Paper Competition, P-IE: Spatial, Community Ecology & Trapping
See more of: Student TMP Competition

<< Previous Presentation | Next Presentation >>

**Attachment 3**

*The letter acknowledging acceptation of the manuscript for "Journal of Economic Entomology"*

From: system@rapidreview.com on behalf of john.trumble@ucr.edu
Sent: Thursday, August 30, 2012 1:09 PM
To: Pszczolkowski, Maciej A
Cc: akahan@entsoc.org; john.trumble@ucr.edu
Subject: Manuscript EC-12-202 Version 2

Dear Dr. Maciej A. Pszczolkowski,

Your manuscript entitled Inexpensive trap for monitoring the green June beetle Cotinis nitida (L.), manuscript #EC-12-202 Version 2 has been accepted for publication. I appreciate your detailed responses to the reviewers' concerns.

It will now be sent out for copyediting and typesetting. You will receive an email notification from the journal's production staff that the page proof is ready for your review in 5-6 weeks.

Thank you for selecting Journal of Economic Entomology to disseminate your research.

Sincerely,
John Trumble
Editor-In-Chief
Journal of Economic Entomology

**Project 9: South Central Ozarks Produce Express**
**South Central Ozarks Produce Express-Floating Farms**
**Final Performance Report**
**Randy Wood**

***Project Summary:***

- Nov. 2009 Design and printing of printed materials.
  Additional outlets identified. MRH School and Salus Center.

- Nov. 2009 1st workshop meeting-training in use of online ordering system.
  Organizing growers, developing schedules using the online ordering system.

- February 2010 (MOA workshop) additional training in retail readiness.
  Held meeting in Houston at USDA office with Ozarks RC&D on May 12, 2010 and again on June 18, 2010 to identify farmers and producers for pick up and deliveries.

- Communication with buyers and food service personnel, labeling and using the online ordering system. There were 30 farmers from the Ozarks region as well as additional farmers who are interested in developing similar delivery systems in their areas. (Northern Missouri and Central Arkansas)

- Additional meetings held in Mountain Grove, to evaluate programs and do additional retail readiness training with newly forming coop.

- Unexpected results: As a result of these efforts, a cooperative of over 30 farmers representing a variety of products including all types of produce, berries, herbs and flowers is being formed. The farmers believe that enough products will be marketed through this cooperative to enable some of them to give up their off-farm jobs, and others to greatly improve their standard of living.

- A steering committee was formed to guide in the formation of a farm cooperatives.

- Established pick-up and delivery routes and accounts that have and will continue to benefit farmers and customers in continuing to build a distribution network that will allow for an increase in farmers, production, variety and customer base.

It was determined that in order to increase the amount of fresh local produce to the St Louis market that rural farmers would have to organize and aggregate product and that those farmers would need to find a St Louis partner to help distribute.

Sappington Farmers Market a full line grocery store in St Louis had been recently purchased by some local farmers not only to help sell locally produced items be to help distribute additional products to restaurants and schools. The store was in the process of developing a delivery system for daycares and value added processing for public schools that was require it to source more local fresh produce.

Sappington Market then contracted with local farmers to produce many of the items needed to meet the required demand and SCOPE with the funding from this grant provided training needed for the farmers to meet the safety requirements to be suppliers to the store and schools and then helped organize those farmers into aggregation points where produce could be picked up by a refrigerated van being provided as part of this grant.

***Project Approach:***

As part of this grant we worked side by side with Sappington Farmers' Market (SFM) to identify farmers and regions that would benefit the rural farmer and create a long term relationship with the Store and in turn the entire St Louis area. Aggregation, communication and adequate training in labeling and food safety were identified as the short coming and needs to better meet customer demands for fresh local produce. To start this process it was necessary

to have regional meetings to identify and organize farmers by region so to help educate them in what needed to be done and communicated to potential customers. Once regional meetings were set up and groups brought together they as a group could decide whether they wanted or need to organize into cooperative groups or if by just gather and becoming informed on food safety, labeling and needed delivery systems was enough to facilitate a needed increase business.

***Meetings consisted of the following:***

- Regional Meetings began in the Bootheel region at the Delta Center in Portageville for a group of 15 farmers who were interested in forming a cooperative and having an aggregation site for produce to be picked up by the SCOPE van.
- 1st meeting was held in July of 2010, approximately 30 farmers attended. Nancy Smith gave a presentation and assisted with crop planning.
- 4 meetings followed, from Dec. 2010 to Dec. 2011. Each meeting had a specific purpose, either crop planning, safety or business training, or organizational planning.

A cooperative group was formed, originally called Missouri Agricultural Producers, but the blowing up of the Birds Point Levee caused most farming operations in the region to be late planting in 2011.
Deliveries were made to Sappington Farmers Market on numerous occasions and the SCOPE van picked up aggregated produce on 3 occasions-once in Fall of 2010, once in Spring of 2011, and once in Fall of 2011.
This cooperative has re-organized, and plans to supply Sappington Farmers Market, and Farm to Family Mobile Market during the growing season of 2012. There will be an analysis of the products by buyers at Sappington Farmers Market resulted in future orders for 2012.

Another series of Regional Meetings were held in Mountain Grove at the Research Station.

- The first meeting was held in Dec. 2010. Approximately 30 farmers were in attendance.

In January of 2011, the farmers formally became the Producers of the Ozark Plateau Cooperative.

- Three subsequent meetings were held in late January, February and March, 2011. The purpose of the meetings was organizational training, crop planning and business planning instruction.

Beginning in April, 2011, deliveries were made of specialty crops, especially herbs and microgreens. Tomatoes, potatoes and squash were planted and contracted to be picked up by the SCOPE van when ripe.
Buyers at Sappington Farmers Market kept records of deliveries and made the determination that the price on the microgreens was too high to be profitable for the store.

Quality was acceptable, but not as high as warranted by the high price. Repeated negotiations with the farmers resulted in the farmers deciding to sell in their own region. They successfully sold and delivered all summer to Homegrown, Farmers Gastropub and Bass Pro Shops restaurant in Springfield, MO. Negotiations are underway to determine if the quantity, price and quality of the specialty crops will warrant sending the SCOPE van during the 2012 season. One new family in the Macomb area has been providing excellent quality produce at good prices, and the addition of this family's produce may enable Sappington Farmers Market to continue buying vanloads weekly of the Producers of the Ozarks Plateau products.

A Sales Meeting was held at the Schlafly Bottleworks in Maplewood, MO in March of 2010. The online ordering system was unveiled at that time. Many chefs and small grocery owners attended.

A simple version for online ordering was included in the Sappington Farmers Market Fresh Fridays program.

***Goals and Outcomes Achieved:***

It was the intent of this project to identify partnerships both urban and rural so as to facilitate the production and distribution of additional local farm produced products by providing connections, communication, education and transportation necessary to meet the needs and expectations of the two groups. The benefits to those two groups were greater than can be summarized as long term lines of communication between these groups has been established and will provide the conduit for additional farmers and consumer/customers to grow from this charter group.

- Through SFM, a relationship is has been developed with a newly-formed cooperative of minority farmers in the Bootheel for the purpose of providing farm-fresh produce for SFM and St. Louis area school systems.

- Through SFM, project partner, the we have picked up and delivered thousands of pounds of produce to several area school systems, restaurants and daycare centers

- Because of approximately 30 producers that we have organized as part of this grant we have been able to provide the produce required by Maplewood Richmond Heights school in calendar 2011 for which the members of the coop are supplied and SFM Market helped pick up and distribute.

- SFM was able to develop software that first a daycare and then other outside customers are able to go on line and order local products for delivery.

***Regarding evaluations, number of pounds generated, and the online ordering system:***

EVALUATIONS: (Quality, Price, Freshness, Promptness of Delivery)

- Throughout the growing seasons of 2010 and 2011, van trips were made to aggregation points and enough produce was picked up to provide at least the minimum goal of 1500# per week.
- Sappington Farmers Market buyers and produce manager evaluated the produce. They agreed to continue to buy specialty crops from the Bootheel coop, Missouri Agricultural Producers, and are developing contracts for 2012. Promptness of delivery was an issue in 2011, but this was understandable due to the flooding of croplands by the breaching of the Birds Point Levee.
- Some of the produce from Producers of the Ozarks Plateau was not acceptable quality, and price was higher than the market will bear. Negotiations are ongoing with this cooperative, but they are finding a good market in Springfield, MO.
- St. Louis prices are highly competitive due to the St. Louis terminal and the ability for stores and restaurants to source produce at low prices. Local prices must be competitive. In Springfield, local produce is going at higher prices. However, the volume at Sappington Farmers Market and the restaurants and schools it sells to provide a market for much larger amounts of produce than this cooperative is selling in Springfield. It is hoped that, as the farmers increase their production, they will see the value in selling volume at slightly lower prices and continue to get high prices for the most select specialty crops in Springfield.

The online ordering system has had a slow beginning, but is expected to be functional during the 2012 growing season. In the meantime, Farm to Family Naturally has provided a scaled-down version and hired a full-time outside sales person to sell to restaurants, schools and other local grocers. This sales person manages the online ordering as well.

***Beneficiaries:***
The entire region benefited by the visibility created by the efforts of this grant to communicate and help aggregate rural farmer produced products into the urban St Louis market, as can be seen by the list of programs, schools and restaurants that received services.

**Previously Identified Farmers**

| | | |
|---|---|---|
| Dove Mountain | Grapes | $ 900 |
| Clinton Cooper | Tomatoes | $1,125 |
| Floating Farms | Basil | $2,400 |
| Goods From Woods | Pine Nuts | $ 240 |

**New Farmers by Region**

**Northwest Missouri**

| | | |
|---|---|---|
| Mystic Foods | melons | $480 |
| Blue Heron Orchards | apple | $700 |
| Sandhill Organics | | $300 |

**Central Missouri**

| | | |
|---|---|---|
| Mosie Miller | | $500 |
| 3 Girls and a Tractor | | $400 |

**Ozarks Region**

| | | |
|---|---|---|
| Jeff and Tammy Johnston | microgreens | $3000 |
| Sam Miller Farms | sweet potatoes | $300 |
| Long Creek Herbs | herbal products | $300 |
| Marina Backes | tomato products | $500 |

**SE MO and Bootheel Region**

| | |
|---|---|
| Martin Rice | $4000 |
| Lillian Hunter and Adrienne Hunter | $1000 |
| Arlin Sweet | $500 |
| Corey Lowe and Curtis Williams | $500 |

**New Programs**
CSA
Winter CSA
Expanded FRESH FRIDAYS That Include Office Deliveries
Farm To Family Naturally Mobile Market

**New Schools**
Mehlville Public School District
Bistro Kids Private School food preparation
St. Louis Public School District
Meramec Community College
Parkway Public School District

**New Restaurants**

| | |
|---|---|
| 4 Seasons | Kaldis |
| Yia Yias | Vin De Set |
| Vega Deli | Café Osage |
| 1111 | Fresh Gatherings |
| Pi PIZZA | |

***Lessons Learned:***
Although we did achieve the dollar impact that we had hoped for it was enough to get the program noticed and as indicated we have coops in the central Ozarks and in the Bootheel region that are now in a position to increase their product selection and available with these newly established relationships that have developed as the results of this grant.

There is a far greater demand in urban areas for locally grown food than is being provided. There are farmers in rural area capable of producing those items if they know what and how much. We are still far short of connecting those two vital components and until we can provide adequate communications between the consumer and the farm producer both will fail to have their needs met.

***Contact Person:***
Randy Wood
630-240-2347
randy@floating-farms.com

***Additional Information***
*a) FarmsReach Flyer-Missouri Farmers Union Convention*

**SCOPE—SOUTH CENTRAL PRODUCE EXPRESS**

**FOR HELP IN MARKETING YOUR FARM PRODUCTS**
**JOIN US ON FRIDAY JANUARY 29**
**AT THE MISSOURI FARMERS UNION CONVENTION**
**CLARION HOTEL, 3333 S. GLENSTONE, SPRINGFIELD, MISSOURI**


HELPING FARMERS LEARN HOW TO PROVIDE

RETAIL-READY FARM PRODUCTS

TO RESTAURANT, GROCERY STORE AND

INSTITUTIONAL MARKETS.

INTRODUCING A SIMPLE AND EFFECTIVE ORDERING/DISTRIBUTION SYSTEM FOR FARM PRODUCTS.

www.sappingtonfarmersmarket.com for more info OR call Randy at 314-843-7848

At Farm to Family Naturally, we understand the problems farmers face in getting their products to market.

We are committed to helping farmers learn the best, easiest and least expensive ways to present their fresh and value-added products to urban markets.

RANDY WOOD of Farm to Family Naturally Sappington Farmers Market and TOM GRACE of FarmsReach will have a booth at the Missouri Farmers Union Convention Friday January 29 to unveil their FarmsReach software and sign up farmers, gardeners and small producers for their distribution network. FarmsReach is an online farm food marketplace that connects farms to buyers in very efficient and specific ways. Basically, the farmer sets up a farmstand on the FarmsReach website and the buyer can buy products and set up a delivery place and time. Farm to Family will help facilitate deliveries to the St. Louis area-to grocery stores, restaurants and institutions.

RANDY WOOD will give a special presentation at 10 am Friday January 29 at the convention.

THERE IS NO COST TO VISIT THE CONVENTION IF YOU ONLY VISIT OUR BOOTH AND ATTEND OUR PRESENTATION. MEALS ARE EXTRA, AND YOU MUST PRE-REGISTER WITH MISSOURI FARMERS UNION TO EAT LUNCH OR DINNER.

To find out more about the Missouri Farmers Union convention, call Ron McNear at 417-867-3777 or 417-576-8853 or e-mail rmcnear@socket.net

*b) FarmsReach Demonstration Flyer-Maplewood*

## SCOPE—SOUTH CENTRAL OZARKS PRODUCE EXPRESS


FarmsReach brings you Farm Fresh Foods

***SCHAFLY BOTTLEWORKS--MAPLEWOOD***

***Thursday, January 28 4 pm***

***FarmsReach Demonstration***

***free admission-sponsored by SCOPE and Sappington Farmers Market***

***Call Randy at 630-240-2347 for more info***

FarmsReach is an online ordering system that simplifies both the presentation of farm-fresh foods and the ordering of those foods.

Basically, each farmer creates his/her own farmstand from which the restaurant or institution can order. Delivery details are determined between the farmer and the restaurant or institution. This innovative system will revolutionize the ability of farmers to sell their products to the urban market and enable chefs to present the freshest products available to their clientele. And it's almost here-in St. Louis.

To learn more about this system-and how easy it is for you to participate-come to Schafly Bottleworks-7260 Southwest Ave. at Manchester Rd. on Thursday, January 28 at 4 pm for an interactive demonstration of the software, presented by Randy Wood of Sappington Farmers Market and Tom Grace of FarmsReach. The presentation will take about 30 minutes and your questions will be answered for another 30 minutes.

Plan to have dinner at the Bottleworks and stay for the showing of the movie FRESH at 6:30 pm. This movie is being presented by St. Louis University, Fair Shares CCSA and Healthy Youth Partnership. Learn where your food comes from and how to get the best and freshest farm food.

*c) Promotional Picture-FarmsReach*

**Project 10: High Tunnel Production of Green Beans and Sweet Pea Cut Flowers**
**Terminated**
**University of Missouri**
**Received Reimbursement Check for terminated funds in the amount of $3438.00–July 19, 2012**
**The project was for $3619.00 total. This is going to go to Personal Service for the Program Contact as long as Missouri Department of Agriculture accounting approves and funds were obligated prior to September 30, 2012.**
**Dr. Mary Ann Gowdy**

College of Agriculture,
Food and Natural Resources

**University of Missouri**

**Division of Plant Sciences**

1-41 Agriculture Building
Columbia, MO 65211-7145, USA

PHONE (573) 882-3001
FAX (573) 882-2699
E-MAIL plantsci@missouri.edu

November 29, 2010

Re: MU Project 00027468, High Tunnel Production of Green Beans and Sweet Pea Cut Flowers

Dear Mr. Anderson:

I'm sorry to report the following unexpected events have negatively affected the outcome of the research project funded by your agency:

1. The high tunnels that we planned to use for this project had high clay content soils. When we began the project, and the spring rains came, I discovered the high tunnels were directly in the pathway of runoff from surrounding research plots. This delayed our planting dates due to excessively wet soil.
2. The undergraduate student conducting the research vanished midway through the project, taking all the data and plot plans with him. This was totally out of character for this student, so there were not duplicate plot plans.
3. A late summer thunderstorm at the Bradford Research Center caused severe damage to the high tunnels we were using for this research.

I have hopes of tracking down the undergraduate student associated with this project and obtaining all data that he might have collected, but there are no guarantees this will occur. While it's unacceptable to not fulfill the terms of this grant, I am writing to inform you that the project cannot be completed. I hope this does not preclude me from future projects and am respectfully returning all remaining funds.

Sincerely,

Mary Ann Gowdy, PhD

College of Agriculture,
Food and Natural Resources

University of Missouri

Division of Plant Sciences

1-41 Agriculture Building
Columbia, MO 65211-7145, USA

PHONE (573) 882-3001
FAX (573) 882-2699
E-MAIL plantsci@missouri.edu

January 20, 2012

Re: MU Project 00027468, High Tunnel Production of Green Beans and Sweet Pea Cut Flowers

Dear Mr. Anderson,

Regarding the above-referenced project, the circumstances have not changed since the letter I wrote you in November, 2010. I regret that I will not be able to complete this project. I have included the text from the original letter for your convenience.

I'm sorry to report the following unexpected events have negatively affected the outcome of the research project funded by your agency:

1. The high tunnels that we planned to use for this project had high clay content soils. When we began the project, and the spring rains came, I discovered the high tunnels were directly in the pathway of runoff from surrounding research plots. This delayed our planting dates due to excessively wet soil.
2. The undergraduate student conducting the research vanished midway through the project, taking all the data and plot plans with him. This was totally out of character for this student, so there were not duplicate plot plans.
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I have hopes of tracking down the undergraduate student associated with this project and obtaining all data that he might have collected, but there are no guarantees this will occur. While it's unacceptable to not fulfill the terms of this grant, I am writing to inform you that the project cannot be completed. I hope this does not preclude me from future projects and am respectfully returning all remaining funds.

Sincerely,

Mary Ann Gowdy, PhD

Michelle K. Schaben, Financial Officer
Sponsored Programs Administration 2/4/12

**Project 11: River Hills Elderberry Producers Growers Recruitment Project**
**River Hills Elderberry Producers**
**Final Performance Report**
**Terry Durham**

***Brief Project Description***
1) To educate potential producers about elderberry production and marketing through on-site visits to conferences and exhibitions, and
2) To provide in depth information at the two-day Comprehensive Elderberry Workshop and Farm Tour.

***Project Summary***
In order to establish a processing plant to help address the need for elderberry juice, thereby adding income and stability to farms, the **Grower Recruitment Project** launched an education module to encourage elderberry production. The Grower Recruitment Project built on the project entitled **New Crop for a New Age: Innovation and Marketing of Elderberry Plantations and Value-Added Products** (SCBG Agreement 12-25-0868), potential growers received information on the marketing advantages and crop production of elderberry plantations, a crop that is under-produced in the United States, resulting in 95% imports of elderberry ingredients, usually in the form of juice.

Elderberry has recently been declared a "super-fruit" with excellent antioxidant and anti-viral components, and is highly sought after by a large number of food and beverage manufacturers. The product they seek is un-concentrated elderberry juice, the first generation of processed elderberry, and the processing goal of Missouri River Hills Elderberry Cooperative.

***Project Approach***
To host a two-day intensive workshop covering cultural information from propagation to pest prevention, marketing of value-added products, and a farm tour during the flowering season. In order to attract participants the project included placing advertising in key agricultural publications, promotion through speaking engagements and exhibitions at conferences, and increasing interest in elderberries through published articles and the River Hills Harvest website.

***Goals & Outcomes Achieved***
1) On-site display and education offerings at local and regional farm conferences and exhibitions: In addition to attendance at the North American Elderberry Summit, MoRHEP presented information at five local and regional conferences and trade shows, showcasing to 5,450 potential growers, adding 86 names to email list, distributing 785 pieces of information and recruiting a total of 8 new growers with a commitment of 14.5 acres from these meetings.
2) Comprehensive Elderberry Workshop and Farm Tour – over 120 unique potential growers attended the workshop and farm tour held June 17-18, 2010. From that number, 45 Missouri growers attended the MoRHEP cooperative organizational meeting.
3) Of the 125 acres necessary to establish an efficient year-round juice processing facility, this project stimulated an additional 85 acres committed to elderberry production in Missouri.

***Beneficiaries***
The impact of this project will be felt in several sectors. First, growers will increase the value of their farms by planting elderberry, and subsequently harvest a new high-value crop that will increase farm income. Those who become members of the cooperative will multiply their income when their harvests are used to create value-added products.

Each grower will benefit from second-year harvests, which is highly unusual for a perennial crop, at an estimated 350 pounds per acre, which, depending on the degree of value added, will result in returns from $1.00 to $5.00 per pound. Third year yields are anticipated to be in the range of 2000 pounds per acre.

Communities will benefit from increased farm value and income, as well as from increased employment opportunities in the form of farm labor and processing employment.
At this time, with membership commitments from 25 growers' totally over 85 acres, MoRHEP has come one step closer to securing the number of growers necessary to build a processing plant and pursue organization as a cooperative.

***Lessons Learned***
1) Missouri growers appreciate the opportunity to participate in a cooperative effort that will add-value to their crops, supplying additional income to their farms and increasing return on investment;
2) Growers are interested in advances in cropping methods and marketing of new crops that will help sustain their farms and keep agricultural land in agricultural use;
3) Growers respond by phone and email to advertising in targeted agricultural publications;
4) Growers will travel to targeted meetings to engage in information gathering and discussions with other growers and experts when the offering is affordable and convenient, e.g., the low cost to growers, subsidized by this funding opportunity, combined with a Thursday/Friday meeting, allowing growers who attend Saturday markets to maintain their harvest and market schedules;
5) Agricultural publishers will print articles on elderberry plantations and value-added possibilities, realizing this new crop has excellent potential for growers; and,
6) More rural areas are implementing internet access and growers are beginning to use the services available through the internet, including communication, research, and purchasing.

***Funding Expended To Date***
The Missouri River Hills Elderberry Producers have received $31,500.00 of the $31,500.00 in total grant funds for the River Hills Elderberry Producers Growers recruitment Project. There is a $0.00 balance for this grant project.

***Contact Information***
Terry Durham
573-999-3034
info@elderberrylife.com

Report prepared by: Deni Phillips
573-424-9693
denire@yahoo.com

***Additional information*** Please see inserted documents and links.
http://bit.ly/dclrbA --- Country Folk Growers article, May 2010, Midwest edition
www.riverhillsharvest.com
http://elderberrylife.com/umcletter.html
http://files.meetup.com/215138/elderberry%20summit%20broc.pdf
http://mtngrv.missouristate.edu/assets/commercial/ByersandThomas.pdf
http://www.elderberryalliance.org/documents/WrolstadRonald.pdf

**Comprehensive Elderberry Workshop & Farm Tour**
**Schedule – Thursday, June 17, 2010**

9 a.m. – Registration and Morning Snacks

10 a.m. – Introduction of River Hills Elderberry Producers
Terry Durham & Joe Wilson – Elderberry growers

10:15 – The Elderberry Improvement Project –
New Introductions - New Variety Trials - Fertility Study - Pruning Study
Patrick Byers, Department of Fruit Science, MSU, Springfield
Andrew Thomas, Southwest Research Center, MU, Mt. Vernon

Noon – Lunch & Discussion of the morning program

1:00 – Carver Center Elderberry Tour ---
Terry Blank, Lincoln University Extension, Greenhouse Manager

1:45 – Crop Management – Establishing & Maintenance
Terry Durham, Eridu Farms, Hartsburg, MO

2:00 – Crop Management – Harvest & Post-Harvest Handling
Terry Durham

3:00 – Short break

3:15 – Inter-planting Vegetables
Joe Wilson, Four Rivers Farm, Nevada, MO

3:45 – Elderberry Processing
John Brewer, Wylde Wood Cellars, Mulvane, KS
Terry Durham, ElderberryLife, Hartsburg, MO

Open invitation to Eridu Farm, Hartsburg. Meal not provided. Primitive camping available. No hookups.

**Schedule – Friday, June 18**

8:30 – Gather at Eridu Farm Elderberry planting

9:00 - Elderberry Propagation Workshop
John Avery, MSU, Mountain Grove, MO
Learn how and take a plant home with you

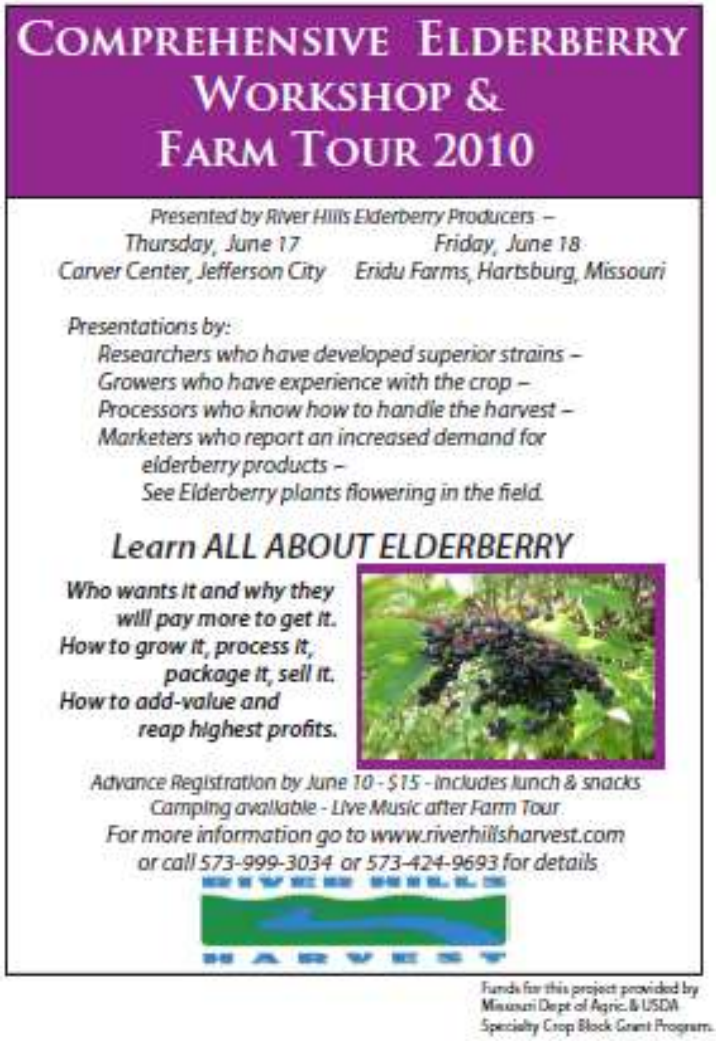
9:30 – Farm Tours

11:00 – Migrate to American Legion Hall

11:15 – Agroforestry
Larry Godsey, MU Center for Agroforestry, Columbia, MO

Noon – Lunch Program: Marketing Your Elderberry Crop
Joe Parcell, ValueAg, Columbia, MO

1:30 – River Hills Elderberry Producers Coop Meeting
Members only – new members accepted at workshop




**Trade Show Contact Results**: and committed acres to date

| Trade Show | Number | List | Publications | New | Number Acres |
|---|---|---|---|---|---|

| | Attending | Additions | Distributed | Growers | New |
|---|---|---|---|---|---|
| Small Farm Today | 2000 | 32 | 300 | 2 | 2 |
| Great Plains Veg Gr | 250 | 19 | 100 | 2 | 11 |
| Sm Fruit & Veg Gr | 100 | 13 | 60 | 1 | |
| Upper MW Org Conf | 3000 | 56 | 250 | 2 | 0.5 |
| Missouri Org Assoc | 100 | 22 | 75 | 1 | 1 |
| Totals | 5450 | 132 | 785 | 8 | 14.5 |

**Project 12: Developing a Strategy for Chestnut Weevil Monitoring**
**University of Missouri**
**Final Performance Report**
**Dr. Bruce Barrett, Terrell Stamps, and Chung-Ho Lin**

***Project Summary***

The most important economic pests of chestnut in the United States are the larger chestnut weevil (*Curculio caryatrypes*) and the lesser chestnut weevil (*Curculio sayi*). In Missouri, the lesser chestnut weevil is the dominant species. Populations of chestnut weevils tend to rapidly reach economically devastating densities and have the propensity to destroy entire chestnut harvests. However, the majority of the work conducted on chestnut weevils since 1930 is European in origin. There are relatively few scientific publications reporting on the basic biology and ecology of chestnut weevils. Consequently, there are no effective means of monitoring the weevils' dispersal and orientation behaviors. Without a reliable monitoring device to detect the beginning of adult chestnut weevil emergence and their movement into and out of the orchards, chestnut growers will be at a distinct disadvantage in determining the economic threat of weevil damage and if and when a chemical control tactic should be implemented. A goal of this overall project was to establish some biological data regarding the orientation mechanisms and preferences of weevils towards chestnut plant volatiles. Our specific objectives during this project were (1) to identify the major components of chestnut volatile organic compounds (VOC); (2) to evaluate adult chestnut weevil behavioral responses (through laboratory bioassays) to chestnut volatiles; (3) to evaluate adult chestnut weevil physiological responses (through electroantennagraphy) to chestnut volatiles. The results from these objectives begin to provide a comprehensive view of the chestnut weevil's relationship to its host tree. This project is the first step towards an effective sustainable management strategy of chestnut weevils and is essential for the continued growth of the chestnut industry.

***Project Approach***

<u>*Identifying chestnut volatiles*</u>. The major chestnut volatile organic compounds (VOCs) were identified from chestnut plant tissues using solid-phase micro extraction (SPME) and gas chromatography, mass spectrometry (GC-MS) procedures. Fifty-nine VOCs were identified from chestnut plant tissues, with relative concentrations determined based on peak area indices, and thirteen compounds were confirmed with authentic standards (Table 1).

<u>*Y-tube Olfactometer Bioassays*</u>. Bioassays examined the behavioral response of adult weevils exposed to plant volatiles emanating from whole plant material (chestnut, bur, catkin, leaf and stem [Qing cultivar]). In behavioral trials, spring emerging weevils (of both sexes) were significantly attracted to odors emanating from

catkins (flowers) and burs, with males also attracted to the odors from the nut. In the late-summer, weevils (of both sexes) emerging or returning to chestnut trees were again significantly attracted to the odors from bur and catkin tissues, with females also being attracted nut tissue. Odors emanating from leaves were not attractive to either sex. Specific plant volatiles identified from the first objective Two VOCs were shown to be significantly attractive for adults, while 21 VOCs were shown to be repellent. Future work will identify the importance of dose-response for all compounds that generated significant behavioral responses.

*Electroantennographic Responses to VOCs*. EAG trials revealed that weevil antennae responded significantly to odors from bur spikes and the inner bur tissue layer, as well as to odors from catkin and leaf tissues; however, the weevils (regardless of sex or season of collection) were not significantly responsive in EAG tests to odors from the nut tissue (site of oviposition). After initial screening using EAG response towards 31 VOCs from plant tissue, 14 were selected for multiple EAG replicates using both male and female antennae from both spring and fall emergences. Thirteen of the fourteen VOCs that were tested generated a larger electrophysiological response by the insect than the air puff control. Several chemicals produced different responses between the sexes and across the seasons (Figure 1).

***Goals and Outcomes Achieved***

The goals of the objectives for this project largely have been met. Numerous promising VOCs were identified and tested, both from a behavioral and physiological perspective. A baseline set of data has been established characterizing the most promising plant volatiles and their attractiveness to the chestnut weevil. This data allows for further refinement of multiple component and dose response for the development of an efficient monitoring system for the adult weevils in the field.

Several papers and poster presentations have been produced from this project. Several posters have been presented at the Entomological Society of America (ESA) Annual meetings in Reno, NV, and Knoxville, TN, as well as at Missouri Life Sciences week at the University of Missouri. The posters presented at the ESA meetings in Reno and Knoxville were available for viewing by the approximately 3000 attendees at each meeting. The attendees included national and international researchers, extension personnel, and students as well as representatives from industry and the public. The Missouri Life Sciences week poster was viewed by several hundred attendees, including faculty, extension, students and the general public. Two peer reviewed publications and a PhD dissertation have been published thus far, as well. These publications are available to interested parties through the internet and interlibrary loan. Following is a list of outputs:

Poster Presentations

The chemical ecology of chestnut: research into the GC-EAD responses to and behavioral bioassays of volatile organic compounds from chestnut tree tissue by *Curculio sayi*. Ian W. Keesey, Bruce A. Barrett, W. Terrell Stamps and Chung-Ho Lin (University of Missouri); Missouri Life Sciences Week; Columbia, MO; April 18-23, 2011.

The role of chemoreception in host plant selection by the lesser chestnut weevil, *Curculio sayi*. Ian W. Keesey, Bruce A. Barrett and W. Terrell Stamps (University of Missouri); Entomological Society of America, Annual Meeting; Reno, NV; November 14, 2011.

Bimodal seasonal emergence and the delayed onset of reproductive development in the lesser chestnut weevil, *Curculio sayi*. W. Terrell Stamps, Ian W. Keesey and Bruce A. Barrett (University of Missouri); Entomological Society of America, Annual Meeting; Reno, NV; November 15, 2011.

Behavioral and electrophysiological responses of the lesser chestnut weevil, *Curculio sayi*, to individual volatile organic compounds identified from host plant. Bruce A. Barrett, Ian W. Keesey, W. Terrell Stamps and Chung-Ho Lin (University of Missouri); Entomological Society of America, Annual Meeting; Reno, NV; November 16, 2011.

Fill, A., B. A. Barrett, and I.W. Keesey. 2012. Preliminary data on the physiological and behavioral dose-responses of the lesser chestnut weevil (Curculio sayi) to volatile organic compounds from its host plant. Entomological Society of America Annual Meeting, Knoxville, TN, Nov. 11-14.

Publications

Keesey, Ian W., Bruce A. Barrett, Chung-Ho Lin, and Robert N. Lerch. 2012. Electroantennographic responses of the small chestnut weevil *Curculio sayi* (Coleoptera: Curculionidae) to volatile organic compounds identified from chestnut reproductive plant tissue. Environmental Entomology 41(4): 933-940.

Keesey, Ian W., and Bruce A. Barrett. 2012. Behavioral and electroantennographic responses of the lesser chestnut weevil, *Curculio sayi* (Coleoptera: Curculionidae), to odors emanating from different chestnut plant tissues. Journal of the Kansas Entomological Society 85(2): 145-154.

Keesey, Ian W. 2011. The chemical ecology of the lesser chestnut weevil: behavioral and electrophysiological responses of *Curculio sayi* (Coleoptera: curculionidae) to host-plant volatile organic compounds. PhD Dissert., University of Missouri.

***Beneficiaries***

The primary beneficiaries from this project have been fellow scientists in the field of chemical ecology because the initial information garnered is foundational in nature. The field of chemical ecology is represented by several hundred researchers and students, in both the public and private sectors. Chestnut growers will benefit from the information built upon this foundation. The number of current and potential chestnut growers in Missouri numbers between 50 and 100. Refinement of dose-response for specific attractive VOCs and investigation of the most attractive mixtures of VOCs will allow us to create a monitoring system to determine chestnut weevil activity periods and economic thresholds. Accurate monitoring should reduce pesticide use and more precisely target pesticides when they are used, greatly reducing grower costs and reducing the negative effects of pesticides on the environment and society. The economic impact could be significant, with results from this study and follow up studies providing a means by which to determine if pesticide spraying is needed and/or to precisely time needed applications, reducing chemical costs by half or more.

***Lessons Learned***

The difficulty in setting up the EAG apparatus and refining the technique for generating reproducible and significant responses from weevil antennae was a challenge, but was overcome by careful and diligent work by the graduate students involved. The sporadic availability of insects as well as not knowing how many insects would be collected each season made timely processing of the insects in various experiments a priority. In optimizing complex equipment such as EAG, practicing on non-essential insect species prior to using the target species is indispensable, especially if there is a limited number of insects and/or a restricted time frame in which to use the target species, as was the case here.

***Contact person***

Bruce A. Barrett
(573) 882-3446
barrettb@missouri.edu

## *Additional Information*

**Table 1.** Chemical profile from *Castanea mollissima* tissues sampled with SPME, including relative concentrations calculated by peak area.

| Peak No. | RT (min) | COMPOUND | BUR | NUT | CATKIN | Criteria |
|---|---|---|---|---|---|---|
| 1 | 1.536 | ethanol | 0.07 | - | - | a |
| 2 | 2.647 | 1-propanol | - | - | 0.03 | b |
| 3 | 3.47 | 2-butanol | - | - | 0.1 | b |
| 4 | 3.842 | ethyl acetate | 4.26 | - | - | a |
| 5 | 4.242 | isobutanol | - | - | 0.18 | b |
| 6 | 6.368 | 1-penten-3-ol | - | - | 0.11 | b |
| 7 | 6.5 | 2-pentanone | - | - | 0.23 | b |
| 8 | 7.088 | 2-pentanol | - | 2.03 | - | b |
| 9 | 7.242 | furan, 2-ethyl | - | - | 0.08 | b |
| 10 | 7.998 | isopropyl acetate | - | - | 0.04 | b |
| 11 | 8.973 | 1-pentanol | - | 2.12 | 0.71 | b |
| 12 | 9.21 | 2-methylbutanol | - | - | 0.56 | b |
| 13 | 10.422 | ethyl isobutyrate | - | 4.74 | - | a |
| 14 | 10.757 | toluene | - | - | 1.16 | a |
| 15 | 12.845 | ethyl butyrate | - | 28.43 | - | a |
| 16 | 12.871 | hexane, 3-ethyl- | - | - | 0.17 | b |
| 17 | 15.843 | ethyl 2-methylbutyrate | - | 22.52 | - | a |
| 18 | 15.874 | (E)-2-hexenal | 0.24 | - | 0.12 | a |
| 19 | 16.157 | (Z)-3-hexenol | 6.55 | - | 4.33 | a |
| 20 | 16.838 | (E)-2-hexenol | 0.1 | - | 1.84 | b |
| 21 | 17.002 | isohexenol | 0.68 | - | - | b |
| 22 | 18.277 | 2-heptanone | 0.05 | - | 3.45 | a |
| 23 | 18.864 | 2-heptanol | 0.26 | - | 6.16 | a |
| 24 | 20.313 | 2-butenoic acid, 3-methyl-, ethyl ester | - | 2.53 | - | b |
| 25 | 21.077 | beta-pinene | - | 1.53 | - | a |
| 26 | 21.097 | alpha-pinene | 0.1 | - | 0.04 | a |
| 27 | 21.271 | ethyl tiglate | - | 1.03 | - | a |
| 28 | 23.146 | 1-heptanol | - | - | 0.15 | b |
| 29 | 24.104 | 5-hepten-2-one, 6-methyl- | - | - | 1.77 | b |
| 30 | 24.373 | 2-octanone | - | - | 0.36 | b |
| 31 | 24.472 | 2-amylfuran | 0.07 | - | 0.46 | b |
| 32 | 25.28 | 4-hexenol, acetate | 49.3 | - | 0.35 | b |
| 33 | 25.667 | n-hexyl acetate | 4.14 | - | 0.81 | b |
| 34 | 25.786 | 2-hexenol, acetate | 0.77 | - | - | b |
| 35 | 26.922 | eucalyptol | 0.14 | - | - | b |
| 36 | 26.965 | benzyl alcohol | - | - | 7.49 | b |
| 37 | 27.406 | 2-decenal, (E)- | - | - | 0.27 | b |
| 38 | 27.761 | (E)-beta-ocimene | 0.04 | - | - | b |
| 39 | 28.514 | 1-phenylethanol | - | - | 20.2 | b |
| 40 | 28.694 | ethyl 2-hydroxy-4-methylpentanoate | - | 1.6 | - | b |
| 41 | 30.621 | (E)-4-hexenol | 0.54 | - | - | b |
| 42 | 30.905 | 2-nonen-1-ol | - | - | 0.36 | b |

| | | | | | | |
|---|---|---|---|---|---|---|
| 43 | 31.423 | phenethylamine | - | - | 2.06 | b |
| 44 | 31.579 | Cyclohexane, 2-ethenyl-1,1-dimethyl-3-methylene- | 1.29 | - | 1.26 | b |
| 45 | 32.058 | ethyl 3-hydroxyhexanoate | - | 2.31 | - | a |
| 46 | 34.482 | trans-3-dodecene | - | - | 0.91 | b |
| 47 | 34.511 | Ethyl benzoate | 0.2 | - | - | b |
| 48 | 35.291 | (E)-3-Hexenyl Butyrate | 1.57 | - | - | b |
| 49 | 35.763 | ethyl caprylate | - | 1.87 | - | a |
| 50 | 35.999 | 2-Propylheptanol | 0.27 | - | - | b |
| 51 | 38.738 | cis-Geraniol | 0.8 | - | 8.12 | b |
| 52 | 39.599 | Geraniol | 0.28 | - | 0.19 | b |
| 53 | 41.083 | 2-butyloctanol | - | - | 2.68 | b |
| 54 | 45.588 | (E)-alpha-bergamotene | - | 1.08 | - | b |
| 55 | 45.75 | 1-Decanol, 2-ethyl- | 0.46 | - | - | b |
| 56 | 47.406 | beta-caryophyllene | - | - | 0.25 | a |
| 57 | 47.748 | alpha bergamotene | - | 0.71 | 6.16 | b |
| 58 | 48.868 | ethyl cinnamate | - | 6.47 | - | a |
| 59 | 50.601 | alpha-farnesene | 2.91 | - | 1 | b |
| | | esters | 60.24 | 67.35 | 1.2 | |
| | | alcohols | 9.52 | 4.15 | 53.23 | |
| | | benzenoids and miscellaneous | 5.29 | 7.45 | 19.77 | |
| | | unknowns | 12.59 | 8.09 | 9.23 | |
| | | total of all compounds | 87.65 | 87.04 | 83.42 | |

[1]*Relative concentrations calculated by peak area.*
[2]*Compound identification criteria: a = comparison of MS and retention time to authenticated standard; b = NIST library match.*

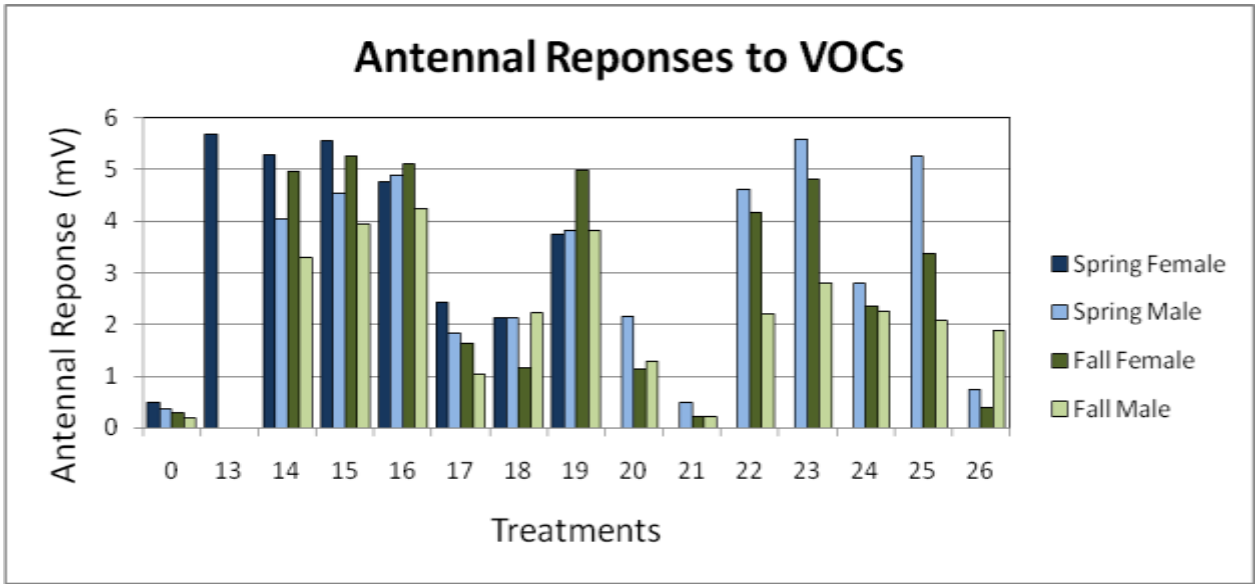



**Figure 1.** Shown are the EAG responses of weevil across sex and season to 14 VOCs. Air was used as the control puff. Table shows the treatments listed by number in key.

**LEGEND**

| | treatments |
|---|---|
| 0 | Air (Control) |
| 13 | Hexane |
| 14 | ethyl 2 methyl butyrate |
| 15 | ethyl isobutyrate |
| 16 | ethyl butyrate |
| 17 | ethyl caprylate |
| 18 | 2 ethyl butyric acid |
| 19 | ethyl tiglate |
| 20 | ethyl 3 hydroxyhexanoate |
| 21 | ethyl cinnamate |
| 22 | 2 heptanol |
| 23 | 2 heptanone |
| 24 | (E) 2 hexen 1 ol |
| 25 | (E) 2 hexen 1 al |
| 26 | (E) 2 nonen 1 ol |

**Project 13: Positioning Missouri Vegetable Growers Association to Lead the Industry in Growth and Competitiveness**
**Missouri Vegetable Growers Association**
**Final Performance Report**
**Rodger Kube-Changed from Errol Ahlers - Roger is the current Secretary of MVGA**

***Project Summary***

Fresh, quality locally grown produce is in high demand by consumers and positive for rural development. MVGA (Missouri Vegetable Growers Association) is Missouri's only statewide vegetable growers association. Strong producer associations are critical to a vibrant agricultural industry, whereby they can actively lead or facilitate in membership education on critical issues like competiveness.

MVGA could more effectively serve its membership and reach out to non members. For example, Missouri's grain and livestock associations are much more fully developed than is MVGA (e.g. Missouri Soybean and Corn Growers

Association as well as Cattleman's Association all have full time staff and membership in the thousands), but then Missouri's vegetable industry pales in size and significance to their industries. Many other states have more well developed state vegetable associations providing greater grower services such as organizing their state's conferences, funding scholarships and research, providing trade or extension publications, and having a comprehensive web site.

A challenge in Missouri for its association is serving the grower diversity given the great physical separation between growers or grower groups. There are three primary themes to this challenge:

- New growers, often more educated, have sprung up around urban environs, where marketing opportunities are much greater. This is notable in contrast to many Amish and Mennonite producers organizing in rural areas around 'produce auctions'. (Technology savvy versus technology adverse!)
- Missouri has a small number of very large processing growers, producing and marketing in ways more akin to 'row crops' than the much greater number of smaller growers marketing fresh produce locally. E.g. the 2007 Census of Ag showed that 1171 out of the total 1335 vegetable farms were less than 15 acres and only six were over 1000 acres.
- Finally, there is a real challenge in effectively serving all the geographical production areas in the state effectively. For example, while the growers in the far SE region have some of the largest fresh vegetable acreage, they have, until recently, chosen to band around a specific crop and partner with Arkansas. Just recently the MO/AR Watermelon Growers Association disbanded.

Given the challenges of serving a diverse and scattered cliental and without a highly developed industry, in size or history, this association needs to undertake a number of initiatives to both grow the membership and better serve members and fellow growers.

This project proposed to position MVGA for the future, by developing its leadership and growing its membership through increased services offered. The educational, outreach, and organizational activities would target new and entering growers, aiding them to be productive, efficient and successful. This is/was an opportune time; when vegetable production is growing and poised for more growth. The project would focus on 6 areas:

1. Dramatically upgrade web and electronic outreach capabilities;
2. Increase membership educational offerings with publication resources and scholarship opportunities;
3. Capture key educational events focusing on Good Agricultural Practices and make available to a wider audience through DVD recordings and YouTube postings;
4. Explore alliances with related specialty crop groups for education and outreach;
5. Enhance technical and leadership skills of officers/directors through attendance opportunities to a premier conference;
6. Further collaborative activities with MU & LU Extension by sponsoring a nationally renowned conference presenter and continue supporting statewide farm tours.

A 2009 project titled 'Growing Missouri's Vegetable Industry Using Statewide On Farm Education' was funded by the Specialty Crops Block Grant Program. The primary purpose of this MVGA project was to assist in membership growth and help growers become more successful. The main goals were to sponsor 8 farm tours with a planned attendance of 50 at each.

MVGA gained 91 new members from the tours and the tour attendance exceeded expectations by about 50%. However, increasing membership is not enough for long term success of an organization. Leadership must be built and more diverse ways be sought for engaging/communicating with the members; through these long term association success can be attained.

***Project Approach***

Upgrade Web and Electronic outreach-

Three meetings were held to develop a new logo, which was successfully accomplished by mid-year 2010. The newsletter was then reformatted to a PDF & incorporating the new logo and logo colors.

After a rather lengthy process, where the original entity identified to do the web site work was dismissed, a contract was signed with the Carlyle Information Systems of North Carolina to conduct this work in October of 2011. What the members wanted on the web site was discussed at the Nov. 2010 and 2011 business meeting. These interests were incorporated if practical and were reviewed in a newsletter article ahead of time to solicit more input.

Increase membership educational opportunities with publications and scholarships-
200 publications were expected to be distributed for 2010 memberships. But by the end of 2009, we had about 200 members and knew many would 'join' with this publication (Midwest Vegetable Production Guide for Commercial Growers- 2010 edition) serving as an incentive. So 300 were purchased and almost all were distributed.

300 publications were expected to be distributed for 2011 as, by the end of 2010, we had over 300 members. For the Midwest Vegetable Production Guide for Commercial Growers- 2011 edition, 150 were ordered, and 140 were distributed. For the Growing for Market newsletter, about 80 subscriptions were contracted.

In 2010 16 scholarships were offered to vegetable growers not attending GPGC previously. Applications were received for 15 (15 was the grant goal) to attend the Jan. 2011 GPGC.

At the November 2011 MVGA business meeting, it was determined there would be sufficient funds to cover additional scholarships, given a no cost grant extension had be granted. The membership viewed this offering as one of the best things to put its money behind. Up to 13 were approved to fund, and they were offered again.

Capture key GAPS oriented activities/events and make available with DVD & YouTube postings-

Presentations, farm tours and other activities have continued to be captured. The recording quality is not high and they are not edited.

Explore alliances with other specialty crop groups
In 2010 MVGA officers attended the following:

- Mid America Fruit Growers Conference
- Agritourism/ Small Fruit Conference
- Missouri Organic Association Conference (on their own $$)
- sent a representative to the Annual Watermelon Meeting in the bootheel in Jan. and Dec. (they moved the annual meeting forward a month in 2010).

For 2010 MVGA was asked to sponsor/organize and entire days' worth of presentations, which was done.

Enhance technical and leadership skills of MVGA officers & regional directors-
The MVGA President, Secretary, Treasurer, and the Regional Directors from the Central, NW and West Central regions all attended the Dec. 2010 Great Lakes Expo as proposed in the grant. No officers attended the 2011 Dec. Great Lakes Expo as proposed in the grant, but one Regional Director was able to attend.

A fall business meeting was held in 2009, 2010, & 2011 at the National Small Farm Conference and trade show (early November). These business meetings were very helpful in keeping the project on track, by allowing ideas or issues to be discussed with the membership, prior to the annual meeting just two months later (early Jan. at GPGC). For the 2011 meeting, a no cost grant extension into 2012 was proposed, discussed and approved. The scholarship offering for 2012 discussed above was dealt with. Finally (and most importantly) the revised membership structure was approved. It had been proposed and discussed previously.

Further collaborative activities-
Farm tours (or similar) with the University of Missouri and Lincoln University Extension:

- 6 in 2010;
- 4 in 2011;
- 1 in 2012.

Support of our region's premier vegetable growers' conference was provided through $1,000 in support of GPVGC in 2010 and 2011. It was used to support their expenses related to providing educational offering featuring Good Agricultural Practices, in addition to the keynote speaker, as proposed in the grant. The $1,000 check was presented at the keynote address and recognized by all those in attendance in 2010. For 2011 it was presented at the MVGA annual meeting.

The MVGA officers of President, Secretary and Treasurer have led the way. Also noteworthy was the West Central regional director who attended both bootheel watermelon meetings and went to the Great Lakes Expo. The relationship with the Morgan County Extension Center was established, and their secretary's assistance with the project has been invaluable. Lastly, James Quinn of MU Extension has assisted MVGA in numerous aspects to keep the project on track.

***Goals and Outcomes Achieved***

The potential impact section of the grant detailed how many growers would be impacted by the different activities. The total estimated was over 1300. Those estimates and the number actually attained are underlined below.

Upgrade Web and Electronic outreach-
The logo is available to any member to use for a farm sign, t-shirt or other promotional material at no charge. At least one member has t-shirts with the logo. The newsletter was sent electronically beginning in 2011 as a PDF. Membership receiving the newsletter electronically has increased from about 20% to 40%.

The web site was functional by July 1 of 2012. It is a significant improvement over the web site that it replaced. The number of members that receive electronic communications (including the monthly blog) is about 90. The estimate was 100.

Increase membership educational opportunities with publications and scholarships-
Membership response exceeded expectations in 2010. MVGA membership exceeded 300 by the end of 2010, which was the goal for the 2011.

Membership declined in 2011 from 300 to just over 230. Some of the decline was because 'free' memberships were eliminated. Total over the 2 years was 530, which slightly exceeded the project expectation of 500 over the two years.

Thirteen of the 15 individuals receiving scholarships came to the conference in 2011. In 2012 scholarships were awarded to 11 individuals. The project anticipated 15 scholarships, and 24 were provided.

Capture key GAPS oriented activities/events and make available with DVD & YouTube postings-
A list of presentations, farm tours and other activities captured are shown in Section 8, which is from a recent newsletter. A modest number of DVDs have been sold (less than 50). An exact number is available upon request. None have been posted to YouTube, however, the new website will allow us to post video to YouTube, and have it accessed from the site. No projection or goal was established for this aspect of the project.

Explore alliances with other specialty crop groups

**Developments from these activities exceeded expectations**. The MidAmerica Fruit Growers Association decided to join the Great Plains Vegetable Growers Conference (permanently). The conference was renamed the Great Plains Growers Conference and given a new web site url and logo, to facilitate everyone's sentiments towards this change. See www.greatplainsgrowers.org . Furthermore, the Small Fruit Conference has ended, with no plan to resurrect it, so the Great Plains Growers Conference is strengthening its small fruit/berry track.

Three watermelon growers joined MVGA, a first for the MVGA to have any bootheel watermelon growers as members. Missouri Organic Association will allow recording of their presenters (who give their permission) at their annual conference and is exploring other ways to 'work together'.

The National Small Farm Conference and trade show (early November):
- For 2010 MVGA was asked to sponsor/organize and entire day's worth or presentations, which was done.
- Business meetings assisted keeping the MVGA officers and directors on track with the project. The most important long term success was the revising of the membership structure. This will allow the association to increase its yearly revenue and not be dependent on grant funding to provide benefits like the complimentary publication(s). Each of these meetings had between 25 and 40 in attendance.

No record was kept on attendance at sessions sponsored by MVGA. However, over the 3 year period about 100 attended the business meetings held at this conference (same number as estimated).
Other alliance exploring activities involved at least 5 MVGA members and resulted in 3 bootheel growers joining, for a combined impact of 8 (versus '5 to 10' estimated).

Enhance technical and leadership skills of MVGA officers & regional directors-
The Great Lakes Expo was attended by 6 in 2010 and 1 in 2011 for a total of 7 (versus an estimate of 10).
There was competition for two regional directors' positions, for the first time in MVGA's history at the Jan. 2011 annual meeting, indicating more interest in the organization. MVGA usually has to beg and browbeat members to volunteer.

Norman Kilmer (the MVGA Secretary from 2006 to 2010) was awarded the Missouri Agricultural Extension Professionals Leadership Award of 2010 at the MVGA Annual Meeting at GPGC in Jan. of 2011.

Further collaborative activities-
Farm tours (or similar) with the University of Missouri and Lincoln University Extension:

- 6 held with 335 total attending for 2010 (attendance per tour detailed in annual report);
- 4 held with 271 total attending for 2011 (attendance per tour detailed in annual report);
- 1 held with 63 attending for 2012 (August in Central Missouri).

Eleven farm activities were held (grant proposed 8) with 669 impacted versus 400 estimated.
Eight of the activities were tours with 3 farms and 3 were single farm events (high tunnel construction hands on work days), thus (8 x 3) + 3 or 27 farms were impacted (versus 24 estimated).

The GPGC presentation was made during the keynote of 2010 and the room was packed beyond the capacity of 200. In 2011 it was made at the MVGA business meeting with well over 50 present. Together this exceeds the estimated impact of 200 by 50.

Impact attained-

- Web site blog- 90
- Publications/membership- 530
- Scholarships- 24
- Small farm conference business meetings- 100

- Misc. alliance building activities- 8
- Great Lakes Expo attendance- 7
- Farm activities- 669
- Farm hosts- 27
- GPGC check presentation- 250 (+)
    - Total 1705 *(versus 'over 1300' estimated)*

***Beneficiaries***

The groups benefiting from the project are as follows:

- (Primarily) The members of MVGA.
- Great Plains Growers Conference, which is a consortium of 5 states' horticulture extension programs and those states' grower's associations.
- Morgan County Extension Center, which was contracted to assist with the project.

The quantitative data is detailed in the previous section. There was not an economic impact component associated with this project.

***Lessons Learned***

The project met with a lot of excitement in the first year, but this waned during the second year. Both the president and secretary changed from 2010 to 2011 and this may have had an impact. There is no 'lesson' here, not much could have been done to anticipate this or prevent it.

MVGA did not hold a spring meeting as proposed, but did hold a November meeting. This November meeting proved instrumental for keeping the project on track, and perhaps project enthusiasm would have remained better if the spring meeting had been held as planned.

The difficulty with the original entity identified to do the web site was frustrating for several individuals associated with the project, the MVGA President, James Quinn, and the Morgan County Extension Center office assistant. In hindsight, MVGA should have moved to finding another company to perform this work (much) sooner.

Having the Mid America Fruit Growers Conference join with GPGC was unexpected, but positive for GPGC. Whether the alliance building activity of having the MVGA president and secretary attend their conference and float that 'trial balloon' for them to join with GPGC was a deciding factor or not, cannot be determined. But we are sure it didn't hurt. Both that fruit conference and the Small Fruit Conference were down in numbers and were not performing well financially, whereas GPGC has become notably more vibrant over the last 5 years. Having a successful GPGC is beneficial to the vegetable industry at large, as it is the premier vegetable educational event for Missouri growers.

The display board was not completed. The best part was that it was not even started, so no time was wasted on it. The funding for the display board went toward providing more scholarships, and this activity was broadly supported by the membership. The display board would have no 'documentable impacts' so this probably was a wise choice.

Under attendance by MVGA officers or directors at the Great Lakes Expo is probably associated with lowered enthusiasm to the project overall.

The restructuring of the membership levels is an unfinished story. It appears that membership has dropped with this change, but the lower price that membership was at was unsustainable without grant funding. The fact that the membership restructuring was rolled out before the new web site was ready was certainly detrimental. Thus it will likely take one if not two more years to fully understand what membership level MVGA can maintain. In that time frame members will become more aware of the full range of benefits the association has to offer.

Associations are a reflection of their membership, and more directly of their board. If they are active, involved and enthused, the association will benefit. Vegetable growers as a group are, by in large, pretty swamped from March until October. MVGA may do better by concentrating on association building during this time frame, with more zeal. During the growing season the farm tours remained, from start to finish, extremely popular and the one thing (unequivocally) that everyone got enthused about.

***Contact Person***
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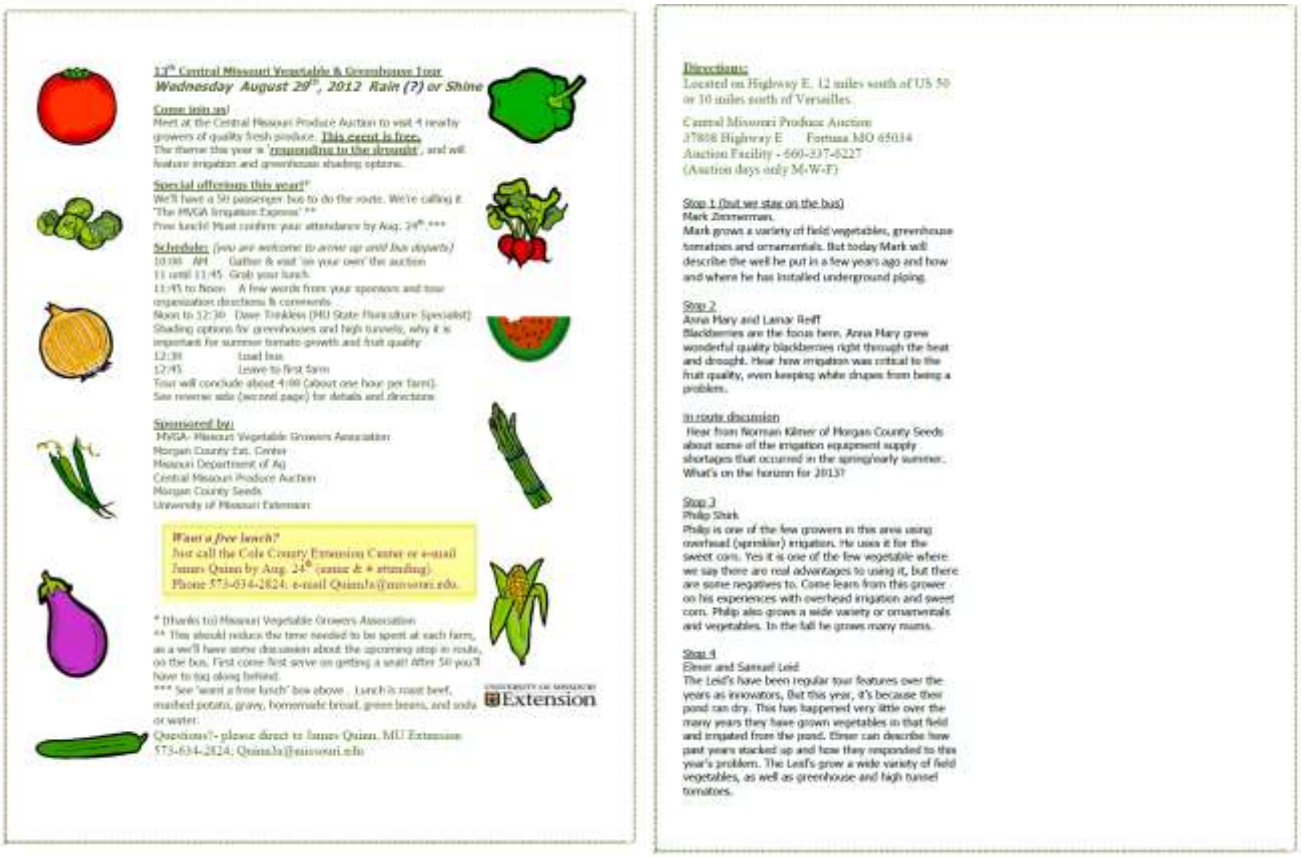
***Additional Information***
http://movegetablegrowers.org/home/index.php/en/homepage

***Logo***

***2012 Vegetable Tour Site Visit Flyer and Photos-August 29, 2012***

***Flyer***



13th Central Missouri Vegetable & Greenhouse Tour

***Wednesday August 29th, 2012 Rain (?) or Shine***

Come join us!

Meet at the Central Missouri Produce Auction to visit 4 nearby growers of quality fresh produce. This event is free.

The theme this year is 'responding to the drought', and will feature irrigation and greenhouse shading options.

Special offerings this year!*

We'll have a 56 passenger bus to do the route. We're calling it "The MVGA Irrigation Express" **

Free lunch! Must confirm your attendance by Aug. 24th. ***

Schedule: *(you are welcome to arrive up until bus departs)*

10:00 AM Gather & visit 'on your own' the auction

11 until 11:45 Grab your lunch

11:45 to Noon A few words from your sponsors and tour organization directions & comments

Noon to 12:30 Dave Trinklein (MU State Horticulture Specialist) Shading options for greenhouses and high tunnels, why it is important for summer tomato growth and fruit quality

12:30 Load bus

12:45 Leave to first farm

Tour will conclude about 4:00 (about one hour per farm).

See reverse side (second page) for details and directions

Sponsored by:

MVGA- Missouri Vegetable Growers Association

Morgan County Ext. Center

Missouri Department of Ag

Central Missouri Produce Auction

Morgan County Seeds

University of Missouri Extension

***Want a free lunch?***

Just call the Cole County Extension Center or e-mail James Quinn by Aug. 24th. (enter & + attending).

Phone 573-634-2824; e-mail QuinnJa@missouri.edu.

* (thanks to) Missouri Vegetable Growers Association

** This should reduce the time needed to be spent at each farm, as we'll have some discussion about the upcoming stop in route, on the bus. First come first serve on getting a seat! After 56 you'll have to tag along behind.

*** See "want a free lunch" box above . Lunch is roast beef, mashed potato, gravy, homemade bread, green beans, and soda or water.

Questions?- please direct to James Quinn, MU Extension 573-634-2824; QuinnJa@missouri.edu

University of Missouri Extension

Directions:

Located on Highway E, 12 miles south of US 50 or 10 miles north of Versailles.

Central Missouri Produce Auction
37808 Highway E Fortuna MO 65034
Auction Facility - 660-237-6227
(Auction days only M-W-F)

Stop 1 (but we stay on the bus)

Mark Zimmerman.

Mark grows a variety of field vegetables, greenhouse tomatoes and ornamentals. But today Mark will describe the well he put in a few years ago and how and where he has installed underground piping.

Stop 2

Anna Mary and Lanay Reift

Blackberries are the focus here. Anna Mary grew wonderful quality blackberries right through the heat and drought. Hear how irrigation was critical to the fruit quality, even keeping white drupes from being a problem.

In route discussion

Hear from Norman Kilmer of Morgan County Seeds about some of the irrigation equipment supply shortages that occurred in the spring/early summer. What's on the horizon for 2013?

Stop 3

Philip Shirk

Philip is one of the few growers in this area using overhead (sprinkler) irrigation. He uses it for the sweet corn. Yes it is one of the few vegetable where we say there are real advantages to using it, but there are some negatives to. Come learn from this grower on his experiences with overhead irrigation and sweet corn. Philip also grows a wide variety or ornamentals and vegetables. In the fall he grows many mums.

Stop 4

Elmer and Samuel Leid

The Leid's have been regular tour features over the years as innovators, But this year, it's because their pond ran dry. This has happened very little over the many years they have grown vegetables in that field and irrigated from the pond. Elmer can describe how past years stacked up and how they responded to this year's problem. The Leid's grow a wide variety of field vegetables, as well as greenhouse and high tunnel tomatoes.

***Photos***

*James Quinn-Horticulture Specialist –University of Missouri Extension*

*Anna Mary and Lamar Reiff #1*

*Anna Mary and Lamar Reiff #2*

*David Trinklein-Associate Professor-Division of Plant Sciences-University of Missouri-Columbia*

*Anna Mary and Lamar Reiff #3*

*Philip Shirk #1*

*Philip Shirk #2*

*Philip Shirk #3*

*Elmer and Samuel Leid-Tomatoes, Peppers, Watermelon Cantaloupe*