



# Missouri Department of Agriculture Specialty Crop Block Grant Program USDA AMS Agreement 12-25-B-1238 Final Report

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## **Project 1: Cold Hardiness Evaluation of Redhaven Peach Floral Buds on Eleven New Rootstocks**

### **University of Missouri**

Dr. Chris Starbuck

Final Performance Report

### **Project Summary**

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Peach production in the U.S valued at \$614.6 million. Currently, 1000 ha of peaches are grown in Missouri for wholesale and retail outlets with a crop value of \$5 million. With the increasing demand for fresh, locally grown produce and high retail prices at farmer's markets, peach production is expanding into parts of Missouri that have cold winter temperatures. In the past, Missouri peach production was concentrated in the southern region of Missouri, with less production in the Waverly-Lexington area. Since 2008, peach production has expanded to more northern locations in the state, with plans for more acreage in the future. However, low-temperature injury is one of the most limiting factors in peach production. In northern Missouri, only two full crops of peaches are harvested every five years. Currently, frost protection is limited to the use of burning fuel to heat the orchards or flying helicopters to mix warm and cold layers of air during a temperature inversion. However, these practices are not practical for small acreages and are cost prohibitive with the high cost of fuel and labor. Thus, the only feasible way to enhance the cold hardiness of peach trees is by planting a tree with a cold-hardy rootstock and scion, such as Redhaven.

Several new peach rootstocks about to be released from Italy, Spain, Russia, and the United States will soon become available to Missouri peach growers. Previous studies conducted on other peach rootstocks have shown that floral bud hardiness is affected by the rootstock. Since 1983, the University of Missouri's Horticulture and Agroforestry Research Center has served as a national cold hardiness test site for the NC-140 regional rootstock committee. In 2009, a trial including several rootstocks with Redhaven as the common scion cultivar was established at the Research Center to evaluate growth characteristics and productivity of these trees over a ten-year period. The purpose of the current study was to conduct freezing tests to determine the relative cold hardiness of Redhaven floral buds on different rootstocks in early, mid, and late winter.

### **Project Approach**

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Rootstocks evaluated in this study were Lovell, Guardian, KV010-123, KV010-127, Krymsk 1, Krymsk 86, Controller 5, HBOK 32 Mirobac, Penta, and Viking. Tissue for freezing tests was collected on November 10, 2011 and January 25, February 29, and November 13, 2012, and January 18, 2013 to assess early, mid, and late winter floral bud hardiness, respectively. At each sampling date, 5-node cuttings were collected from the middle portion of terminal shoots of 6 trees (replications) of each rootstock. Tissue was placed in moist cheesecloth and wrapped in aluminum foil for each of six test temperatures. A 0.01mm copper constantan thermocouple was placed in contact with a bud of a sample to monitor tissue temperature. Samples were then placed in a programmable freezer at -2°C and held at this temperature for one hour and then cooled at 3°C/hr. Samples were removed from the freezer at 3° intervals at tissue temperatures estimated to result in bud injury and were thawed slowly. Tissue was incubated for 5 days at 21°C, examined for oxidative browning under a dissecting microscope, and the number of injured buds was recorded. T<sub>50</sub> values (temperature at which 50% bud mortality occurred) were calculated for each rootstock and these data were subjected to an analysis of variance using the

PROC GLM procedure of SAS Version 9.2. Means were separated by a protected Fisher's least significant difference test,  $P \leq 0.05$  (Table 1).

In the 2 weeks preceding the Nov. 2011 sampling date, evening temperatures dropped below freezing on 4 days with a low of  $-1.7^{\circ}\text{C}$ . Daily high temperatures during this time ranged from 11 to  $25^{\circ}\text{C}$ . Mean  $T_{50}$  values of peach buds only varied  $2.2^{\circ}\text{C}$  at the November test date. Although not statistically significant, Viking, and Penta buds were relatively hardier than those of Mirobac in the fall. However, Viking trees have a high mortality rate after five year's growth in a University of Missouri (MU) field trial. By mid-winter, buds acclimated to lower temperatures. However, mean  $T_{50}$  values of peach buds only varied by  $1.1^{\circ}\text{C}$  among the rootstocks tested, which was likely due to mild mid-winter temperatures. In the two week period before Jan. 25, daily high temperatures ranged from 20 to  $-8^{\circ}\text{C}$  and daily low temperatures ranged from 0 to  $-12.8^{\circ}\text{C}$ .

In the two weeks preceding Feb. 29, daily high temperatures ranged from 19.4 to  $5.5^{\circ}\text{C}$ . Daily low temperatures during this time ranged from 3.3 to  $-5.0^{\circ}\text{C}$ . At the late Feb. test date, buds on HBOK 32 and KV010-127 trees were the most cold-tolerant, whereas those on Viking, Controller 5, Mirobac, and Krymsk 1 were the most susceptible to low temperature injury. Krymsk 1 rootstock originated from Russia but is poorly adapted to Missouri. This rootstock produces a dwarf tree with very low yields and has had 38% mortality in a MU research trial. Lovell rootstock, which is the currently recommended peach rootstock for Missouri, ranked in the middle of  $T_{50}$  values as compared to all other rootstocks at each test date.

Additional freezing tests were conducted on November 13, 2012 and January 18, 2013 due to the unseasonably warm temperatures during the previous fall and winter. Daily high temperatures ranged from 23.8 to  $6.7^{\circ}\text{C}$  during the two week period preceding the November 2012 experiment. Daily low temperatures during this time ranged from  $-5.0$  to  $15.6^{\circ}\text{C}$ . There were no significant differences detected in the mean bud  $T_{50}$  values among rootstocks. However, buds of HBOK 32 and Penta trees generally had the lowest  $T_{50}$  values and those on Mirobac trees were the most susceptible to low temperature injury. Additionally, statistical differences in floral bud hardiness were not detected among rootstocks in January 2013, with  $T_{50}$  values varying by only  $1.3^{\circ}\text{C}$ .

Research results were presented to the NC-140 Pome and Stone Fruit Rootstock Committee meeting in Portland, Maine on November 8, 2012 and posted on a web site at <http://extension.missouri.edu/warmund/cold-hardiness-redhaven.htm>.

Dr. Chris Starbuck, Associate Professor, was responsible for overall project management and oversight. Dr. Michele Warmund, Professor, and Audrey Davis, Graduate Student conducted freezing tests, statistical analyses, and developed the web site information.

## Goals & Outcomes Achieved

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This study demonstrated that rootstocks did not affect the peach bud hardiness in the fall during the acclimation period or in mid-winter under the environmental conditions of 2011 and 2012. However, just before spring bud break, rootstocks affected the temperature at which buds survived low temperature exposure. Buds on HBOK 32 and KV010-127 trees were the most cold-tolerant, whereas those on Viking, Controller 5, Mirobac, and Krymsk 1 were the most susceptible to low temperature injury. After four years of growth in a MU field research trial, KV010-127 tree mortality has been low and fruit yield has been greater than other rootstocks included in this study. HBOK 32 trees have had 50% mortality with lower fruit yields, and would not be recommended for planting in Missouri. Lovell rootstock, which is the currently recommended peach rootstock for Missouri, ranked in the middle of  $T_{50}$  values as compared to all other rootstocks at each test date, but ranks among the higher yielding rootstocks. These results

have been widely disseminated via reporting at the national NC-140 Regional Rootstock meeting and the MU Extension web site at <http://extension.missouri.edu/warmund/cold-hardiness-redhaven.htm>. Seventy scientists attended the rootstock meeting and there have been over 500 hits on the website.

## Beneficiaries

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All current and future peach producers benefit from future planting of trees with enhanced bud hardiness. If peach trees grafted onto rootstocks, such as KV010-127 and fruit loss due to low winter temperatures is reduced by as little as 10%, the value of this crop will increase by \$500 thousand in Missouri. Additionally, minimizing losses due to the annual fluctuation in peach production will stabilize peach production in Missouri and thereby enhance farm viability and profitability. Missouri citizens will also be provided with a source of nutritious, locally-grown fruit.

## Lessons Learned

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Due to unseasonably warm climatic conditions during fall 2011 and mid-winter 2012, the maximum effect of the rootstock on bud hardiness may not have been expressed. However, this study provides preliminary bud hardiness data that will be useful in developing future rootstock recommendations when used with 8 year fruit yield data.

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## Additional Information

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Table 1. Mean  $T_{50}$  values of Redhaven peach buds on various rootstocks following exposure to low temperatures at three sampling dates. <sup>z</sup>

Rootstock	$T_{50}$ value (°C)				
	Nov. 10 2011	Jan. 25 2011	Feb. 29 2011	Nov. 13 2012	Jan. 18 2013
Viking	- 12.7	- 18.7	- 13.2 cd	-15.4	-18.5
Krymsk 1	- 12.2	- 19.3	- 12.8 d	-15.2	-18.6
KV010-123	- 12.1	- 19.3	- 14.1 abcd	-16.1	-19.0
Lovell	- 12.0	- 19.4	- 14.0 abcd	-15.4	-19.2
KV010-127	- 11.5	- 19.2	- 14.9 ab	-15.7	-18.6
Krymsk 86	- 11.5	- 19.0	- 13.6 bcd	-15.1	-18.9
Controller 5	- 11.5	- 19.6	- 13.5 cd	-15.1	-18.3
Guardian	- 11.3	- 18.8	- 14.2 abc	-15.9	-19.0
Mirobac	- 10.9	- 19.2	- 13.3 cd	-14.5	-19.5
HBOK 32	---- <sup>y</sup>	- 18.9	- 15.0 a	-16.4	-19.1
Penta	- 13.1	- 18.5	-13.9 abcd	-16.4	-18.6

<sup>z</sup> Means represent 6 replications of each 5-node cutting for each rootstock. Mean separation within columns by Fisher's protected LSD test ( $P \leq 0.05$ ).

<sup>y</sup> Bud samples not collected at this date.

## **Project 2: The Community Farm: Expanding Markets, Increasing Access**

### **Community Action Agency of St Louis County**

Gabriel Hahn

Final Performance Report

### **Project Summary**

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The Community Farm project succeeded in establishing a small, highly intensive production and education farm in the food desert of Spanish Lake, Missouri. By marketing and implementing its small scale tiered CSA for three consecutive years, the farm increasingly improved access and affordability of fresh produce in a low-income community and food desert. Revenues from harvested produce were gained through the CSA, wholesale, and local farmers markets. Unsold produce was donated to local pantries to increase local vegetable consumption. Educational outreach was primarily achieved through distribution of weekly newsletters to CSA members, cooking demonstrations and monthly CSA cooking classes and farm dinners hosted on site and at neighboring locales. The tiered marketing strategy was promoted to other local farmers through the local St. Louis Urban Grown group, hosted by Lincoln University Cooperative Extension, at farm tours and workshops, and the Great Plains Growers Conference in January 2014. In each of the three growing seasons, an apprentice was trained in multiple principles of SPIN Farming and community involvement.

The mission of the CAASTLC Farm was to be an economically and ecologically sustainable farm that serves the needs of its community by:

- Establishing a new marketing model for fresh, organic produce that includes low-income communities
- Building capacity for low-income families to access fresh, healthy food either by growing it themselves or participating in the farm's CSA
- Educating others in organic agriculture practices and nutrition health
- Creating sustainable, green, living-wage apprenticeship opportunities
- Support the apprentices as they create independent farming enterprises
- Develop a community space dedicated to health and learning

Importance of timeliness and location: The CAASTLC Community Farm project was established in Spanish Lake, MO, an unincorporated food desert area of St. Louis County. The Economic Research Service of the USDA has identified that 45% of Spanish Lake residents live in a **food desert**. Although Spanish Lake covers 7.4 square miles, the community only has one grocery store, located at the southern boundary of Spanish Lake. Annually, over \$9,200,000 in consumer food spending leaves Spanish Lake due to a lack of local grocer availability (Neighborhood Data Gateway).

Low-income families and people with the least food security are at the highest risk to obesity and obesity related health vulnerabilities. CAASTLC's mission is to end poverty by addressing issues that create the conditions of poverty.

The above data, combined with the rising demand for organic, locally grown food made Spanish Lake an ideal location for establishing a community farm and profitable enterprise. By placing the farm in the heart of the food desert, low-income families had access to fresh produce without need for transport.

The rising demand for locally grown, organic food had increasingly built momentum of the “Food Movement.” By selling food at its true cost of production, locally produced foods are often available only to the more affluent sectors of society. These local food consumers have the option of where to buy food. By creating a tiered CSA where ‘sponsors’ pay over the value of a weekly share to create a subsidy so that low-income members can purchase the same share at a subsidized price; creating a business model that creates local food access to people of varied economic backgrounds.

The farm’s location, sharing grounds with both a church and food pantry increased its potential as a gathering place for obtaining food, education, and building community.

## **Project Approach**

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The farm was initiated in March of 2012; greenhouse schedules, crop plans and maps were created. March 2012 was also spent applying amendments, seeding cold hardy crops, purchasing equipment, supplies, acquiring donated greenhouse space from Hummert International, and marketing the CSA. The apprentice was hired in May in this and each of the two consecutive years. During the grant period, crops were continually planted from March to October of each year; harvested and sold from May to December, and on occasion beyond these months. It should be noted that during the grant period, September 2011 to January 2014, grant funds were exhausted and the project continues.

A post harvest station, shed, and cooler were also constructed for efficiency and safe food handling. The walk-in cooler was constructed within a utility trailer so that it could comply with county code and also be a mobile unit if proven necessary.

The hoop house initially listed in the grant was deemed a ‘permanent structure’ by St Louis County Zoning Officials and the structure was not built. In its place the farm purchased many of the same materials so that it could accomplish season extension while complying with County code.

For educational outreach, the farm partnered with Lincoln University Cooperative Extension for weekly food demonstrations and nutrition education for pantry clients. Pantry clients were also encouraged to join the CSA and community gardens.

A solid partnership was also formed with Operation Food Search where CSA patrons and interested community members gathered for monthly cooking classes and dinners during the growing season, May through November.

The tiered CSA model was introduced and encouraged to a number of growers through a variety of means, primarily to a group of urban farmers, formed by Lincoln University’s Small Farm Program, publicized on three local news channels, and one live radio show. The model was also showcased at Missouri’s War on Poverty meeting in April 2013 and at the Great Plains Growers Conference in Kansas City, MO in January 2014. The community farm’s manager was a featured speaker at the conference.

## **Goals and Outcomes Achieved**

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The approved project contained two primary goals: 1) Providing low-income families subsidized CSA shares through the community farm and to more broadly increase access through promoting the tiered CSA marketing model. 2) Educate CSA and community members on nutrition and food preparation.

Both goals were achieved to one degree or another. Increased accessibility was achieved though for smaller numbers than anticipated. Educational goals were exceeded on many accounts, both in number and frequency.

The original goal of 50 CSA members in the initial year was reduced to a target of 25. The distribution period for the year was also shortened to 18 weeks from 25. In total for the season the project served 11 low-income members a total of 73 low-income shares; 265 shares in total. 12 sponsor members received shares for a total of 18 weeks, and 3 members enrolled for a 3 week season extension into December. The numbers fluctuate due to low-income member drop out and failure to pick up shares.

In terms of education, year one goal was to have 150+ people attend on farm education events. Each week of the month, 60 to 70 clients of the Helping Hands food pantry were exposed to a food demo led by Lincoln University. Participation and sampling varied, from 5-20 most weeks from March through October, estimated at 200 for the year. Members of varying socioeconomic backgrounds attended the monthly CSA cooking classes and dinners. Attendance here also varied, from 8-20 per dinner, averaging around 12, but a total of 112 participating in dinners throughout the year. Often these were repeat attendees.

All CSA members received a weekly newsletter with an item list, recipes, nutritional information, storage suggestions, and sometimes information on safe preservation methods. All members reported using the majority of their shares each week, though a few remarked the shares were too much food for small families.

Volunteer days were hosted and always featured an educational element. On one such occasion, 22 attended the Crop Mob event where volunteers transplanted, composted beds, and harvested sweet potatoes. 34 total volunteers participated in on-farm events; 22 being low-income; total of 144 volunteer hours donated.

Beginning in November 2012, monthly presentations of the tiered CSA model were showcased to the Urban Farmer meetup group. Group attendance ranged from 12 to 30 members each meeting. To our knowledge, no other local farms had as of yet adopted the tiered CSA marketing model.

In year two, 2013, grant award target was to sell 100 shares but this was with the assumption that a second farm would be starting and all infrastructure was in place. After year one, the new CSA target was set at 24, with 12 being sponsors and 12 subsidized. A total of 30 members were enrolled; 21 sponsor, 9 subsidized. Of these, 14 sponsors were repeat members and 5 of the subsidized were repeat members, an 82.6% retention rate.

Monthly dinners continued to receive an average of 13 attendees per dinner, mostly repeats from May through November, 73 attendees across the year, mostly repeats. The farm received a total of 105 volunteer hours in 2013. Several farm tours were given where microclimate and nutrition were discussed, local preschools and Boys and Girls Clubs attended with a combined total of 45 attendees.

The pantry demos hadn't proven to be effectively improving eating habits or increased interest in the CSA. Quarterly demonstrations led by Operation Food Search were then held at CAASTLC, attendance being quite low.

In August 2013 CAASTLC was awarded a three year grant to expand its current farm model and replicate the Spanish Lake project in Bel-Ridge, MO. The grant included not only increased food access

and production, but also provided funds for a community liaison/organizer to expand outreach and education, a teen farmer program where local teens would learn basics of small scale urban agriculture.

## **Beneficiaries**

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Specialty crop groups were primarily affected by this project through the Urban Farmer meet up group with Lincoln University Cooperative Extension. This group was a platform for local growers to exchange ideas, knowledge, methods, concerns, and build community on a monthly basis. The farm manager of this project was a regular attendee of these meetings and played a lead role in knowledge and experience.

Community stakeholders in both Bel-Ridge and Spanish Lake areas benefitted from this project. Churches, like Bethany Peace UCC, St Peter's Lutheran, gained recognition and outside involvement and support. Local organizations like the Spanish Lake Youth Center, Helping Hands Food Pantry (and their clients) gained food access and knowledge, the Spanish Lake Community Association gained increased readership of its newsletter with focus on the farm project, Operation Food Search received donations of produce and also gained a local supplier of fresh produce with similar goals. This farm project regularly contributed to their Cooking Matters programs, served as a place to bring kids for hands on experience, and hosted the CSA cooking class/farm dinners the OFS led.

Local residents of both Bel-Ridge and Spanish Lake enjoyed increased food access and volunteer/education opportunities through the CSA, volunteer days, dinners, demos, and workshops. All CSA members gained nutritional education, easier access to food, and all low-income members enjoyed cost savings on produce. Volunteers gain gardening knowledge and community gardeners gained a place to grow their own food. These gardeners are also lent tools and given growing advice throughout the growing season.

Pantry clients of both Helping Hands and CAASTLC received more fresh produce more often. Several local restaurants and small grocers also received higher availability of locally grown, fresh produce as a result of this project.

Each year an apprentice has gained full-time employment for a set term, a great deal of knowledge and experience in regard to small scale urban farming, working for a non-profit, farm management, food safety, production planning, and community building.

Numbers of people who benefitted, directly or indirectly is difficult to scale as the outreach of this farm is wide. For instance, 102 people follow the Seeds of Hope Farm blog through the RSS feed. The blog features weekly newsletters with recipes and various nutrition and preservation material. 138 people= presently follow the farm on Facebook as well.

Roughly 20 families receive produce for 28 weeks of the year through the CSA, and much of that produce is given to friends and neighbors. From 150 to 250 people visit the farm each year and are exposed to various bits of information about growing plants, the community, building, nature, nutrition, or various other topics and often take part in one project or another. Many return. In year two alone, the farm partnered with 24 local organizations on various projects.

Over ½ acre of ground that was previously only a lawn that required weekly mowing has, to date, produced around 34000 pounds of sustainably and organically grown food.

## **Lessons Learned**

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While the project had and continues to have a great number of successes in terms of community and food access, it fell the most short of goals in revenues produced. The reasons for this are multi fold:

The ½ acre available for production is not capable of producing the types of revenues initially targeted in the grant at current St. Louis area prices (56k/year). The SPIN model by which those numbers assume profitability at New England prices and revenues by square foot with no account for crop loss to disease, pests, weather, etc. The model does not account for the capacity of a two person staff who is not only responsible for production but for community outreach, event planning, public speaking, responsibilities to a nonprofit, and so on.

The grant award also called for hoop house production, a vital component of high revenues. Inquiry with county officials proved the hoop house could not be built in the farm's location in compliance with county code. Despite repeated attempts, even from architects, representatives from the NRCS, local Universities and Extension offices, no variance or permission would be granted for this structure.

Due to funding delays, the project began 6 months after its proposed initiation. This period was crucial for planning the farm layout, building infrastructure, acquiring tools, materials, equipment, crop planning, sourcing seeds and starts, marketing the CSA, writing land use contracts and CSA membership agreements, hiring of staff, building partnerships, engaging community, etc. The farm manager was hired in late February 2012, essentially the start of the 2012 growing season. With the pressures of production for spring, summer, fall and grant writing in the spring; a solid infrastructure wasn't completed until the project's third year.

The first two years of the project saw great difficulty in both raising and retaining low-income membership in the CSA model. Time showed that for the low-income demographic, the reasons behind CSA such as local, organic, relationship with a farmer, and sustainability, were extra information that caused confusion and disinterest. Year three, (2014) the marketing to low-income targets was changed to focus on fresh produce, half cost, every week. By season end, over 60 low-income people were on the waiting list for the CSA.

Even in year three, consistent pick-up of shares by low-income members proved challenging. Low-income members cannot meet the conventional requirement of paying for an entire CSA season up front, so low-income members were permitted to pay for produce week by week. This left some members feeling non-committal, led to wasted shares, and sometimes member frustration that shares hadn't been packed for them. One way this was curbed was by requiring low-income members to pay for shares a week in advance. Though an improvement, the weekly collection of payments adds much to the farm staff's work load. This requires staff to be present to collect funds and pass out shares, both of which counter the model of CSA from the farmer's standpoint.

Small scale farm production is most likely to succeed in one of two avenues: The primary goal needs to be either on education and community involvement or on niche market, high end production for profitability. This project startup focused on both. Without staffing or funding/time capacity for community involvement, it is highly unlikely for such a small scale to be financially profitable. Attempts to bridge the gap across both require efforts financially, energetically, and inherently creates inefficiencies toward both ends.

Partnering with multiple organizations was of great benefit. It is highly advised that any startup project establish relations with many organizations with similar goals to create efficiency, ease, cut costs, and learn from others' experiences. Three seasons of experience have shown that with proper timing and planting location, select crops can be harvested outside their normal prime and collect much higher premiums, i.e. head lettuces in late July. Fall season was also extended by multiple weeks by planting cool loving crops in an area with protection to the North. Crops planted here could avoid multiple frosts.

## Contact Information

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## Additional Information

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Current project information is available at: [seedsofhopefarm.org](http://seedsofhopefarm.org) and [facebook.com/SeedsofHopeFarm](https://facebook.com/SeedsofHopeFarm)



SEEDS *of* HOPE  
**F A R M**



### **Project 3: Elucidating the Role of Walnut Curculio (*Conotrachelus retentus*) and Bacterial Isolates Associated with Black Walnut Kernel Necrosis**

**University of Missouri**  
Dr. Michele Warmund  
Final Performance Report

#### **Project Summary**

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In the United States, black walnuts (*Juglans nigra*) are a valuable niche market with 13,607 t of in-shell nuts harvested annually. Sixty-five percent of the harvested walnuts are produced in Missouri (Brian Hammons, 2009). Currently, the demand for black walnut kernels exceeds the supply. Reasons for the short supply of black walnut kernels include losses from walnut shoot moth (*Acrobasis demotella*), walnut curculio (*Conotrachelus retentus*), walnut husk fly (*Rhagoletis completa*), erratic bearing patterns, and kernel necrosis and shriveling (also known as “ambers”). Of these losses, kernel necrosis is the most limiting factor in marketable yield. Kernel necrosis not only destroys the nutmeats, but also results in very thin shells, which also makes them non-saleable. Although this disorder has long been recognized as a major source of crop loss (Stokes, 1941), the cause of kernel necrosis remains unknown.

Recently, the incidence of ambers was quantified for four consecutive years at two sites, including a commercial planting in Windsor, MO and in the repository at the Horticulture and Agroforestry Research Center, New Franklin, MO (M.R. Warmund, unpublished data). In 2007, 68% of the fruits sampled from Football and Sparrow trees at Windsor had kernels exhibiting ambers. At this same location, thirty-seven trees and 16% of the fruits from Emma K and Kwik Krop trees, respectively, had ambered kernels.

Earlier observations revealed that not all walnuts produced on a terminal fruiting shoot exhibit kernel necrosis. Thus, it is unlikely that ambered kernels are the result of tree moisture status or poor tree nutrition. Preliminary studies revealed that symptoms of kernel necrosis may be visible early in the growing season (M.R. Warmund, unpublished data).

In 2010, bacteria, including *Pantoea agglomerans*, *Rahnella* sp., *Enterobacter ludwigii*, and *Enterobacter aerogenes*, were cultured from black walnuts exhibiting kernel necrosis, but were not found in undamaged nuts. Although these bacteria are not known plant pathogens, they are associated with insect guts and feces. Thus, the role of these bacteria found in walnut kernels is not clear. Bacteria may directly cause black walnut kernel necrosis or these organisms may be transmitted to the kernel by walnut curculio when they feed early in the growing season.

Therefore, the objectives of this study were to: 1) ascertain if bacterial isolates induce kernel necrosis; 2) determine if black walnut curculio prefer to feed on leaves, pistillate flowers, or catkins; 3) evaluate the incidence of kernel necrosis when insects are excluded from shoots after pollination until harvest; and 4) communicate the results of this study to walnut producers.

## Project Approach

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Objective 1. In 2010, bacteria, including *Pantoea agglomerans*, *Rahnella* sp., *Enterobacter ludwigii*, and *Enterobacter aerogenes*, were cultured from black walnuts exhibiting kernel necrosis in 2010, but these bacteria were not found in undamaged nuts. To ascertain if bacteria induce kernel necrosis, six isolates cultured in 2010 were maintained and used to inoculate black walnut pistillate flowers at bloom and fruits at one month after pollination in 2012. On May 17, 2012, five flowers each on five trees of Kwik Krop, Emma K, and Thomas/Meyer black were treated with each resuspended isolate or sterile water using an atomizer to spray runoff. On June 14, bacterial isolate treatments were injected into the distal end of five fruits (2 cm-wide x 4 mm-long) per five replications of each cultivar using a syringe. Additional treatments included an injection of sterile water control and an injection without water. One week after treatments were applied, flowers and fruits were enclosed in insect exclusion bags. In September, nuts were harvested and the presence or absence of kernel necrosis was recorded for each nut. Results from these studies indicated that bacterial isolates applied by spraying pistillate flowers or injecting developing fruits had similar percentages of kernel necrosis at harvest (Table 1).

Objective 2 . To determine if black walnut curculio preferred to feed on leaves, pistillate flowers, or catkins, 25 soil emergence traps were placed in a mature black walnut orchard on March 13, 2012 but only five curculios were trapped. Thus, an alternative method was used to collect insects. On May 2, 9, 10, and 15, curculios were collected on a drop cloth after beating tree limbs. Insects were examined under a light microscope and a total of 138 female and 150 male insects were identified and used for feeding preference trials. Males and females were separated and no more than 25 of each sex were placed in containers with a screen top with a water-moistened sponge, but no food source was provided for 24 hours before the feeding trial. To conduct this trial, four types of plant material were placed in each quadrant of a 140 mm-diameter by 25 mm-deep petri dish. Plant material included a pistillate flower ( $\approx$  2 cm-long), a similar length of a catkin, and a 2 cm x 1 cm section of a black walnut or pin oak leaf. One insect was placed in each petri dish on a laboratory bench in a lighted room at 9:00 am and the occurrence of feeding on any plant material was recorded at 15, 30, 45, 60, 75, 90, 105, 120, 180, 240, 300, 360 min. After this time, lighting was eliminated until 8:00 a.m. when data were recorded again at hourly intervals for 4 hours. After the last feeding data was recorded, the number of eggs in each pistillate flower was recorded. The experimental design for the feeding preference trial was a split plot in time (i.e., repeated measurements). Because feeding was confined to catkins and pistillate flowers, data were not normally distributed. Thus, the odds (i.e., probability) of male and female insects feeding on catkins at each time of data collection was estimated, using the GLMMIX procedure of SAS with a

link=logit function for a binary distribution. Mean differences among logits were determined using the LSMEANS statement ( $P \leq 0.05$ ). Total numbers of eggs deposited in each pistillate flower on each test date were subjected to analysis of variance (ANOVA) using the PROC GLM procedure of SAS and means were separated by Fisher's protected LSD test ( $P \leq 0.05$ ). Results from this study revealed that male and female curculios had similar feeding preferences. Both sexes were observed feeding on catkins most often and female flowers to a lesser extent. The probability of females and males feeding on the catkins was 3.0 and 4.7 times greater, respectively, than that of feeding on pistillate flowers during the trial. Thus, females and males fed on catkins at 75% and 82% of the times recorded. Insects were never seen feeding on walnut or oak leaves. Pistillate flowers had the greatest number of ovipositional scars on May 9 and the fewest on May 15. Also, females oviposited an average of five eggs per pistillate flower on May 9 and less than one per flower on May 15 (Table 2). However, as many as 12 eggs were deposited in a single flower on May 9.

Objective 3: To evaluate the incidence of kernel necrosis when insects were excluded from shoots after pollination until harvest, bags were placed on 100 nut bearing shoots (20 bags on each of five trees) of Football trees on April 15, 2012. Walnuts within the exclusion bags and 20 non-excluded nuts from each of five trees were harvested on September 1. Bagged fruits were visually smaller in size and some had shriveled husks as compared to non-bagged fruits. After husking, all nuts were bisected using a band saw. The number of nuts exhibiting kernel necrosis was recorded. Only 4 of the 100 insect-excluded nuts contained non-ambered kernels. In contrast, 34 of 100 non-bagged nuts contained necrotic kernels. These results indicate that kernel necrosis was not induced by insect feeding at this site and bagging adversely affected nut growth and development.

Objective 4. To communicate research results to clientele across the U.S., presentations were delivered to 50 Extension Specialists at In-Service training sessions on June 28 and 29, 2012 and to the public (75 participants) at MU Horticulture and Agroforestry Research Center field day on June 30, 2012. Other presentations were delivered to more than 750 researchers/Extension Specialists at the American Society for Horticultural Science (ASHS) annual conference at Palm Desert, California on July 24, 2013 and to 100 producers at the Northern Nut Growers Association (NNGA) annual meeting in East Lansing, Michigan on August 12, 2013. A University of Missouri publication, G7185 Black Walnut Curculio was developed, printed, distributed to producers at the NNGA meeting, and posted online at <http://extension.missouri.edu/p/g7185>. A manuscript, Black Walnut Curculio-Such a Pest! was submitted for publication in the 104<sup>th</sup> Annual Report of the Northern Nut Growers Association in September 2013.

Dr. Michele Warmund (MU Professor of Horticulture), Audrey Davis (Graduate Student) and Shannon Bage conducted the curculio feeding preference tests. These researchers, as well as Andrew Biggs (Graduate Student) and Tyler Carey (Undergraduate student) conducted the bacterial inoculation studies. Dr. Warmund performed data analyses and delivered presentations at meetings and prepared publications of this work.

## Goals & Outcomes Achieved

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This study found that bacterial isolates of *Pantoea agglomerans*, *Rahnella* sp., *Enterobacter ludwigii*, and *Enterobacter aerogenes* applied to pistillate flowers or young fruits were not associated with kernel necrosis. Also, male and female black walnut curculios had similar feeding preferences and spent the greatest amount of time feeding on catkins, and to a lesser extent, the pistillate flowers. Although females oviposited an average of five eggs per flower across all sampling dates, as many as 12 eggs were found after the feeding trial conducted on May 9. However, after excluding insects from black walnut flowers on trees in mid-April, kernel necrosis at harvest was apparently not induced by walnut curculio feeding. These findings, in addition to others, indicate that kernel necrosis is caused by another unidentified factor. Experimental results were presented, as well as publications produced from this

project, were communicated to more than 1225 contacts at various public events. A guide on black walnut curculio damage and its control was created and published in June 2013, with more than 1753 visits to online version of this publication at <http://extension.missouri.edu/p/g7185>, 364 downloads of the file, and about 250 hard copies of this guide distributed to interested clients. An article, Black Walnut Curculio-Such a Pest! will be published in the 104<sup>th</sup> Annual Report of the Northern Nut Growers Association and will be available online via the NNGA web site in the future.

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## Beneficiaries

Current and future nut producers will benefit from the work performed in this study. Information on black walnut curculio feeding, which limits nut production was elucidated and will be used to refine the timing of control strategies for this pest and to maintain sustainable yields. While a causal organism for black walnut kernel necrosis was not identified, the possibility of transmitting specific bacteria during flowering and early fruit set via black walnut curculio feeding in early spring was eliminated. As a result of these key findings, Dr. Warmund will now investigate mechanisms that might induce anatomical aberrations that occur in black walnut fruits exhibiting kernel necrosis symptoms. Such studies will potentially assist future workers in developing methods to avert kernel necrosis.

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## Lessons Learned

This project revealed that large numbers of soil emergence traps are necessary to successfully collect large numbers of black walnut curculios. However, it was found that these insects are easily dislodged from tree limbs and can be collected from the ground. During curculio emergence, these insects prefer black walnut floral organs over walnut or oak leaves. During this study, another important observation was made. In early July, embryo abortion was found in developing black walnut kernels. Also, throughout the growing season and at harvest, aborted or undersized embryos and cotyledons were observed in walnut fruits containing necrotic and partially shriveled kernels. More detailed studies will be conducted to confirm these findings and to identify causal factors associated with kernel necrosis.

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## Contact Information

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## Additional Information

**Table 1.** Mean percentage of kernel necrosis at harvest when bacterial isolates were applied to pistillate flowers or developing fruit.

Treatment	Kernel necrosis (%)	
	Application to Flowers	Application to Fruit
Sterile water	4.8	9.0
Needle prick only	----	16.0
WB1T #41	4.5	6.0

WB1A #3	2.4	9.0
WB3F #12	2.0	9.0
WB13B #20	4.6	12.0
WB15A #30	3.8	10.0
WB20 #2	4.8	14.0

Means represent 25 treated nuts on 5 replications of each tree. Some treated flowers dropped soon after treatment and were not pollinated.

**Table 2.** Mean number of ovipositional scars and eggs per fruit following each feeding trial.

Date	No. of ovipositional scars/fruit	No. of eggs/fruit
May 2	1.7 c	1.6 c
May 9	6.1 a	5.4 a
May 10	2.4 b	2.0 b
May 15	0.5 d	0.5 d

Values with different letters in a column are statistically different at  $P \leq 0.05$ .

**Table 3.** Percent graft union success, number of trees with galls, and average length of scion growth at 4 weeks after grafting 'Qing' buds that had been immersed in water at 52 or 53°C for 10 min or untreated.<sup>1</sup>

Treatment temperature (°C)	Successful grafts (%)	Number of galls/tree	Scion growth (cm) <sup>2</sup>
52	75	0	14.9
53	25	0	18.0
Untreated	80	10	15.0

<sup>1</sup> Heat-treated or untreated 'Qing' buds were grafted onto seedling AU-Cropper rootstock. Thirty grafted trees of each treatment were maintained in at growth chamber at 24°C day/18°C night on a 12 h cycle for 4 weeks.

<sup>2</sup> Mean scion growth among treatments was not statistically significant when analysis of variance was performed,  $P \leq 0.05$ .

#### **Project 4: Increasing Nutrition and Consumption of Specialty Crop through the Farmers Market of the Ozarks Regional Marketing Campaign**

##### **Farmers Market of the Ozarks (FMO)**

Lane McConnell, Market Manager

Final Performance Report

## Project Summary

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The purpose of our grant project:

1. Develop the Farmers Market of the Ozarks on the south side of Springfield, Mo., that will be housed in a year-round pavilion by 2013 that will be open to vendors from 150 miles from the market location,
2. Organize producer education seminars,
3. Inform consumers about the nutritional benefits of the region's specialty crops,
4. Create a strategic marketing campaign.

We accomplished all purposes of this grant project. In addition, through innovative marketing the market increased the consumption of specialty crops in the Ozarks and expanded current market share. The LoveYourFarmer.com website was created, which is an interactive website that serves as the hub of consumer information to increase regional knowledge about where the market's specialty crops derive from and cooking instructions for fresh products. FMO created a Facebook page that has grown in major popularity since 2012, now with more than 14,500 likes.

When FMO applied for the SCBG, the market organizers knew the possibilities that were available for a well-organized, large scale market in Springfield, but FMO has surpassed all expectations over the past 2 years. The area has seen multiple new farmers in the areas of vegetables, organic ag and small berry production. FMO grew from 25 vendors in February 2012 to more than 100 by the end of 2013, with a waiting list of farmers wanting to become a member. Consumers in this area are demanding fresh, locally grown produce and are seeking out options to purchase specialty crops. FMO has made a major impact on the community and region as the market has become a regional attraction.

Through the grant project specific activities were planned to promote local specialty crops throughout the region. In 2013 our market held monthly seasonal festivals, just as we did in 2012 on the same weekends. We saw an average increase of 32.3% in customer counts from 2012 to 2013. This data was collected by paid staff to conduct customer counts on these festival dates. In addition, through numerous dot surveys conducted in 2012 and 2013 on the access of local specialty crops in our region we saw a 15% increase in customer knowledge on the number of specialty crops and varieties that customers purchased.

FMO worked with local chefs to conduct cooking demonstrations throughout the year. Our website, LoveYourFarmer.com was revamped in 2013 to better suit customers, adding a blog and social media plug-ins. The site is much more user-friendly now and will be added to in 2014 to add an interactive farmer map of all vendors. Lastly, in early fall of 2013 one garden plot was established and used by the YMCA and market as a teaching garden. Then, in October 2013, working with SUAC and MU Extension, we prepared our micro-orchard plot and planted 30 fruit trees across from the market pavilion. Ten raised beds were added to our garden areas in Dec 2013 to complete our school-yard garden project. These gardens will be planted in April of 2014 in partnership with the YMCA.

The motivation behind this project was to serve the underserved market share available to specialty crop growers in the Ozarks. Its aim was to build a highly successful market to give growers from around the region a place to sell their farm products to consumers on a weekly basis, year-round. Through the work of this project, FMO is not only the largest market in the region in only 2 years, it also has grown the demand for local specialty crops, which was demonstrated in vendor sales compared from 2012 and 2013. We saw sales grow for specialty crops by 43.5%. All vendors that sell at FMO must record gross to the manager at the close of each market day and pay 3% of total sales back to the market. Our specialty crop vendors have seen such a demand by customers and restaurants that many of them increased the scope of their farm in 2013 to meet the needs in 2014. This helped fulfill another purpose

to the project, which was to increase the gross sales for specialty crop farmers. Three significant aspects of the success of this market are that we have had eight vendors quit their full-time jobs to work on their specialty crop farm year-round, six have put up high tunnels to grow and five have constructed additional greenhouses for the 2014 year to grow year-round and more diversity of their product mix.

Through the assistance of this project, consumers were educated on the availability of specialty crops in the Ozarks region, through the following goals that were accomplished: social media marketing campaign, recipes from local dieticians that were created to represent the seasons (tomato, sweet corn, greens, melons, berries, peaches, apples), creation of unique marketing materials that were handed out at market and consumer trade shows (FMO handed out 6,000 pamphlets in 2012 and over 10,000 in 2013), the increase in sales from 2012 to 2013 by specialty crop vendors at FMO (this data of sales increase is displayed in the final report), creation of school yard gardens was completed in late 2013, FMO vendors that are specialty crop farmers received a custom market sign and FMO hosted all educational seminars to complete the SCBG.

## **Project Approach**

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FMO began as a start-up market in Springfield, Mo., in 2012. Many start-up farmers markets do not succeed after 3 years in operation due to lack of management, funds and vendors. However, FMO, under the management of Matt O'Reilly the owner of the development the market is located in and Lane McConnell, the current Market Manager, the market has seen nothing but success since its opening. McConnell began as a consultant for O'Reilly's development and once the market was operational was asked to step-up as manager. McConnell has 8 years of experiences working with the Department of Agriculture in local foods and as a consultant for her agricultural business, Agri-Comm Services.

The market began with strict guidelines such as sales reporting, farm inspections for all vendors and stall assignments. With unique social media marketing and partnerships with community programs and businesses, the market has become one of the best attractions to the 417 Land. The market was named the Number 15 Farmers Market in the Country in 2013 by the Daily Meal and voted Best Farmers Market in the Best of Issue of 417 Magazine. St. Louis Dispatch also called FMO, "the best farmers market to visit in the Midwest for everything local."

## **Goals and Outcomes Achieved**

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- Goal 1: Evaluate Target Market: FMO hired part-time staff to establish baselines in year 1 to compare in year 2.
- Goal 2: Social Media Marketing Campaign: Social media marketing was used in year 1 and year 2 to market the market and specialty crop festivals that were held monthly, as well as to highlight locally grown specialty crops with recipes on LoveYourFarmer.com and on the Facebook page. The market manager and market interns were responsible for researching information and working with Mercy Health dieticians.
- Goal 3: Cooking Demos, recipes, videos: Through the assistance of Mercy Health, healthy and nutritionally balanced recipes were created and placed on the website and social media platforms by market staff. In addition, short videos were placed on the Facebook page that highlighted seasonal specialty crops from local farmers to inform customers of when specific products came into season.
- Goal 4: Produce Marketing Materials: The market manager led all advertising marketing materials

the market used to promote the market and its farmers. Brochures, recipe fliers, SNAP brochure, print media ads and a harvest calendar were all created and highlight special specialty crops grown in the region.

- Goal 5: Record Sales: The market manager and market assistant recorded sales of market vendors in year 1 and year 2, to compare the sales of vendors and create a baseline to see if specific marketing through the grant were successful. All gross sales were recorded in an Excel spreadsheet and shared vendor category results with our vendors.
- Goal 6: School Yard Market Gardens: Market establishes organic school yard gardens for students in partnership with YMCA and Dirt Program behind the market pavilion area. These gardens were created late in 2013.
- Goal 7: Record web traffic and present project findings: All website traffic was evaluated by the market website designer and the market has presented the grant project at the MFMA 2014 conference, with ways in which the market used SCBGP funds to help market specialty crops in the region and build farmers' sales at the local market. In addition, the manager provided a presentation on the success of the market's social media campaign that was assisted through the grant project.
- Goal 8: Produce Vendor Signs: Our market created produce and other specialty crop vendor signs for our vendors to list the type of specialty crops they grow and how many miles from market their farms are located.
- Goal 9: Producer Educational Seminars: Structured producer specialty crop educational seminars for vendors that will teach vendors skills to help aid the market in providing consumers with safe food choices and specialty crop diversity offered at the market. Over the past 2 years the market hosted seminars of pest management, irrigation, small berry production, farm safety, marketing at the farmers market, structuring a crop harvest plan, beginning farmer class, farm finance 101, heirloom production for market, hydroponics 101 and various marketing seminars. The market manager worked with local MU Extension Horticulture Specialist on structuring and organizing these seminars.

The market's activities that were SCBGP projects were all documented and kept separately from other market activities. With the help of the market's accountant, the manager was able to keep receipts and expenses separate. All seminars were geared towards specialty crop vendors, all market activities that were funded through the SCBGP funds were focused on main seasonal specialty crops, recipes all included specialty crops grown by our vendors, marketing materials and advertising were geared to promote and educate consumers on the availability of fresh specialty crops grown locally in the community.

Specialty crop vendor sales have been increased by 43.5% between 2012 and 2013.

Increase in vendors from 20 in February 2012 to 105 in 2013.

Facebook page has grown to over 14,500 likes, when the goal was to reach only 3,000 likes by 2013.

Development of 2 organic school yard gardens was the goal of this project, but with the teamwork of local entities FMO has constructed 10 raised beds, two school yard gardens and a micro orchard onsite by the FMO pavilion.

Customer counts at that market continue to increase as well, with the market hitting over 10,000 customers on July 13, 2013. We saw an average increase of 32.3% in customer counts from 2012 to 2013. This data was collected by paid staff to conduct customer counts on specific market festival dates. In addition, through numerous dot surveys conducted in 2012 and 2013 on the access of local specialty crops in our region we saw a 15% increase in customer knowledge on the number of specialty crops and varieties that customers purchased.

Sixteen cooking demonstrations were conducted at market in 2013 and 21 in 2012 to exceed the 26 planned for in the grant project.

Through dot surveys conducted throughout 2013, the market found that although the majority of customers live in Springfield, another 30% drive in from surrounding towns like Rogersville, Ozark, Nixa, Fair Grove and even as far as Branson. The increased traffic at market provides farmers a more self-sustainable business plan with a solvent farmers market that is open year-round. Through the increased marketing that FMO accomplished through the SCBG, such as cooking demonstrations, website development, social media, seasonal festivals and more, the market was able to increase the knowledge of the vast varieties of specialty crops grown locally in the Ozarks. This in turn, has helped to introduce consumers to a healthier way to eat and our hope is to see a healthier population long-term.

Our partners grew over the last two years to help our market grow through the assistance of the SCBG. Not only was the Farmers Park Development, where the market is located in, a huge partner on the success of the market, but other local groups joined forces with our market to help create consumer awareness of specialty crops in the Ozarks. Organizations such as Harvest on Wheels, Ozarks Food Harvest, Ronald McDonald House, various grocery stores and restaurant chefs, Springfield Urban Agricultural Coalition, University of Missouri Extension, Master Gardeners of Greene County, Webb City Farmers Market, Ozark Downtown Farmers Market, Greene County Health Department, Homegrown Foods, Mama Jean's Natural Food Market, Baker Creek Seeds, White Harvest Seed Company, ANPAC, Springfield Food Day, FoodCORE and numerous local restaurants.

The launch of the FMO website and Facebook page were in early 2012, followed by development of recipes from registered dieticians that were used in cooking demonstrations at market in 2012 and 2013 and posted on the website's blog and Facebook. Advertising materials (FMO magazine, magnets, vendor signs, Food Stamp brochures, recipe cards, FMO brochure and festival fliers were created in 2012 and similar promotional pieces were also created in 2013 as part of the grant project. FMO vendors began recording sales data to management in April 2012, this data was used as the baseline to compare 2013 data. School gardens, raised beds and orchard were not started and completed until fall 2013. All FMO specialty crop vendors receive a custom market sign to use at their booth, therefore signs were printed in 2012 and 2013. FMO hosted four educational sessions in 2012 and eight in 2013, the average attendance to the sessions was 33. FMO has already shared many of the successes and lessons learned of the project at the 2014 MFMA Conference in Washington, MO. The market is also part of the Ozarks Regional Food Policy Council and has shared the information at meetings in late fall 2013.

We expected to create consumer awareness of the availability of fresh and healthy specialty crops at a regional southwest Missouri farmers market and develop healthy eating habits. Our market's educational programs that were assisted by the SCBG have started this process, but to continue the educational and promotion our market has already applied and received a Community Foundation of the Ozarks grant for continuing education on the availability of local crops and cooking programs that will launch in April 2014. In addition, FMO has seen a huge success with its educational sessions that through the partnership with University of Missouri Extension and Springfield Urban Ag Coalition the market will offer continuing educational courses to the community on topics that will help beginning farmers, offer social media marketing classes, prepare farmers with accounting management and organize four farm tours for young

or beginning farmers to learn about growing a success farm. Through offering these educational sessions the market hopes to build a new crop of farmers that will someday be ready to bring their product to market.

## **Beneficiaries**

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Specialty crop farmers in southern Missouri as well as Northern Arkansas benefitted from this project due to specialty crop farmers becoming more financially stable through their increased sales at FMO. In addition, the general population of southwest Missouri who learned about specialty crops through the grant project will allow consumers to improve their food options and enable them to positively impact their long-term health.

Throughout this project data was collected to demonstrate the success of the project. All vendors that sell at FMO must report their total sales at the close of each market day. Data in gross sales was collected in 2012 and 2013 and the sales of our local specialty crop vendors (105 vendors, 69 of which are specialty crop vendors) saw a 43.5% in a year- which was above expectations. In addition, the local community in Springfield benefited in learning ways to eat healthy through the market by attending cooking classes, market festivals and the marketing materials presented.

Customer counts were also collected by paid market staff on specific market festivals in 2012 and 2013. In July 2013, FMO welcomed 10,203 customers through the pavilion, an increase of 3,450 on the same weekend in 2012. Overall the market saw an average increase of 32.3% in customer counts from 2012 to 2013.

As written in the grant, SCBGP funds would cover market specialty crop festivals. One of the project's outcomes was to hold 5 seasonal festivals throughout each year that highlight different specialty crops. These will include a Spring Gardening Festival, Tomato Fest, Berry Blast, Sweet Corn Roast and a Fall Harvest. All of these festivals were held both years and funds were used to promote the specific specialty crop for each festival.

## **Lessons Learned**

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With any project there are delays and FMO experienced a few unexpected delays over the grant period that put our objectives behind, but we made time up in the last year of the grant in 2013. The major delay that we experienced was installing our school gardens at the market location. This was due to our development being built. Our market is located in the Farmers Park development and construction began in 2012 for the multi-million dollar green, sustainable facility. FMO held market inside large white tents in 2012, as ground was broke for the development. Then, in July 2013, our market moved to our permanent pavilion. Although, this was a great move for our facility, it came with its downside. Construction noise, traffic, parking, area was demolished and an eye-sore, but we still opened our first day to over 10,000 customers. Since construction was taking place in 2012, there was no ground to build our gardens. We hoped to start on the gardens in April 2013, but again, due to construction we could not start any garden beds until late fall 2013. We worked with SUAC, Missouri State University and volunteers to prepare garden beds with a local nursery and landscape company in Springfield, Mo., to accomplish this. We installed a micro-orchard and prepared garden beds to plan in May 2014.

Lessons learned through this project include: The power of community! FMO's success is in part due to the tireless efforts of building relationships with community members, groups and organizations. Through the assistance of the groups listed in the Project Approach, the project's goals were achieved. The market recruited from these market partners to assist in cooking demos, blog writing, dot surveys and customer counts and to help prepare and build garden areas.

Second lesson learned of this project: The Power of Social Media! FMO social love is off the charts, boasting more than 14,500 likes in two years, which is something short of amazing. The market's website sees a lot of traffic, but the Facebook page has become the way the market informs the public of everything from festivals to fundraisers and membership meetings to snow/ice cancellations. Facebook is how FMO has told its story to the public and it has worked. Any market looking at finding a way to market to a wide demographic MUST include social media in their plans.

We learned one major aspect of appropriate funding through this project: cooking demonstrations cost a lot more than expected! We accounted only \$170 for cooking supplies and actually spent well over this amount. With new health department regulations in our county there were many added expense like pH stripes, bleach, hand-washing units, soap, paper towels, sampling cups and other various items.

The market expected to film videos and add them to the website, however this did not happen. FMO did film numerous videos using camera phones and placed them on Facebook, which we found to be much easier, more cost-effective and worked better in our marketing plans. Initially, it was believed that short videos on the website were an important item of the marketing plan, but in 2013 we saw the growing social media presence of FMO and turned to filming short videos and placing them on Facebook reached more customers. In addition, it was the goal of this project to provide a magnetic harvest calendar to customers, but after seeing the size the magnets would have been, it was decided to design and print a ½ sheet harvest calendar to hand out at market. The designed harvest calendar was also included in the 2014 FMO calendars, so we can extend the use of this graphic that was created through this project.

No specialty crop funds were used for the FMO fundraisers, all these expenses were charitable donations from our community. We were documenting these in lessons learned because we felt as though this was part of the overall market project. We can assure that there were no SCBGP funds used to assist in the FMO fundraisers in any way.

## **Contact Information**

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## **Additional Information**

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All videos, photos, festivals, cooking demos, banners, marketing materials, educational sessions, and gardens are documented on our Facebook page, Farmers Market of the Ozarks and on our website at <http://loveyourfarmer.com/>

## **Project 5: The Organization and Hosting of the First International Elderberry Symposium**

**University of Missouri**, Southwest Research Center  
Andrew Thomas  
Final Performance Report

## Project Summary

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The American elderberry is a perennial woody shrub native to eastern and Midwestern North America that produces edible flowers and berries. Within the last ten years, the common elderberry has rapidly become one of the most promising “new” agricultural specialty crops, not only in Missouri, but also nationally and internationally. The primary markets for elderberry fruit and flowers are wines, jellies, natural food colorants, and medicinal products or dietary supplements. Elderberry products, some of which are clinically proven to treat and prevent viral infections, consistently rank among the top ten best-selling dietary supplements in both North America and Europe. The vast majority of elderberry products available in the U.S. are produced in Europe from the European elderberry (a different subspecies), despite the fact that the American subspecies may be superior in terms of anti-oxidant efficacy and stability. The rapidly-increasing interest in both American and European elderberry has inspired a diverse group of international scientists to undertake research on numerous aspects of the species. This proliferation of scientific research on elderberry runs the gamut of agricultural, biochemical, and medicinal disciplines, and serves to acknowledge the emergence of elderberry as a legitimate specialty crop. Elderberry, nevertheless, remains a largely undeveloped crop, with tremendous opportunity for significant strides in the scientific advancement of its agricultural and biomedical potential. Meanwhile, dozens of Missouri and Midwest producers are now growing elderberry. A recently-formed growers’ organization in Missouri, “The River Hills Elderberry Producers”, is moving rapidly forward, not only with significant acreages of new elderberry plantings, but also with plans to construct a state-of-the-art processing and marketing facility. With this rapidly-increasing interest in elderberry production and consumption comes the concomitant need for scientific research and the dissemination of research-based information, not only on the production, processing, and marketing of elderberry products, but also on the true medicinal benefits of elderberry products. Furthermore, as the community of elderberry researchers grows, and as the research becomes more sophisticated and focused, the need for communication and interaction among researchers and producers around the world becomes more and more important.

## Project Approach

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With the support of this grant, we planned, organized, and hosted the First International Elderberry Symposium and Elderberry Producers Forum, held June 10 – 15, 2013, at the Stoney Creek Inn, Columbia, Missouri. Our goal was to assemble 150 or so of the world’s leading elderberry researchers, processors, and producers for five days of exchange and fellowship. The Symposium was organized under the auspices of the International Society for Horticultural Science (ISHS), and was hosted by the University of Missouri, Lincoln University, Missouri State University, Missouri Botanical Garden, and the Missouri Department of Agriculture. Numerous sponsors not only provided financial and moral support, but significantly contributed to the dynamic interaction and dialog that occurred among scientists, producers, and processor over several very stimulating days. Unique to this Symposium was the melding of scientists and farmers from around the world. In addition to several days of scientific exchange, the event included tours of several Missouri elderberry farms and a bus trip to Missouri Botanical Gardens in St. Louis. A significant goal and outcome of this Symposium is the publication of a volume of *Acta Horticulturae*, a highly-regarded, stand-alone book of peer-reviewed research papers resulting from all ISHS symposia. This publication, containing a plethora of published international elderberry research from numerous disciplines, will serve as a foundation for the future development and advancement of elderberry as a viable specialty crop. Its publication is anticipated in June 2014.

The following timeline of activities outlined in the original grant proposal was achieved as proposed, except the final publication of the *Acta Horticulturae* volume and the second follow-up survey have been pushed back from Dec. 2013 to June 2014.

- Oct. – Nov. 2011: Obtain official approval by ISHS Board and University of Missouri Legal; release of first circular / announcement with general outline of meeting; scientific and editorial committees finalized and called to action; invitation of keynote speakers; sign formal commitment for venue.
- Mar. – June 2012: Second circular and Call for Papers; release preliminary scientific program; finalize most logistical preparations one year in advance.
- Dec. 2012: Deadline for abstracts
- Mar. 2013: Deadline for advanced registration; definitive program released.
- June 2013: Host Symposium; manuscripts due.
- Dec. 2013: Complete reviews of manuscripts for *Acta Horticulturae* and submit for publication; post-conference survey sent and compiled.

## Goals & Outcomes Achieved

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The First International Symposium on Elderberry was a tremendous success on all accounts. The first part of the Symposium featured scientific presentations and discussions among researchers from 12 countries, with additional attendance from numerous elderberry producers and processors. In addition to horticulture, a significant number of scientific presentations focused on elderberry's biochemistry and use as a medicinal plant. Colloquia included Elderberry Botany and Ethnobotany, Elderberry Biochemistry, Elderberry and Human Health, Elderberry Horticulture, Elderberry Business and Marketing, and the Albert Y. Sun Memorial Colloquium on Berries and Brain Health. Keynote addresses from Ákos Máthé (Hungary), Madeleine Mumcuoglu (Israel), Sigrun Chrubasik (Germany), and Vivian Barak (Israel) helped to place elderberry knowledge and background into a current context. Presentations on elderberry taxonomy, ethnobotany, genetic resources, pests, and cultivar evaluations were rounded out by outstanding papers on *in vitro* and *in vivo* effects of elderberry against cancer, stroke, inflammation, diabetes, and infectious diseases.

The second part of the Symposium focused on elderberry producers and processors with continued participation by numerous international scientists. We were thrilled to have presentations from the two largest cooperative groups of elderberry growers in the world: the Styrian Berry Cooperative (Austria) and the Botesz Growers Cooperative (Hungary). These, along with keynote presentations by international scientists and industry representatives, were of tremendous interest – especially to North American producers.

A high point of the International Elderberry Symposium was the mid-symposium tours. The first tour left Columbia early for a trip to St. Louis and the Missouri Botanical Garden, a world-class research facility and botanical garden. The group was met at the Monsanto Center, the Garden's research facility, by Wendy Applequist and Doug Holland. Dr. Applequist led a tour of the Herbarium, comprising over 6.3 million preserved plant specimens, and specifically showcased the *Sambucus* collection. Mr. Holland, Director of the extraordinary Peter H. Raven Library, displayed selections from the rare book collection, including herbals from the 15th and 16th centuries that describe several *Sambucus* species and their medicinal use. The tour then moved to the Botanical Garden for an *al fresco* lunch and garden tour. The next tour stop was at Watershed Farm, an elderberry farm owned by John Bunge. After touring the elderberry plantings and the propagation greenhouse, the group enjoyed an informal tasting of Mr. Bunge's elderberry wines. The final stop on the tour was the evening gala at Nature's Organic Haven Farm near Hermann.

The second tour started with visits to two of the premier research laboratories on the University of Missouri campus. The Center for Translational Neurosciences, directed by Grace Sun, conducts fascinating research on the effects of elderberry on stroke, using mouse models. The group toured the neurosurgical and histology units, the digital microscopy facilities, and the animal behavioral unit. Kevin Fritsche then led a tour of the Animal Sciences laboratories, where additional cutting-edge research on

the effects of elderberry against cancer and infectious disease is conducted. Following the laboratory tours the group traveled to Eridu Farm at Hartsburg, owned by Terry Durham. Mr. Durham is a leading force in the development of the commercial elderberry industry in Missouri, with 15 hectares of elderberry under cultivation. The tour visited production fields, propagation facilities, and viewed specialized harvest and handling equipment. The next stop on the tour was Stone Hill Winery in Hermann, one of the oldest and most historically significant of Missouri's wineries. A cellar tour and tasting of Stone Hill wines were enjoyed by all. The group then drove to Nature's Organic Haven Farm for the evening gala.

Two separate evening banquets provided fun and informal atmospheres to bring together researchers with elderberry producers and processors. The first evening gala was hosted by Phyllis Hannan at Nature's Organic Haven, a certified organic elderberry farm with a spectacular view of the Missouri River Valley. The evening included horse-drawn wagon tours of the elderberry plantings, a tasting of elderberry and other wines, music by a local band, and a hog-roast banquet under a huge tent on the lawn. Materials and services for these important social events were either donated or paid for from attendee registration fees. Symposium Convener Andrew Thomas was presented with a medal of appreciation by Ákos Máthé on behalf of the International Society for Horticultural Science that evening. The final formal banquet was themed "Scientists Meet the Farmers" and featured an elderberry-based feast created by Daniel Pliska, Executive Chef of the University Club of Missouri. This event provided yet another opportunity to bridge the various disciplines and people devoted to all aspects of elderberry.

A Trade Show featuring a plethora of elderberry plants, equipment, and internationally-made elderberry products, including juices, wines, jellies, and dietary supplements, complemented the Symposium and provided a terrific forum for exchange of ideas. Plenty of elderberry wine and elderberry ice cream further stimulated camaraderie among international scientists, producers, and processors.

As outlined in the original grant proposal, a post-Symposium survey of attendees was conducted to assess then-current status of elderberry producers and the potential impact of their attendance. The results of this survey are included as an attached addendum. In the grant proposal, we also indicated that we would conduct a second follow-up survey six months after the Symposium to assess changes in production and marketing practices resulting from attending the Symposium. We have now decided to conduct this survey in June, 2014 (one year post-Symposium) because that will give producers entering into a new growing season the opportunity to implement changes, and will allow us to better assess the benefits of attending the Symposium (we can provide those results to MDA / USDA after they are compiled this summer).

## **Beneficiaries**

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Two hundred and five scientists, industry processors, and elderberry producers from 13 countries benefitted tremendously from the Symposium. A very exciting outcome was a tremendous amount of international contacts, friendships, and "deals" made among attendees, including scientists, processors, and producers. Prior to this Symposium, few of the widely-scattered international elderberry researchers had had the opportunity to gather for the exchange of research results and ideas. We believe the First International Symposium on Elderberry served as a tremendous boost to the stature and awareness of elderberry as a viable agricultural crop and food product, and as a legitimate dietary supplement both nationally and internationally. New collaborations, partnerships, and initiatives were developed over these few days in Missouri, and will continue to develop over the coming years from friendships made. Publication of the all-elderberry volume of *Acta Horticulturae* will form the cornerstone of elderberry research and advancement for decades to come, and will serve as a springboard for additional international research, collaborations, and conferences.

## Lessons Learned

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Organizing an international Symposium of this magnitude was truly a team effort, made possible by the hard work of dozens of professional people, financial support from numerous sources, and numerous factors that simply fell into place as the momentum and interest increased. This was truly a once-in-a-lifetime opportunity for many of the participants, which would not have been possible without this grant.

## Contact Information

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## Additional Information

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Please see refer to the 60-page Symposium Proceedings with scientific abstracts, Symposium schedule, sponsors, etc.:

<http://www.centerforagroforestry.org/profit/ElderberrySymposiumGuide.pdf>

Farmers Forum Evaluation Report:



**Elderberry Farmers Forum  
June 13, Columbia, MO 2013**

### **Evaluation Report**

The University of Missouri Center for Agroforestry (UMCA) developed a set of two surveys to evaluate the results of the Elderberry Farmers Forum set of workshops held on June 13, 2013 in Columbia, Missouri. The Farmers Forum was part of the First International Symposium on Elderberry held in Columbia, MO at Stoney Creek Inn, June 9-14, 2013.

The symposium was the world's first gathering of international scientists from multiple disciplines studying all aspects of the elderberry plant and fruit, and its use as a food and dietary supplement. The Producers Forum was held immediately following the scientific portion of the Symposium, on June 13-14, consisting of two days of

additional exchange among elderberry scientists and producers / processors. The first day, June 13 consisted of a set of workshops held at Stoney Creek Inn and was followed by a farm visit and hands-on activities on June 14 at the Eridu Farm in Hartsburg, MO.

On June 13, the forum started with plenary presentations by international scientists and practitioners followed by concurrent sessions: track 1- elderberry production and track 2 - elderberry marketing and development.

About half of farmers attended the whole symposium and about half attended only the Farmers Forum. Some researchers who presented or attended the scientific part of the symposium participated also in the Farmers Forum some of them as presenters, some as attendants.

At the beginning of the workshop, a survey was administered to all participants to assess both their motivation to participate in this event and the level of knowledge about the topics presented. At the end of the day, a second survey was administered to assess the participants' perception about the event, to determine the level of satisfaction with the content and organization, the gain in knowledge after listening to the presentations, assess how the workshop changed their interest in elderberry and future plans.

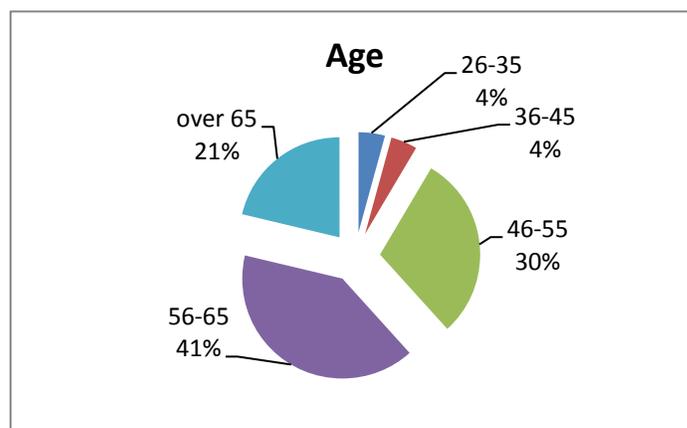
The survey had the following objectives:

1. Document the demographic characteristics of the participants at the Elderberry Farmers Forum.
2. Identify participants' motivation to attend the event.
3. Evaluate participants' reaction to the content and organization of the set of workshops.
4. Assess the level of knowledge before the workshops related to specific topics and compare it with the level of knowledge after the workshops to estimate the gain in knowledge.
5. Obtain suggestions that will help better organize similar events in future years.
6. Assess participants' initial interest in elderberry and how the interest changed after participating in this forum.

**Objective 1: Document the demographic characteristics of the participants at the Elderberry Farmers Forum.**

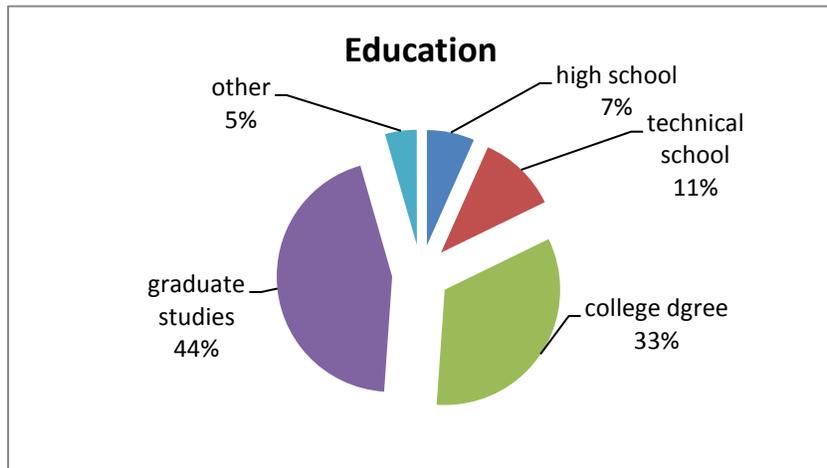
About 120 people (including organizers and presenters) participated in the Farmers Forum. The demographic characteristics, based on 47 surveys collected at the beginning of the event are as follows:

Eight percent of respondents were younger than 45 years, 30% between 46 and 55 years old, 41% between 56 and 65 years old and 21% over 65 years.



N=47, pre-workshop survey

Eighteen percent of respondents attended high school or technical school, 33% held a college degree and 44% held a graduate degree.

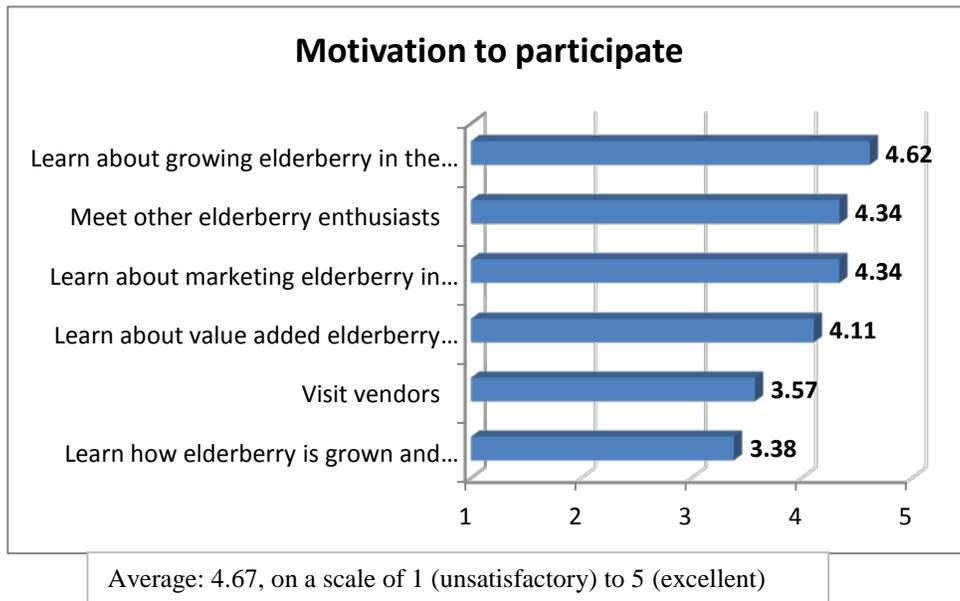


N=47, pre-workshop survey

**Objective 2: Identify the motivation to attend the workshop.**

Participants at the Producers Forum were mainly interested to learn about growing and marketing elderberry in the USA as well as meeting other people interested in elderberry.

On a scale of 1 (not at all) to 5 (very much), the average ratings for how much each topic motivated the participants to register for this forum are presented below:



N=47, pre-workshop survey

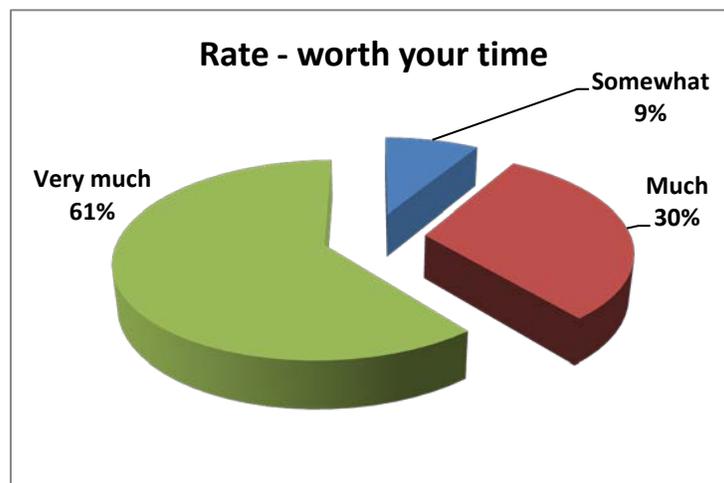
**Objective 3: Evaluate participants' reaction to the content and organization of the workshop**

Participants were very satisfied with the Producers Forum. The quality of workshop overall was rated excellent by 69% of participants and good by 29%.



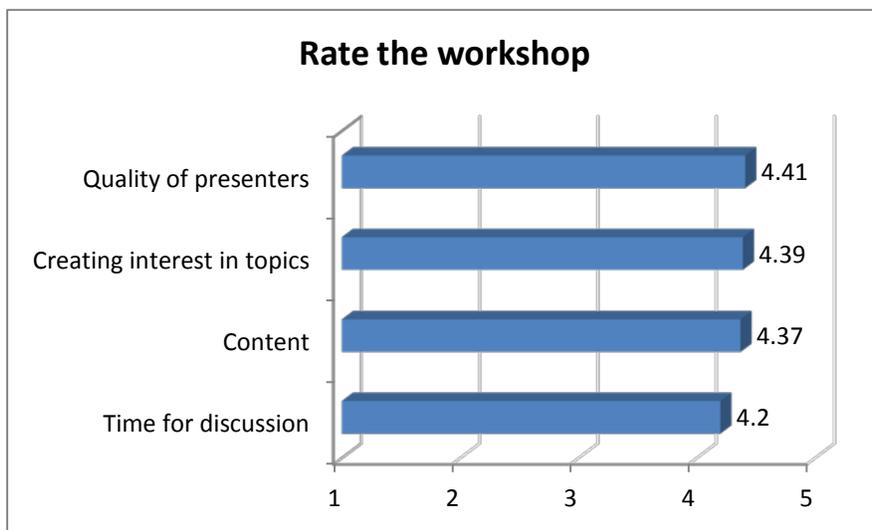
N=46, post-workshop survey

Sixty-one percent of respondents declared that participating in the workshop at the Producers Forum was worth their time “very much” and 30% “much”.



N=46, post-workshop survey

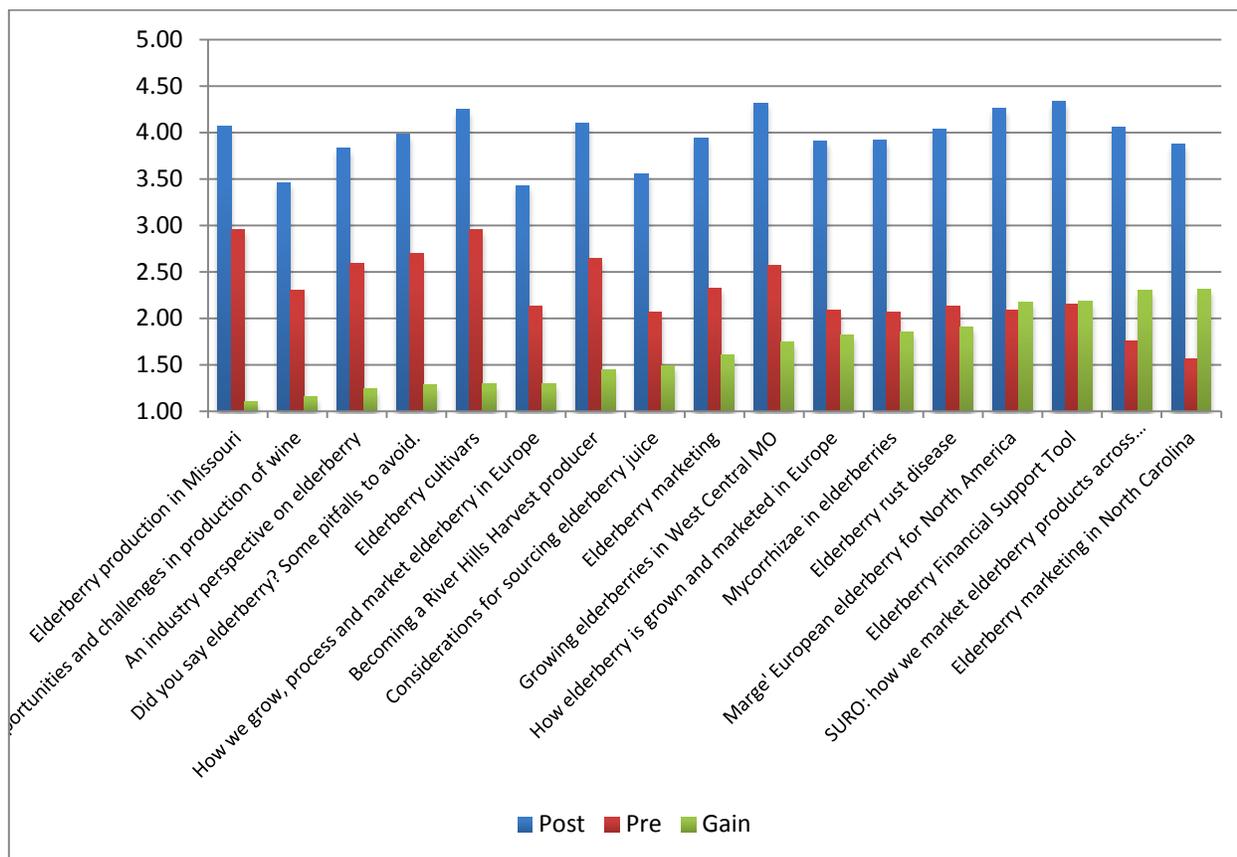
The quality of presenters was rated 4.41 average on a scale of 1(poor) to 5(excellent). Creating interest in the topic was rated 4.39 on a scale of 1(boring) to 5(stimulating). Content of presentations received a 4.37 rating on a scale of 1(of little use) to 5(useful) and time for discussion received a score of 4.2.



N=46, post-workshop survey

**Objective 4: Assess the level of knowledge before the workshop related to specific topics and compare it with the level of knowledge after the workshop (Pre (N=47) and Post (N=46) workshop surveys).**

A scale of 1 (nothing), 2 (very little), 3 (some), 4 (quite a bit) and 5 (a lot) was used to assess the level of knowledge. The level of knowledge before, after and the gain in knowledge is presented below (average ratings):



Participants had some limited knowledge about the topics presented (between 1.1 and 2.3 in average on the 1-5 scale) by participating in previous workshops or self study. After the workshop, the average knowledge ranged between 3.42 to 4.33 on the scale of 1-5, each topic obtaining a gain in knowledge.

**Objective 5: Obtain suggestions that will help better organize similar events.**

The workshop participants provided many comments and suggestions regarding the workshop’s topics and organization. Their comments are presented below.

What from this series of workshops were most helpful to you?<sup>1</sup>:

Workshop participants found a lot of good information in the topics presented at the workshop, especially those related to elderberry cultivation and marketing.

<i>Wide variety of topics; varying degrees of info</i>
<i>Overall knowledge</i>
<i>Pests, pruning, practices, mulch, irrigation</i>
<i>Cultivar discussion, exposure to Marge variety</i>
<i>Cultivars, diseases, how to grow</i>
<i>Explanation on new regulations</i>
<i>I've learn a lot about cultivars &amp; harvest &amp; growing methods</i>
<i>Identifying the needs in the market and who and how to get things done with elderberry</i>
<i>Marketing, GAP</i>
<i>Pests and diseases</i>
<i>Propagation</i>
<i>University of Missouri presentations, NC marketing strategies</i>
<i>What varieties grows the best in Missouri</i>
<i>Production protocol, Plant pathology and entomology, cultivar description</i>
<i>Growers presenting methods. European growers’ inputs.</i>
<i>Overview of where the market is and rules and regulations in developing market</i>
<i>Photos and anecdotes regarding growing tips; info/descriptions of various cultivars; maintenance and disease prevention</i>
<i>Cultivars that were most productive</i>
<i>Getting a basic understanding of where research and production is</i>

Besides the information presented, participants found the interaction with other growers, and between producers and researchers very valuable.

<i>Meet people with different perspectives and experiences.</i>
<i>Hearing real world experiences from local producers</i>
<i>Networking with fellow growers</i>
<i>An opportunity to have a direct exchange between producers and researchers</i>
<i>As I am just getting started, it was the information (and advice) that has been most helpful.</i>
<i>Connecting with people in various stages of production</i>

<sup>1</sup> Text in italic represents exact quote

<i>Contacts</i>
<i>Grower comments</i>
<i>Talking with growers</i>
<i>Discussions by growers of their experiences in growing elderberry. Discussions of their processes and successes</i>
<i>Experienced growers sharing their knowledge</i>

What wasn't covered in this workshop that you expected?

Respondents shared some of the topics that they would have liked to see covered or presented in more detail during these workshops.

<i>Fertilization, amount and techniques</i>
<i>How to produce/source "clean" plants/cuttings</i>
<i>I might learn more about the costs/benefits of making elderberry juice here vs. buying European concentrate</i>
<i>Irrigation systems</i>
<i>Harvesting, processing, berries</i>
<i>Machine harvest method, de-stemming options</i>
<i>More info needed on organic methods and markets</i>
<i>More on organic treatment of soil preparation, fertilizing, pest control, companion planting</i>
<i>I would have liked more advice regarding navigation of federal programs</i>
<i>What and where is the market for elderberry? How profitable is producing (per acre) on average? What is minimum acreage to be profitable?</i>
<i>Where to sell?</i>
<i>Production of items beyond wine</i>
<i>More on developing co-ops; Facilitation the formation of National and Regional Elderberry Association</i>

Besides that, one participant expected more detail on topics (*Could drive deeper on topics. I now know a little about a lot. Need to know more about a lot in elderberries*) while for another one the information presented was too technical (*It was a bit too technical for my level of education*). Various attendants were at different stages of involvement with elderberry and it was difficult to provide to each of them according to their needs.

**Do you have any comments/ recommendations regarding the content or organization of this forum that can help us organize better events in the future?**

Some respondents suggested providing better directions to the location of the event. Another suggestion was to provide participants with links to presentations and information about presenters. Some growers participated at the scientific part of the symposium, some not. The ones that only came for the Producers Forum, felt that they needed more time for discussion and interaction with scientists and other growers. Also, some respondents preferred to only have one track of presentations instead of two so they can attend more and get information on both, production and marketing and not only on one of them.

All the comments are provided below:

<i>Map to finding location of conference</i>
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<i>No split courses, one class at a time</i>
<i>List address/map of symposium site. Took some time to find it. Not clearly visible from the highway.</i>
<i>Plan more Q&amp;A time for growers. As a grower I felt I missed a lot by not attending the first part of the week</i>
<i>Since so much was presented it would be great if talks, papers, presentations would be made available online or on DVD</i>
<i>Provide links to power point presentations along with email &amp; website info on presenters</i>

**Objective 6. Assess participants' initial interest in elderberry and how the interest changed as a result of the workshop**

Before the workshop we asked: Tell us a few words about your involvement and interest in elderberry. Participants varied greatly in level of involvement and interest, from active growers already involved in commercial production, to beginning growers that are propagating plants or want to expand production, to people exploring their interest in potentially growing elderberry as a new farm crop or to use elderberry from the wild. Here are their comments:

<i>Began production in 2012, small scale 1/3 acre, hope to expand</i>
<i>Beginning producer</i>
<i>Certified organic 4.5 acre farm in MN with about 1/4 acre elderberry</i>
<i>Grower</i>
<i>Grower with 1/2 acre</i>
<i>Grower, 1 acre + of elderberries</i>
<i>Grower, wholesale marketer, grower coop organizer</i>
<i>Growing berries</i>
<i>Growing, processing</i>
<i>Have approximately 600 plants &amp; plan to focus on marketing Oklahoma native plants and products</i>
<i>I am a grower and have 7,500 plants on a certified organic farm</i>
<i>I am cultivating "wild crafting" on my property now</i>
<i>I have elderberry on my land and have had a very successful crop of plants and wish to grow elderberry as a crop</i>
<i>I have some plants. Investigating scaling up production and serving the food/medicinal market</i>
<i>I recently planted elderberries, so a great interest</i>
<i>One acre, 960 plants Bob Gordon &amp; Wyldewood Cellars plus 8 test plants of Marge planted in 2011</i>
<i>Perennial fruit farm in MN with 1/4 acre of elderberries</i>
<i>As a fruit grower, growing orchard fruit, we also want to try the elderberry for market, medicine and income</i>
<i>Consider becoming a producer</i>
<i>Farmer, 3 years, 3 orchards</i>
<i>Have harvested and used for years personally, grows well in the area, looking for something to add value to the farm</i>

<i>I am interested in growing elderberries and have been preparing my farm for planting a few years ago. I attended Terry Durham's workshop at his farm and now, I am here to learn as much as I can and network with other growers, researchers, and industry representatives.</i>
<i>I am interested in planting 10-30 acres for commercial production</i>
<i>I hope to learn more about growing elderberries in MO.</i>
<i>Just purchased a small farm south of Belle Mo. Interested in growing if not too capital intensive</i>
<i>Used wild elderberries for jellies, juice, pies. Interested in growing elderberry commercially</i>
<i>We farm for human health, so all aspects of all products supporting or enhancing human wellness are of extreme value to us</i>
<i>We plan to start an elderberry farm</i>
<i>Would like to grow elderberry mostly for health reasons</i>
<i>My interest grows rapidly as I learn more - both science and growing aspects</i>
<i>Made wine, made selections of plants from the wild</i>

After the workshop, we asked: Has your interest in elderberry changed in any way after participating in this workshop? How? What are your plans regarding elderberry?

Many respondents increased their interest in elderberry as a result of the workshop (75%). According with their initial involvement, most plan to expand and pursue commercial production, to add or expand production of value added products while others plan to get started.

<i>Still figuring out the plan</i>
<i>Unsure, probably increase number of plants</i>
<i>Continue to develop my knowledge of elderberry</i>
<i>Try to plant 1/2 - 1 acre to start</i>
<i>Planting 1-2 acres</i>
<i>Expanding planting. Currently at 1/2 acres. Eventually 2-3 acres</i>
<i>Plant 4-5 acres plus process fruit</i>
<i>More research, and planting</i>
<i>Begin growing commercially</i>
<i>Begin harvesting, search for superior wild types</i>
<i>Complete evaluation to decide on scale</i>
<i>Hope to establish orchard of cider apples and elderberries</i>
<i>Continue</i>
<i>Continue to grow growing operation</i>
<i>Continue to plant up to 12 acres</i>
<i>Continue with original plans but some changes based on info from this symposium</i>
<i>Grow</i>
<i>Grow broader and deeper</i>
<i>Growing</i>

<i>I want to do more</i>
<i>Improve product manufacturing &amp; packaging &amp; thinking about how to improve relations with growers in order to meet GAP requirements</i>
<i>My interests are towards flowers and what they can contribute to health market</i>
<i>Plant more</i>
<i>Possibly expand</i>
<i>Produce more plants for sale, produce ag. bulletin for distribution nationally</i>
<i>Production</i>
<i>Raise for production, research more on flower use</i>
<i>25 acres, de-stemming and freezing, producing wine</i>
<i>Still high. Continue to expand our growing operation to 15 acres over the next 3 years.</i>
<i>Strengthened. Expand production, plant Marge</i>
<i>To begin growing next year</i>
<i>To eliminate some of my varieties in my plantation &amp; re-plant with varieties I've learned of here.</i>

In conclusion, the Producers Forum set of workshops, held as part of the First International Elderberry Symposium was very successful. The event strengthened communication among people interested in elderberry production, among them and established producers and among them and researchers. The scientific and international perspective added a lot to the forum. There was a significant gain in knowledge that improved the understanding of the design and application of elderberry production and marketing. The workshop helped advance towards adoption of elderberry as a profitable crop across Missouri and the U.S.

The participants' comments and recommendations are a valuable resource for improving future efforts in organizing similar events and for increasing farmers' awareness, acceptance and adoption of elderberry as a profitable crop.

**Project 6: Increasing Sales and Distribution of Specialty Crops through Columbia Farmers' Market**

**Columbia Farmers Market**

Corrina Smith  
Final Performance Report

**Project Summary**

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Since the Columbia Farmers Market first began in 1980 it has received popular support and has rapidly grown into a much larger market of approximately 90 vendors. With 2 outdoor locations and 1 indoor winter location the market offers local specialty crops to the community 50 weeks through the year. In

accordance with the mission of the farmers market to, “provide the local farmer and consumer a reliable, regulated marketplace for the exchange of high quality and safe food... while encouraging sustainable agriculture in mid-Missouri,” and the continued demand for local food products, the Columbia Farmers Market has developed this project to 1) increase the presence of locally grown specialty crops at multiple locations throughout the City of Columbia and 2) provide customers the opportunity to taste specialty crops while they are in season, thus boosting sales of those crops.

An important issue for us was the lack of public awareness about the presence and location of local food markets which has affected the sale of our farmers’ specialty crops. In addition, we see that consumers are often unaware of the nutritional and culinary potentials of fresh produce, its variety and qualities. Based on current trends, we sought to meet the community’s needs for better health through healthy eating of fresh, whole foods, broadening their experiences by exposing them to new vegetables and fruits and the various ways to prepare them.

### Project Approach

Funds received for this project were used to develop an advertising campaign for the Columbia Farmers Market. Working with the Columbia City Transit, we purchased a ‘bus wrap’ on a Columbia city bus in order to advertise the times and locations of CFM at different locations and display specialty crops. The City of Columbia was very supportive of the advertisements and they certainly raised awareness about the Columbia Farmers Market in the community. This wrap was to end on November 15, 2012 however the City continued running it for free through the summer of 2013. The advertisement campaign on the city buses was a huge success.

While it was difficult to track if customers were coming to the Columbia Farmers Market because of these advertisements, we did see an increase in customer counts while the bus wraps were in place. The bus advertisements had a picture of a Missouri EBT card as well as the statement, “We accept SNAP and Debit cards at all locations”. CFM saw over a \$15,000 increase in SNAP swipes from 2012 to 2013. The table below shows the increase from 2012 to 2013. In 2013 the Columbia Farmers Market dispensed \$37,902 SNAP tokens! Our partner organization Sustainable Farms and Communities (SF&C) runs a match program called Access to Healthy Foods (AHF) for any SNAP recipient with children under the age of 10 (up to \$25 each week per family). This program was so successful that AHF had to put the program on hold during the winter months to raise more money for the 2014 season.

**2012 and 2013 SNAP Swipes and SNAP Match through Access to Healthy Foods (AHF)**

	<b>2012</b>	
	<b>SNAP swipes</b>	<b>AHF Match</b>
January	\$ 207.00	\$ -
February	\$ 145.00	\$ -
March	\$ 339.00	\$ 55.00
April	\$ 829.00	\$ 255.00
May	\$ 1,923.50	\$ 510.00
June	\$ 2,060.00	\$ 921.00
July	\$ 1,829.00	\$ 815.00
August	\$ 2,679.00	\$ 1,207.00
September	\$ 2,457.00	\$ 1,589.00
October	\$ 1,264.00	\$ 907.00
November	\$ 783.00	\$ 580.00
December	\$ 647.00	\$ 480.00
<b>2012 Totals</b>	<b>\$ 15,162.50</b>	<b>\$ 7,319.00</b>
Total SNAP Dollars dispensed at Columbia Farmers Market in 2012 <b>\$ 22,481.50</b>		

	<b>2013</b>	
	<b>SNAP swipes</b>	<b>AHF Match</b>
January	\$ 645.00	\$ 424.00
February	\$ 454.00	\$ 350.00
March	\$ 749.00	\$ 644.00
April	\$ 1,565.00	\$ 960.00
May	\$ 2,365.00	\$ 1,553.00
June	\$ 2,611.00	\$ 1,888.00
July	\$ 3,495.00	\$ 2,605.00
August	\$ 4,081.00	\$ 2,605.00
September	\$ 2,861.00	\$ 2,147.00
October	\$ 1,986.00	\$ 1,930.00
November	\$ 889.00	\$ 242.00
December	\$ 853.00	\$ -
<b>2013 Totals</b>	<b>\$ 22,554.00</b>	<b>\$ 15,348.00</b>
Total SNAP Dollars dispensed at Columbia Farmers Market in 2013 <b>\$ 37,902.00</b>		

As well, project funds were used to procure portable hand washing stations used at designated local food sampling stations at market. Market employees collected specialty crop donations from various CFM vendors and used them in demonstrations and samplings at market. Specialty crops such as tomatoes, cucumbers, cantaloupe, kohlrabi, apples, peppers, persimmons, sweet potatoes, strawberry and blackberries were donated from vendors for sampling. The samples dispersed to customers were beneficial to customers and vendors. Many customers tasted items that they had never heard of before; such as kohlrabi, which resulted in the increased purchasing of them from vendors that donated such items.

Customer counts were taken for all markets to estimate the amount of people exposed to our specialty crop samplings. The table below shows the increases over the last three years. The highest count during the 2013 summer season reached 5238 on September 14<sup>th</sup>. While we did not reach the goal of 6,500 customers on Saturdays, we are very satisfied with this increase in customers.

<u>Year</u>	<u>Opening Day</u>	<u>3<sup>rd</sup> Saturday</u>	<u>28<sup>th</sup> Saturday</u>
2013	1334	1338	5238
2012	900	1250	1890
2011	400	600	1200

With the purchase of the portable hand washing stations, sampling of specialty crops at market were possible. Through this sampling CFM was able to increase the competitiveness of specialty crops at market. Customers and vendors reported that because of the sampling new and different specialty crops, more specialty crops were purchased and sold. In addition to ensure the competitiveness of specialty crops at CFM only specialty crops were sampled.

By working with Transit Advertising, CFM was able to create a bus wrap that focused on specialty crops and the service offered at CFM to swipe SNAP cards. There were not any non-specialty crops displayed on the bus wraps ensuring that only specialty crops were being promoted. During the time period that the specialty crop bus wrap advertisements were displayed, CFM's customer counts and SNAP card swipes increased. Because of this increase of customers, more specialty crops were sold by CFM vendors at market.

## **Goals & Outcomes Achieved**

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Goal 1, 2, 3: CFM worked with the City of Columbia to develop a six month advertising schedule with the Columbia public bus service, and contracted with Transit Advertising, Inc. to create artwork displaying specialty crops on the bus wrap. The bus wrap advertisements displayed the Columbia Farmers Market logo, featured specialty crops, and a picture of a SNAP card stating that we accept SNAP and debit cards. The advertisements ran from April to November 2012. The customer counts were completed at each market. The highest Saturday market count occurred during the 2013 summer season reaching 5238 on September 14<sup>th</sup>. The original baseline was 4000 customers and the goal was 6500 customers. CFM did not quite reach the goal, but saw this increase as a success. The most customers we saw at a Wednesday market was 900 in the summer of 2013. The original baseline was 500 customers and the goal was to reach 1100. Again, we did not quite reach the goal, but saw this increase as a success. CFM's vendors rarely attended the Monday and Friday markets, making it difficult for CFM to continue having them. In 2013 the Friday market was permanently cancelled. The Monday market occurs on a week by week basis depending on vendor's attendance.

Goal 4: In 2011, CFM began operating a satellite market on Thursdays located in the parking lot of the

Forum Christian Church. This market has continued to be a successful location featuring specialty crops and sampling. This location was one of the routes served by the Specialty Crops bus during the 2012 market season. CFM saw an average of 100 customers each week with a maximum of 200 customers attend the Thursday market. With it being in its 3<sup>rd</sup> year, CFM determined this amount of customers attending a success. The Thursday market location has a bathroom with a sink on sight, therefore there was no need for one of the two hand washing stations to be moved there each Thursday. Samplings were done at this location. In late 2011, CFM had started a fourth weekday satellite market on Fridays. By the 2013 season, we found this market to be unsuccessful. It spread our weekday vendors out too thin and wasn't viable. In addition, CFM decided it was important to focus on and grow the already established weekday markets.

The use of SNAP benefits increased at our satellite markets; with an average of four people per market purchasing tokens. In 2013 CFM dispersed \$933 SNAP tokens between the Wednesday and Thursday weekday markets. Reports from the farmers selling at the South Columbia Thursday market have stated that it is one of the most lucrative markets for them, although not many SNAP transactions have taken place there.

Goal 5: Two hand washing stations and six hoses were purchased in order to perform market samplings of specialty crops from local vendors at the market. Each week a market employee would set up a table in the center aisle to distribute specialty crop samples to customers. At this location customers had immediate access to one of the two hand washing stations. In addition to sampling local food, market employees developed a new 'Vendor of the Week' program to highlight the local growers as well as specialty crops. Vendors selling these items donated produce to be used for market sampling. The program was considered a success by both the customers and vendors so it will be continued for next year supported by the vendors and volunteers of the Columbia Farmers Market. Some of the most popular products sampled were kohlrabi, persimmons, apples, cantaloupe, tomatoes and honey. All vendors reported increased sales and positive customer anecdotes about product samples when featured as the 'Vendor of the Week.'

Goal 6: CFM successfully completed specialty crop grant 12-25-B-1078 by promoting specialty crops at the indoor winter market location and the Winter Market Kick-Off while reinforcing the message of the market's ability to accept SNAP benefits.

CFM was unable to update interior ads due to inconsistent personal at CFM. The exterior ads that were displayed on the bus were not needed to be updated as the ad showcased a wide selection of specialty crops that could be found year round at CFM. Transit Advertising ran the bus wrap for free for the following 2013 market season.

## **Beneficiaries**

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There were several groups that benefited from the project's accomplishments. Customers at market were introduced to specialty crops through sampling and gained from learning the various ways to prepare and cook these fruits and vegetables. On the community level, the bus advertising program increased the general awareness of the farmers market and its ability to accept EBT/SNAP. Although the benefits didn't surface in 2012, we saw over a \$15,000 increase of EBT transaction in 2013. In turn, the growth of EBT transactions and customer attendance at market has affected the CFM vendors who have benefited from increased sales at market.

In addition, the project helped benefit SF&C and foster the continued development of their program AHF. In 2012, SF&C reported that the number of families doubled from the previous year. There were 93 families enrolled in 2012, increasing to 120 families in 2013. From 2012 to 2013 there was a net increase

of \$8029 tokens matched for AHF. The program became so successful that SF&C ran out of funds for 2013's winter market. However, through their own fundraising efforts they have acquired enough funds to continue the program in March of 2014. The overall growth of their program stems from this project's successes. However no SCBGP funds were used to fund this program.

## **Lessons Learned**

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CFM has learned that in order to execute long term, multiple year projects such as this grant, they need to have more continuity with its staff and Board members. The turnover in Columbia Farmers Market staff and Board Members has created a situation where maintaining consistency executing, tracking and reporting the activities of the grant was challenging. However, with the help of the new market manager, we have recovered much of the ground lost during these transitions. The Columbia Farmers Market staff and its Board Members are committed to working with the market vendors to help the organization be successful.

Transit System stated they had a graphic design department that would be able to produce any ads we wanted on the bus. Unfortunately the graphic design person was very hard to work with, unable to produce different examples, and caused frustration on our end. However, by being extremely persistent CFM was able to get the ad that satisfies the Market's needs. In addition, the Transit System kept the ad on the bus for the 2013 market season for free.

In regard to the grant's activities, we have found that doing customer counts has been a valuable means of tracking our customer base. It has helped us determine some of the factors that influence attendance, like weather, college events and what's at market. Through advertising with the city's transportation system, we have learned that sometimes traditional advertising and simple exposure isn't sufficient to increase our customer base. Therefore we have diversified our promotion program by creating a Facebook, Twitter and Flickr page as well as redesigning our web page to be more interactive. We also have advertised on both the radio and TV, which allow for more communication than a moving bus. Through feedback from customers and monitoring our online traffic, we have already experienced significant improvement in these efforts.

As for the sampling of specialty crops at market, we found it to be an enjoyable and interactive event for customers that promoted their involvement with the market. The program was an effective means of helping increase market sales of specialty crops, as well as promoting awareness of their diverse uses. From seeing and tasting the samples, customers were able to make connections between vendors at market, the whole foods they sold and a finished, delicious product ready to eat. CFM will be able to continue offering samples at market through the help of volunteers found through our newly developed volunteer recruitment system.

CFM found that having five markets a week (Monday, Wednesday, Thursday, Friday and Saturday) in addition to two other markets in Columbia wasn't viable. CFM's vendors rarely attended the Monday and Friday markets, making it difficult for CFM to continue having them. In 2013 the Friday market was permanently cancelled. The Monday market occurs on a week by week basis depending on vendor's attendance.

## **Contact Information**

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## Additional Information

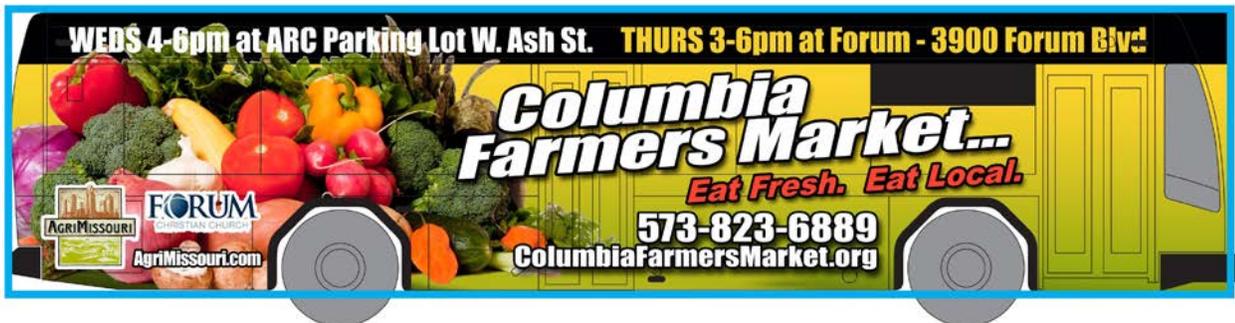
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Each "Vendor Spotlight" that was done is on our website. To view the stories visit <http://columbiafarmersmarket.org/blog/vendor-spotlight/>.

Included are the designs for the bus wraps.







**Project 7: Biology and Behavior of the Black Walnut Curculio**

**University of Missouri, Center for Agroforestry**  
 Dr. W. Terrell Stamps and Dr. Bruce A. Barrett  
 Final Performance Report

## Project Summary

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Missouri is an important nut producing state, supplying the industry with over 15 million pounds of black walnuts annually. The University of Missouri Center for Agroforestry wants to establish 1,000 acres of nut-producing black walnut orchards in Missouri by 2025. While a plantation environment has the potential to produce a large nut crop, it also has the potential to intensify pest problems. The black walnut curculio, *Conotrachelus retentus*, is the most important pest, with annual nut loss at times reaching 32% of the nut crop. The overall goal of our proposal was to examine the attraction of curculios both to plant volatiles and to possible sex pheromones to determine whether potential exists for the development of monitoring programs utilizing the volatiles for pest management.

Our specific objectives were to: (1) Evaluate adult curculio behavioral response to walnut plant parts and volatile organic components (VOCs) through laboratory bioassays, (2) Evaluate curculio physiological response to plant parts and VOCs through electroantennography, (3) Evaluate adult curculio behavioral response to curculio volatiles through laboratory bioassays, (4) Evaluate curculio physiological response to curculio volatiles through electroantennography.

This project is necessary because no IPM program currently exists for walnut pests in the Midwest and identifying attractive volatiles for this pest will provide a starting point for developing traps.

## Project Approach

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We have made progress towards the above goals in the following manner:

In the first year, approximately 250 weevils were collected in the field from the end of April 2012 through the beginning of June 2012. The second year, few weevils were collected and hampered the experimental design. Nut weevil populations can be cyclic, alternating years of high and low population numbers. Of the insects collected, adult weevils were sexed, separated by sex into rearing cups and provided food and water. The ratio of males to females was roughly 1:1. Walnut fruits (developing fruits with female flowers), catkins (male flowers), and leaves were collected throughout the assay period and stored in a cold chamber until used in experiments.

- 1) Walnut curculio behavioral response to plant tissues. A series of Y-tube olfactometer experiments were carried out using the walnut plant tissues. The experiment was a repeated complete block design with every combination of leaf, catkin, flower, and empty control tested against each other. A minimum of 20 weevils, both males and females, per treatment were tested for each combination. Males and females were not significantly different in their response to the plant tissues and there was not a significant sex-choice interaction. There were significant differences in the insects' attraction to the various plant parts, but no clear pattern (Table 1). The odds of a weevil going to catkins or the control over fruits was ca. 4 to 1, but the odds of a weevil going to the catkins or the control over leaves was ca. 2.5 to 1. The odds were 1:1 of a weevil choosing catkins over the control.
- 2) Walnut curculio physiological response to plant tissues. Experiments involving the electrophysiological response of the weevil determined with electroantennography (EAG) were initiated. EAG response was determined for fruits, catkins, and leaves for both male and female antennae. Initial testing to determine proper concentrations of volatiles as well as perfecting techniques for antennal removal and mounting reduced the pool of available insects initially. Over 70 individuals of each sex were tested. Measurement of depolarization peaks and data analysis is ongoing. Figure 1 is a typical EAG response graph.

## **Goals & Outcomes Achieved**

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The first objective, weevil behavioral response to plant tissues largely has been met. Difficulties encountered with degradation of plant tissues over time, low numbers of insects in the second year, determining proper plant volatile extraction concentrations over time, and loss of employees due to lack of salary, precluded us from performing VOC testing.

The second objective, weevil physiological response to plant tissues, is ongoing and will require many more experiments and weevils to complete. The first round of EAG experiments has been completed, though the data analysis is ongoing, though more data is needed.

The third and fourth objectives, weevil behavioral and physiological response to weevil volatiles, were not addressed due to the same reasons as stated in the above paragraph: namely lack of insects, time and personnel.

Though all objectives were not met, a great deal of information was gathered and will provide a strong basis for further investigation in this area of study.

## **Beneficiaries**

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The beneficiaries of this study include researchers as well as growers. Researchers in the area of nut pests as well as those in the broader area of insect behavior and electrophysiological responses in insects will benefit from the knowledge provide about the walnut curculio. Researchers will also benefit from the technical knowledge gained in determining best techniques for conducting experiments with weevils, especially EAG techniques. Preliminary results from the above objectives have been presented at the Annual Entomological Society Meeting in Knoxville, TN, in November 2012. Growers will benefit from the knowledge of what attracts the weevils to nut trees and inform them as to the best times and areas to look for these pests. Both behavioral and preliminary physiological data suggest catkins are highly attractive to weevils and thus may be the best target for pest control measures.

Dr. Terrell Stamps is no longer with the University of Missouri and Dr. Bruce Barrett is his replacement. Dr. Stamps has yet to respond to Dr. Barrett's request for the information. At this time, Dr. Barrett does not have the information to provide a quantification of the beneficiaries affected by the implementation of this project and/or a potential economic impact of the project.

The data from the project was primarily presented/reported as poster presentations given at scientific and professional meetings. The number of participants at these meetings who actually read the posters or listened to talks is unknown. However, we estimate the total number of people at such meetings that were interested in the data to be about 100-200 people; this is the total over the course of the project.

## **Lessons Learned**

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One of the many lessons learned is that field sourced insects for laboratory experiments can be difficult in providing consistent subjects for experimentation. The cyclic nature of weevil populations over years as well as the labor intensive methods of collection can limit progress towards goals. Unfortunately, lab rearing techniques have not been developed for nut weevils and researchers are at the mercy of the wild populations. Timing factors into getting consistent results as well. Delicate plant tissues such as catkins degrade quickly in a lab setting and are available for only a short period of time on trees; consequently experiments involving these tissues are limited. Another factor that limited this study was the lack of

funds to cover the personnel. The labor involved in studies such as this require more personnel hours than are allowed in the grant budget structure.

## Contact Information

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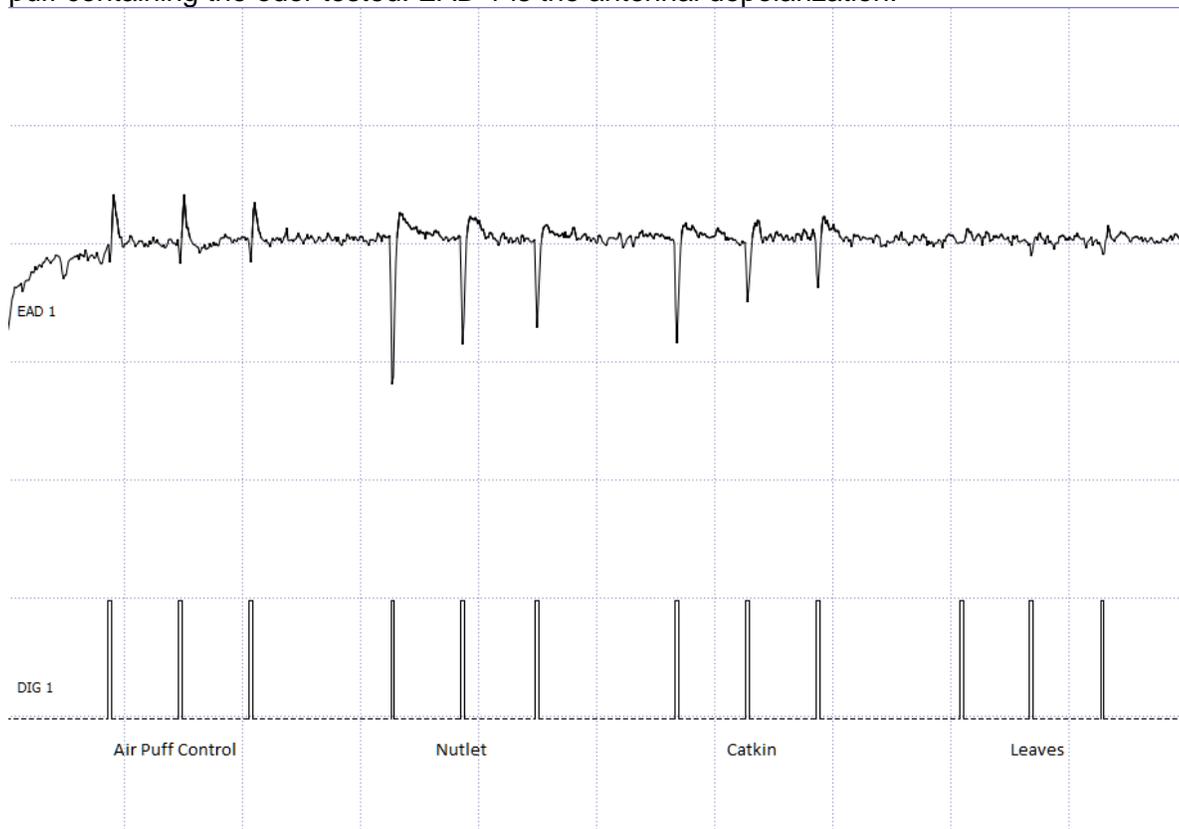
## Additional Information

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**Table 1.** Black walnut curculio response to plant tissue odors in a Y-tube olfactometer.  
 \*Indicates significant odds ratio for the two plant tissues tested.

Outcome	DF	t value	Pr > t	Odds ratio
Catkins vs Control	6	-0.18	0.8622	0.95:1
Catkins vs Fruits	6	4.36	0.0048*	3.85:1
Catkins vs Leaves	6	3.00	0.0240*	2.48:1
Control vs Fruits	6	4.50	0.0041*	4.06:1
Control vs Leaves	6	3.16	0.0196*	2.62:1
Fruits vs Leaves	6	-1.42	0.2043	0.65:1

**Figure 1.** EAG response of female weevil antennae to fruits, catkins, and leaves. DIG indicates the air puff containing the odor tested. EAD 1 is the antennal depolarization.



## **Project 8: The 2012 Missouri Blueberry School and Workshops**

**University of Missouri Extension**, Southwest Research Center

Patrick Byers

Final Performance Report

### **Project Summary**

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Commercial blueberry production is a recent development in Missouri (since the 1970's), and the industry's development to date is the result of a coordinated effort on the part of farmers, extension workers, and researchers. Missouri currently has a small (217 acres) blueberry industry that is focused on direct market sales of fresh fruit. The vast majority of blueberries consumed in Missouri, whether fresh or processed, are grown outside the state. While Missouri has the resources and population base to support an expanded blueberry industry, coordinated outreach activities directed to blueberry farmers are sadly lacking.

The current Missouri Blueberry School was built on an initial effort to address the above-mentioned dearth of coordinated outreach to Missouri's blueberry industry, which was a two-day workshop for blueberry growers that took place in October 2011. The Missouri Blueberry Council has expressed support for this effort and provided initial seed funding, as did several commercial blueberry producers. The Missouri Blueberry School and Workshops expanded on this initial effort and offered a comprehensive outreach opportunity for Missouri blueberry farmers, marketers, and consumers. In-depth educational sessions and tours of successful blueberry farms were the features in the Blueberry School. The Workshops stressed hands-on experiential learning onsite at blueberry farms. While the Blueberry School and Workshops focused on Missouri, interest from blueberry growers in neighboring states indicated a potential for multi-state participation in the future.

The Missouri Blueberry School was a new initiative, and did not build on previously completed work funded with the SCBGP.

### **Project Approach**

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Activities performed:

2012 Winter Management Workshop, which was held March 3, 2012. The workshop was held at The Berry Patch, the farm of Tom and Penny Willis near Cleveland, MO. The workshop attracted 26 attendees. Workshop topics included planting design, irrigation, and pruning. Impact survey results are included in the quarterly report and summarized below.

2012 Spring/Summer Management Workshop, which was held June 2, 2012. The workshop was held at Highland Blueberry Farm, the farm of Bob and Ronnie Hershey near Perryville, MO. The workshop attracted 28 attendees. Workshop topics included site selection, planting establishment, irrigation, harvest management, and marketing. Impact survey results are included in the quarterly report and summarized below.

2012 Missouri Blueberry School Fall Conference, which was held October 19-20, 2012. The conference was held in Springfield, MO. Attendance was 61 for the October 19 educational sessions, and 41 for the tour on October 20. Conference topics included establishing a blueberry farm, evaluating soils for blueberry production, overview of blueberry diseases, a blueberry disease management plan,

postharvest management of blueberry, brown marmorated stink bug and spotted wing drosophila, examination of blueberry startup costs, design considerations for drip irrigation, and growing a blueberry business.

2013 Winter Blueberry Management Workshop, which was held March 1, 2013. The workshop was held at Lost Branch Blueberry Farm, Kirksville, MO. The workshop attracted 23 attendees. Workshop topics included food safety, weed control, disease management, pruning, and companion crops. Impact survey results are included in the quarterly report and summarized below.

The Missouri Blueberry School is a collaboration among blueberry specialists with the University of Missouri, Missouri State University, and the Missouri Department of Agriculture. The planning committee consisted of Gordon Carriker (MU), Jay Chism (MU), Ed Browning (MU), Martin Kaps (MSU), John Avery (MSU), and Ben Fuqua (MSU). All planning committee members contributed significantly to the project with subject matter expertise, experience with the Missouri blueberry industry, and logistical support. Additional project partners included the Missouri Blueberry Council (funding and program suggestions) and Missouri blueberry producers (hosts of on-farm workshops and funding). Several speakers of national stature participated in the two day conference.

## **Goals & Outcomes Achieved**

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Completed activities:

- 2012 Winter Management Workshop, which was held March 3, 2012.
- 2012 Spring/Summer Management Workshop, which was held June 2, 2012.
- 2012 Missouri Blueberry School Fall Conference, which was held October 19-20, 2012.
- 2013 Winter Blueberry Management Workshop, which was held March 1, 2013.

While we are planning to conduct a long-term impact survey, this information is not available at the present time.

The Missouri Blueberry School activities have met the goals established for the reporting period (the 4 conferences and workshops), with the exception of long term impact survey results.

Comprehensive impact and outcome survey data are available. Below is a summary of these data.

2012 Winter Management Workshop - When asked to consider the program as a whole, the attendees who responded to the survey (n=26) reported an average knowledge gain of 3.50 on a 1-4 Likert scale, with 4=great deal of knowledge gain. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: blueberry irrigation system design, 1.04; blueberry irrigation system maintenance, 0.92; acid injection to modify irrigation water pH, 1.23; pruning young blueberry bushes, 1.38; and pruning mature blueberry bushes, 1.35. Following the program, attendees reported confidence in understanding these topics at a considerable level, 26% a moderate level, 63%, or a minimal level, 11%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following actions were planned within the next 6 months: establish a blueberry enterprise on my farm, 48%; install an irrigation system on existing blueberries, 48%; use new (or different) irrigation management on existing blueberries, 60%; and change the pruning techniques on my blueberry plants, 71%.

2012 Spring/Summer Management Workshop - When asked to consider the program as a whole, the attendees who responded to the survey (n=26) reported an average knowledge gain of 3.76 on a 1-4

Likert scale, with 4=great deal of knowledge gain. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: blueberry irrigation system design and maintenance, 1.43; choosing a site for blueberries, 1.33; blueberry site preparation and establishment, 1.57; and blueberry harvest management, 1.28. Following the program, attendees reported confidence in understanding these topics at a considerable level, 62% a moderate level, 37%, or a minimal level, 1%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following actions were planned within the next 6 months: establish a blueberry enterprise on my farm, 43%; install an irrigation system on existing blueberries, 24%; use new (or different) irrigation management on existing blueberries, 38%; and change the way that I manage blueberry harvest, 50%.

2012 Missouri Blueberry School Fall Conference - When asked to consider the program as a whole, the attendees who responded to the survey (n=30) reported an average knowledge gain of 3.11 on a 1-4 Likert scale, with 4=great deal of knowledge gain. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: establishing a blueberry farm, 0.41; evaluating blueberry soils, 0.41; understanding blueberry diseases, 0.98; developing a blueberry disease management plan, 0.93; postharvest management of blueberry plants, 0.85; brown marmorated stink bug, 1.45; spotted wing drosophila, 1.33; startup costs for a blueberry farm, 0.11; growing a blueberry business, 0.44; and design considerations for blueberry irrigation, 0.63. Following the program, attendees reported confidence in understanding these topics at a considerable level, 61% or a moderate level, 39%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following actions were planned within the next 6 months: establish a blueberry enterprise on my farm, 34%; use new (or different) nutrition management on existing blueberries, 54%; plant new cultivars of blueberries on my farm, 67%; adapt or implement irrigation systems for blueberries on my farm, 58%; and use a new technique for managing blueberry diseases on my farm, 81%.

2013 Winter Blueberry Management Workshop - When asked to consider the program as a whole, the attendees who responded to the survey (n=22) reported an average knowledge gain of 3.611 on a 1-4 Likert scale, with 4=great deal of knowledge gain. Attendees were surveyed on knowledge of workshop topics before and after the program, and average knowledge gain on a 1-4 Likert scale, with 4=considerable knowledge gain, was the following: Food safety concerns for blueberry growers, 0.850; Blueberry weed control, 1.092; Potential for small fruit production in Missouri, 1.304; Blueberry disease management, 1.340; and Blueberry pruning, 1.467. Blueberry pruning has scored a high level of knowledge gain in several evaluations of workshop focused on blueberry management practices. The overall knowledge gain was 2.211, a high reported knowledge gain across the workshop topics. Following the program, attendees reported confidence in understanding these topics at a considerable level, 44%, moderate level, 50%, or minimal level, 6%. The attendees who responded to the survey were asked to describe behavior change as a result of the program. The following actions were planned within the next 6 months: Establish a blueberry enterprise on my farm, 31% of respondents; Develop a food safety plan for my farm, 50%; Change the way that I control weeds in my blueberry planting, 69%; Change the pruning techniques on my blueberry plants, 92%; Add a new small fruit crop to my farm, 46%; and Develop a plan to manage diseases with my blueberry plants, 92%.

## **Beneficiaries**

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The Missouri Blueberry School activities directly benefited Missouri's commercial blueberry farmers. The project also raised the awareness of blueberry production as a viable alternative for produce farmers. In

addition, a diverse group of non-farmers benefited from the project – extension specialists, researchers, fruit processors, fruit marketers, and fruit consumers.

In total, the Missouri Blueberry School project directly impacted 179 individuals at the various conferences and workshops. We are preparing a 12 month survey to measure medium and long term impact of the project, which will include a measurement of economic impact. Anecdotally the project coordinators know of blueberry farmers who have stated that their farms have benefited from the information gathered during the Missouri Blueberry School activities. Several prospective producers have planted blueberries, and credit the information gathered during the Missouri Blueberry School as important to their success.

## **Lessons Learned**

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The Missouri Blueberry School project demonstrated the interest among Missouri blueberry producers for an ongoing, sustainable outreach program targeting issues of interest. Blueberries are a challenging crop to produce under Missouri conditions, and several issues of particular concern (such as insect and disease management) have gained visibility as a result of the project; these issues will become the focus of future blueberry programming. Blueberry producers value hands-on learning experiences, as evidenced by the impact evaluations, so this approach will be emphasized in future programming.

We did not experience any unexpected outcomes or results.

The goals of the project were met, with the exception of a measurement of long term impact. We expect to accomplish this goal during the next few months.

## **Contact Information**

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## **Project 9: The Kansas City Beans&Greens Mobile Market Program**

### **Menorah Legacy Foundation**

Gayla Brockman  
Final Performance Report

## **Project Summary**

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In the article “Opportunities to Reduce Childhood Hunger and Obesity - Restructuring the Supplemental Nutrition Assistance Program (the Food Stamp Program)” David S. Ludwig, MD, PhD, Susan J. Blumenthal, MD, MPA and Walter C. Willett, MD, DrPH, discuss the importance of good nutrition on optimal physical development and how many children from low-income families receiving Supplemental

Nutrition Assistance Program (SNAP) benefits do not consume adequate amounts of nutritious foods.<sup>2</sup> The highest rates of obesity are found in people with the lowest incomes. Among poor populations, 7 times as many children are obese as are underweight.<sup>3</sup> The causes of this are many. Low-income families are challenged in having dependable access to affordable, high-quality food. Low-income families often live in neighborhoods lacking full-service grocery stores. Fresh produce, if available, is more expensive and often of poorer quality in low-income neighborhoods. Traveling to better markets is expensive and often difficult. Additionally, families with limited financial resources may experience long-term, cyclical variation in food availability, with overconsumption at the beginning of the month after distribution of SNAP benefits followed by deprivation at the end of the month when benefits have been exhausted. At the same time, low-income families often try to stretch their food budgets by purchasing cheap, high-calorie foods that are filling but nutritionally low-quality. SNAP benefits can be used to purchase any food or beverage, except alcohol, tobacco, vitamins, and hot prepared items. Recent data indicate that, among low-income adults, SNAP participants have lower dietary quality than nonparticipants.<sup>4</sup> The public pays for sugary drinks, candy, and other junk foods included in SNAP benefits twice: once at the time of purchase, and later for the treatment of diet-induced disease through Medicaid and Medicare.<sup>5</sup> Obesity remains one of the leading causes of preventable death and illness in Kansas and Missouri. The obesity rates for Kansas and Missouri are 29.8% in Kansas and 29.6% in Missouri according to the 2013 America's Health Rankings report.

According to the USDA Economic Research Service Food Environment Atlas, the number of Americans using SNAP continues to rise from 40.3 million in 2010, to 44.7 million in 2011 to 46.6 million in 2012. Locally, SNAP participation rose from 15.7% in 2011 to 18% in 2012 in Jackson County, Missouri and from 10.41% in 2011 to 22% in 2012 in Wyandotte County, Kansas.

SNAP provides America's low-income population with resources to purchase food in an effort to alleviate hunger and improve nutritional status. In the 2012 report, *A Fresh Approach to Strengthening the Supplemental Nutrition Assistance Program*, from the Washington DC Center for the Study of the Presidency and Congress; the authors' site ten evidence-based strategies for improving nutrition for SNAP participants. These include the following:

1. Protect current funding levels for SNAP
2. Collect data on SNAP purchases.
3. Identify a set of integrated strategies that would help align SNAP purchases with the 2010 Dietary Guidelines for Americans.
4. Focus attention on children's health in SNAP
5. Use incentives to make fruits, vegetable, and whole grains the easy choice
6. Establish stronger food stocking standards for SNAP retailer
7. Provide states with flexibility to evaluate fresh approaches to SNAP
8. Promote innovation in SNAP
9. Create a partnership to move SNAP towards health.
10. Establish a national strategy of fresh approaches to strengthen SNAP.<sup>6</sup>

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<sup>2</sup> 1. Ludwig DS, Blumenthal SJ, Willett WC Opportunities to Reduce Childhood Hunger and Obesity. *JAMA*, December 26, 2012 – Vol. 308, No. 24.

<sup>3</sup> Coleman-Jensen A, Nord M, Andrews M, Carlson S. Household Food Security in the United States in 2011. Washington, DC; US Dept. of Agriculture; September 2012. Economic Research Service Report ERR-141. <http://www.ers.usda.gov/media/884525/err141.pdf>. Accessed December 3, 2012.

<sup>4</sup> Polhemus B, Dalenius K, Mackintosh H, Smith B, Grimmer-Strawn L. *Pediatric Nutrition Surveillance 2009 Report*. Atlanta, GA: US Dept of Health & Human Services, Centers for Disease Control and Prevention; 2011.

<sup>5</sup> Ludwig DS, Blumenthal SJ, Willett WC Opportunities to Reduce Childhood Hunger and Obesity. *JAMA*. December 26, 2012-Vol. 308, No. 24

<sup>6</sup> Blumenthal SJ, Hoffnagle E, Willet W, et al *SNAP to Health: A Fresh Approach to Strengthening the Supplemental Nutrition Assistance Program*. 2012 Washington DC: Center for the Study of the Presidency and Congress; July 2012.

[http://www.thepresidency.org/storage/documents/CSPP\\_SNAP\\_Report.pdf](http://www.thepresidency.org/storage/documents/CSPP_SNAP_Report.pdf).

The Kansas City Beans&Greens Program is addressing eight of the ten strategies through its innovative incentives, supportive program design, nutrition education and cooking demonstrations and community and state mobilization activities.

In 2010, the Menorah Legacy Foundation launched the Kansas City Beans&Greens Program to address the lack of access and lack of affordability of fresh, nutrient-rich foods in low-income neighborhoods. Beans&Greens matches food assistance benefits - such as Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI) and Senior Farmers Market Nutrition Program (SFMNP) - dollar-for-dollar at twenty (20) participating farmers' markets in Jackson and Clay Counties in Missouri and Douglas, Johnson and Wyandotte Counties in Kansas. The participating markets are provided with the technology to accept the food assistance debit card, program support for staffing and administration and nutrition education and cooking demonstrations.

In 2011, the Beans&Greens launched the Mobile Market Program to reduce the barrier of access to fresh, specialty crop produce to low-income, food desert communities. By bringing the market to these communities, and using the Cooking Corps to teach them about healthy eating and cooking, we are increasing the likelihood that buying fresh, healthy produce is the easy choice for low-income families and one with which they can make into a regular, weekly habit.

Of the 24 farmers markets and mobile market sites participating in the Beans&Greens program, 17 sell only fruits and vegetables. Therefore, the majority of our sales tracking numbers are reflecting sales of fresh fruits and vegetables.

Each year the Beans&Greens staff conducts customer surveys. Each year our returning customers as compared to new customers consistently indicate the following reasons for returning to the Beans&Greens participating farmers markets:

Customers reported higher mean scores for questions regarding:

- ▶ enjoyment of fruits and vegetables
- ▶ child enjoyment of fruits and vegetables
- ▶ knowledge of preparation techniques for fruits and vegetables
- ▶ knowledge that fruits and vegetables are beneficial for one's health
- ▶ affordability of fruits and vegetables

Customers already reported that their average weekly intake of fruits and vegetables was **higher** for repeat Beans&Greens users.

In addition, Beans&Greens is able to track SNAP reimbursements by individual farmer at some of our markets. This data over time clearly demonstrates how Beans&Greens is important for specialty crops. In 2009, before Beans&Greens was launched, farmers who sell at the City Market in downtown Kansas City, Missouri began to accept the SNAP EBT card. That year **produce** farmers were reimbursed a total of \$4,459.22 for SNAP purchases. In 2010, the KC Beans&Greens Program was launched and SNAP reimbursements for produce farmers increased to \$35,748.14. In 2011, SNAP reimbursement for produce farmers increased to \$65,618.16 and in 2012 SNAP reimbursements rose to \$100,186.53. That is a dramatic rise in sales that occurred immediately with the launching of Beans&Greens and has continued since.

Additionally, farmers continue to ask us each year to survey our customers for their fruit and vegetable preferences so that they may attract SNAP customers to their stalls.

## Project Approach

The Beans and Greens staff focused on the following activities:

Project Activity	Who	Outcome
Assess previous season EBT sales and match data for all participating farmers markets and mobile market & survey data	Beans&Greens Program Manager, Mobile Market Manager, Beans&Greens partners, volunteers	Increased number of stops from 3 weekly to 9 weekly or bi-weekly stops. On Tuesdays and Wednesdays we would go to stops every other week in an effort to respond to increase demand from low-income communities
Schedule meetings with neighborhood partners to de-brief 2011 project, plan and adjust for 2012	Mobile Market Manager, Beans&Greens staff, neighborhood partners	Community members become engaged in the project and assist with site set-up and take-down, promotion and community outreach.
Debrief/Renew purchase agreements with farmer suppliers for 2012	Mobile Market Manager, local growers	Increased number of area farmers to regularly provide produce to the Mobile Market
Review previous season cooking demonstrations and schedule and determine schedule for 2012	Mobile Market Manager, University of Missouri and Kansas State Extension educators and volunteers	Expanded number of cooking demonstrations to farmers markets and mobile market sites from 17 to 36 visits impacting 7,000 customers throughout the season.
Commence marketing, outreach for 2012, including fliers to agencies, signs, social media, radio advertising, etc. Have all materials translated into Spanish	Mobile Market Coordinator, Beans&Greens staff and translator	Created ads for newspapers. Saw spike in sales when ads came out.
Commence weekly sales routes and analyze sales data	Mobile Market Coordinator, assistant, volunteers and Beans&Greens consultant	Sales rose slightly in the 2012 season as compared to 2011.

- Indicate how you ensured that Specialty Crop Block Grant Program funds were used to solely enhance the competitiveness of specialty crops.

Specialty Crop Block Grant Program funds were SOLELY used to enhance the competitiveness of specialty crops because, as mentioned above, the majority of our markets sold only fruits and vegetables. We were able to secure funding for the sale and promotion of locally grown meat and eggs by other funders.

Update Food Desert map to target two more staff, neighborhoods for 2012

- In 2012, we added four new mobile market sites – 3 in Jackson County, Missouri and one in Wyandotte County, Kansas. These sites were specifically located in designated food deserts where there was limited if no access to fresh fruit and vegetables.

Initiate meetings, selection of additional neighborhood routes in KCMO

- Requests were reviewed and meetings were set up in the Beacon Hill neighborhood, at Operation Breakthrough and at the Thomas Roque Head Start Program.

Complete permits, licenses, insurance for 2012 operations.

- During the grant period we completed the annual truck inspection and registration, renewed the liability insurance policy, and renewed the egg license and staff went through an annual workers compensation physical exam.
- Conduct resource allocation assessment to accommodate expansion and respond as needed.
- Conduct consumer surveys.
- Students were hired to conduct annual customer and farmer surveys at participating markets and at the mobile market sites. More details were provided in the Project Summary section.

## Goals & Outcomes Achieved

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There were three main outcomes as a result of these activities:

### Outcome 1:

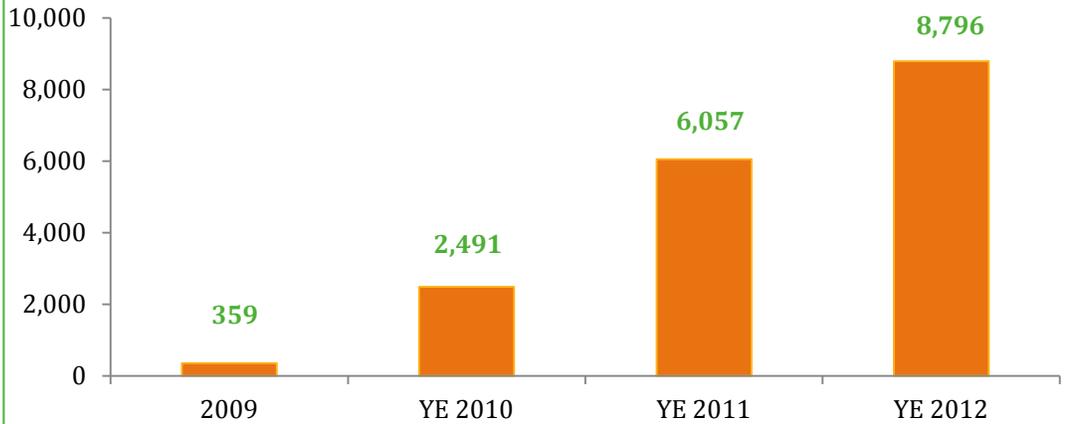
Increase access to fresh, locally grown fruits and vegetables for Kansas City residents who receive food stamps and who live in neighborhoods that do not have either grocery stores or farmers' markets within 1.5 miles. A "Food Desert Map" completed by the Mid-America Regional Council, the KC Center for Urban Agriculture and Beans&Greens shows the locations of existing stores/markets relative to large populations of food stamp recipients. The map is used to select neighborhoods to be served by the Beans&Greens Mobile Market. Three target neighborhoods have been selected for 2011 and up to five neighborhoods will be selected in 2012. Electronic Benefits Transfer (EBT) transactions are analyzed to capture data regarding the purchasing habits of food stamp recipients in order to determine the number of low-income persons served by the Mobile Market and whether it is serving its target population.

In 2012, the Mobile Market added six new locations – three in Wyandotte County, Kansas and three stops in Jackson County, Missouri. The three new locations in Jackson County along with the original sites are:

- 1) The Kansas City Health Department, 3200 Wayne, KC, MO 64109 – NEW – 2<sup>nd</sup> and 4<sup>th</sup> Friday morning
- 2) Operation Breakthrough – a child development center at 3039 Troost, KC, MO 64109 – NEW – 2<sup>nd</sup> and 4<sup>th</sup> Wednesday afternoon
- 3) Thomas Roque Head Start – 3800 East 51<sup>st</sup> Street, KC, MO 64130-NEW- 2<sup>nd</sup> and 4<sup>th</sup> Tuesday afternoon
- 4) Marlborough – 8401 Euclid, KC, MO 64132 – ORIGINAL – every Thursday
- 5) Guadalupe Center – 1015 Avenida Cesar E Chavez, KC, MO 64108 ORIGINAL-every Saturday
- 6) Argentine Community – 1404 S. 29<sup>th</sup> St, KC, KS 66106 – ORIGINAL – every Sunday
- 7) Catholic Charities – 2220 Central, KC, KS 66102 – NEW – 1<sup>st</sup> and 3<sup>rd</sup> Tuesday morning
- 8) KCK Housing Authority – 1124 N. 9<sup>th</sup> St, KC, KS 66106 – NEW – 1<sup>st</sup> and 3<sup>rd</sup> Wednesday morning
- 9) Wyandotte County – 42 and Mission, KC, KS 66101 – NEW – 1<sup>st</sup> and 3<sup>rd</sup> Wednesday afternoon

By expanding the number of weekly Mobile Market stops, the Kansas City Beans&Greens Program was able to increase access to healthy food for a greater number of persons living or congregating in designated food desert neighborhoods or agencies as evidenced from the chart below. Each transaction represents 3.46 persons.

## # SNAP Transactions Matched ( 2010-2012)



# of SNAP Trans by Market Type (Peer Group)	2010	2011	2012	2010-2012 Totals by Type	% Change
Farmers Markets (All Other)	898	2,181	2,852	5,931	218%
Farmers Market (City)	1,593	3,565	4,808	9,966	202%
Retail Market - WHM	-	112	718	830	541%
Mobile (All Sites)	-	199	418	617	110%
<b>Totals by Year</b>	<b>2,491</b>	<b>6,057</b>	<b>8,796</b>	<b>17,344</b>	<b>253%</b>

### Outcome 2:

Increase sales revenues for local farmers, while also providing low-income Kansas Citizens with fresh fruits and vegetables at an affordable price. In 2010, Beans&Greens provided almost \$50,000 in matching funds for almost \$100,000 of purchases made with food stamps at seven participating farmers' markets. In 2011, Beans&Greens expanded to 17 farmers' markets and 8 mobile market stops and is projected to provide up to \$100,000 in matching funds for \$200,000 worth of food stamp purchases. The success of the program is measured by weekly purchase receipts from farmer suppliers and customer sales receipts. The Mobile Market has purchasing agreements with up to 10 local farmers who provide weekly supplies of fruits and vegetables. (Total sales figures will include sales of local foods not covered by the Specialty Crop grant, such as meats and dairy.)



## Beans&Greens Impact on Market Sales

Total Food Assistance Dollars + Match Dollars



▶ 6

### Sales Breakdown at Mobile Market (2011-2012)

Food Assistance Spend	2011	2012	Totals
Total Shopper SNAP Spend at Mobile Market	4,451	4,474	8,925
Total Match on SNAP	199	418	617
Total SFMNP Spend	165	555	720
Total Match on SFMNP	165	555	720
<b>Totals</b>	<b>\$ 4,980</b>	<b>\$ 6,002</b>	<b>\$10,982</b>

#### Outcome 3:

Increase purchase and consumption of fruits and vegetables by food stamp recipients in Kansas City from an average weekly consumption of 1.95 cups (according to the USDA) to 2.5 cups. Changes in shopping and eating habits will be measured with the use of “Retrospective Pre-Tests” given to food stamp recipients, asking them to compare their shopping and eating habits before and after the availability of the Beans&Greens Mobile Market and dollar-for-dollar match. The surveys will be developed with the assistance of researchers from the University of Missouri Extension Services who serve on the Beans&Greens Steering Committee and the University of Kansas. Survey results will be reviewed to evaluate marketing and outreach efforts.

In 2012, 231 surveys were given to SNAP customers at nine participating farmers markets and mobile market stops.

Survey results are as follows:

	BEFORE	AFTER	% Change
I like the taste of fresh fruit*	84.1%	88.9%	4.8%
I like the taste of fresh vegetables*	78.6%	85%	6.4%
My children like the taste of fresh fruit*	59.6%	65.9%	6%
My children like the taste of fresh vegetables*	52.4%	55.6%	3.2%
I know how to prepare fresh fruit for a meal	78.6%	80.2%	1.6%
I know how to prepare fresh vegetables for a meal	78.6%	81.7%	3.1%
I know fresh produce is good for my health	84.1%	88.1%	4%
I can afford fresh produce*	46.9%	58.7%	11.8%

## Beneficiaries

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- 18% of the population or 120,448 persons enrolled in SNAP and living in Jackson County, Missouri;
- 10% of the population or 22,004 persons enrolled in SNAP and living in Clay County, Missouri;
- 22% of the population or 35,389 persons enrolled in SNAP and living in Wyandotte County, Kansas;
- 4% of the population or 22,851 persons enrolled in SNAP and living in Johnson County, Kansas;
- 8% of the population or 8,791 persons enrolled in SNAP and living in Douglas County, Kansas;
- The 2,500 seniors who receive Senior Farmers Markets Nutrition Program assistance in Kansas and reside in Johnson and Wyandotte counties;
- Local area growers and urban farmers.

Specialty crop stakeholders/groups that benefited from the completion of this project's objectives are as follows:

- 22,000 Persons receiving SNAP benefits who live in and around Jackson and Clay counties in Missouri and Wyandotte, Johnson and Douglas counties in Kansas
- 200 Farmers within a 500-miles radius who sold produce to our Mobile Market and at our participating farmers markets

## **Lessons Learned**

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Although we achieved our goal of expanding the number of mobile market stops in 2012 from 3 to 9 stops, the every other week stops did not build customer loyalty as compared to the weekly stops, and, as a result, sales were significantly lower than projected. For the 2013 season we will revamp the schedule so that all stops are weekly and not bi-weekly stops.

In 2012, we launched the Cooking Corps, a group of trained volunteers who provided cooking demonstrations, safe food handling instruction and nutrition education at participating Beans&Greens farmers markets. These demonstrations drew large crowds. What we did not expect or realize is that it would have a significant impact on sales in some key markets. The Independence Farmers Market, the Brookside Farmers Market, Westport/Plaza Farmers Market, Bad Seed and the Overland Park Farmers Market all doubled their sales in 2012. Farmers reported that the demonstrations attracted new customers who returned often and brought along other friends and family. We will work on insuring that the Cooking Corps volunteers include the Mobile Market sites in their schedule for 2013.

## **Contact Information**

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### **Project 10: Determining Maturity Groups for Edamame Soybeans for Fresh Production in Missouri**

**Lincoln University**  
Dr. Todd R. Higgins  
Final Performance Report

## **Project Summary**

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- a) There are many edamame varieties available to Missouri vegetable growers, but little information is available on the relative maturities of the varieties when grown under Missouri conditions.
- b) Edamame is becoming a more popular vegetable and currently the US imports about 90% of its frozen edamame supply from China. The crop can be grown locally and can generate a significant per acre return to Missouri producers.

- c) This was an original project and did not build on previously funded projects.

## Project Approach

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- a) Our approach was to sow the soybeans and grow them to maturity (R6 stage) for fresh/frozen harvest and determine the number of days from planting that required so that different varieties of soybeans could be grouped into relative maturity groups.
- b) The entire project was carried out on the Lincoln University George Washington Carver Farm.
- c) Twenty-one edamame varieties were sown in 6 X 25 foot plots with four replicates at Carver Farm on June 23 and 24, 2012 using a Cole 12MX three-row planter set at 30 inch row width and equipped with a #30-433 soybean plate. Five varieties did not plant well due to their size. We contacted Cole and ordered peanut plates (POX-467) and replanted the large seeded soybeans on June 28th.
- d) Three reference oilseed varieties were supplied by Stine Seed Co. These varieties, 3522-4, 35AR02, and 3923-4, had maturity group ratings of 3.5, 2.5, and 3.8/3.9, respectively.

## Goals & Outcomes Achieved

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- a) We set out to grow the edamame varieties included in the study to maturity. We succeeded in doing so with 18 of 21 varieties. We attempted to use oilseed soybeans of known maturity groups as references and succeeded to some extent in doing so.
- b) The results of the 2012 study will need to be confirmed by a 2013 and 2014 study.
- c) We planned to determine the maturity groupings of the edamame soybeans in our study and we accomplished our objective.
- d) We were able to place the edamame soybeans into four maturity groups based on the week in which they achieved 50% of the replicates attaining the R6 stage of maturity. Our data was analyzed statistically using Julian dates and was found to be highly significant.
- e) Mean separations of the edamame varieties used in the study:

White Lion	a**
Beer Friend	a
Tohoya	a
Kouri	a
Bunker's Favorite	a
Envy	a
Black Jet	a
Hakucho Early	a
Tankuro	b
Be Sweet 292	b
Lucky Lion	bc
Triple Play	bc
Mojo Green	c
Midori Giant	c
Butterbean	c
Shirofumi	c
Sunrise	cd
Be Sweet 282	d
3522-4*	de
3923-4*	de

\* Oilseed soybean varieties used as references.

\*\* Varieties having a different letter are statistically significant at the  $P>0.01$  level of significance.

- f) Prior to statistical analysis, edamame varieties were grouped subjectively within the week that they first reached maturity. The varieties in this trial matured over a period of four weeks. The analysis confirmed the groupings of the edamame varieties made subjectively using weeks as the discriminator. Some varieties matured earlier or later in a week and could easily move to the next higher or lower group, but for grower variety selection purposes, the following groupings work well:
- Group 1 (Earliest)
    - White Lion
    - Kouri
    - Beer Friend
    - Envy
    - Tohoya
  - Group 2
    - Bunker's Favorite
    - Mojo Green
    - Hakucho Early
    - Tankuro
    - Lucky Lion
    - Triple Play
    - Be Sweet 292
    - Black Jet
  - Group 3
    - Midori Giant
    - Shirofumi
    - Sunrise
    - Butterbean
  - Group 4 (Latest)
    - Be Sweet 282
- g) A copy of the CSSA presentation (PowerPoint) was sent to the Secretary of the Missouri Vegetable Growers Association and it was followed by a summary research report that was sent to the seed houses that cooperated on this project (see report included in additional information).
- h) The results were not presented or made available at the National Small Farm Trade Show and Conference due to a scheduling conflict.

## **Beneficiaries**

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- a) Missouri soybean and vegetable producers will benefit from the results of this work.

- b) The information gleaned from the report will be shared with Missouri producers. Those producers entering the edamame market can expect to significantly increase their return per acre.
- c) An Extension Bulletin is being developed at this time to summarize the findings of the study and it will be made available to all Cooperative Extension outlets in Missouri and will be placed on the web for access by growers outside of Missouri.

## **Lessons Learned**

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- a) Edamame seed size is variable and we had to make adjustments to our seeder based on seed size to ensure that we got good seeding.
- b) One of the two edamame varieties (Tamba Kuro Otsuba) that did not germinate was also problematic in an edamame variety trial conducted in 2011 by the University of Illinois at Champaign.
- c) The drought of 2012 impacted our results. We believe that had soil moisture been higher at the time of planting our germination percentages would have been higher. Low germination of some varieties may have skewed our results somewhat by limiting the development of the soybean plants. Poor stands prevented us from measuring yields due to insufficient plant numbers in many of the replicates for many of the varieties. Not measuring yields was a management decision made by the PI.
- d) Weed control was an issue. The plot had been in semi-permanent sod prior to plowing for this study in the spring of 2012. Our weed control (Treflan) did not work well and thus primarily grassy weeds were problematic for us throughout the study and probably impacted growth and productivity of the plants.
- e) Plot widths needed to be wider to prevent border issues between varieties. Plots were six feet wide for three 30 inch rows. In the future we will go to eight foot wide plots with three 30 inch rows to make between variety identification and cultivation easier.
- f) Reference beans were not as widely spaced in terms of maturity groups as we had wanted, but securing them was a challenge. As can be seen by the results of the statistical analysis, the reference varieties were among the latest maturing varieties. We appreciate Stine Seed Co. supplying these beans to us, but think that they did not fully understand what we were looking for in terms of a spread of maturity groups. For next year's study, we intend to request a greater number of specific varieties to use as reference varieties; thus, enabling us to better categorize edamame variety maturities with the existing oilseed soybean maturity groupings.

## **Contact Information**

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## **Additional Information**

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- The results of this study were presented at the Crop Science Society of America meetings in 2012. The abstract of the paper can be found at

<http://scisoc.confex.com/scisoc/2012am/webprogram/Paper74901.html>

- The combined 2012 ASA-CSSA-SSSA meetings attracted 3598 attendees. Of these approximately 20 persons were in the session room at the time the PI presented the research. The ASA-CSSA-SSSA made compact discs of the abstracts of the conference and 308 CD's were sold. Additionally, the session was videotaped and was made available on the Societies' website.
- Word Document of Report to Cooperators:

## Report to Cooperators: Relative Maturity Dates for Edamame Soybeans in Missouri

### Objective

Determine the relative maturities of a number of edamame soybean cultivars to enable Missouri edamame producers to better select edamame cultivars for full season production.

### Methods

Twenty-one edamame cultivars were secured for the 2012 trials. These were sown into 6 by 25 foot plots in three rows, with 30 inches between rows. Also included were three oilseed soybean varieties of known relative maturity groups. All soybean cultivars were planted in a randomized complete block plot design with four replications. A Cole seeder was used to plant the seed.

Inoculated seed from 21 edamame varieties was sown on June 28th and 29th, 2012 in a prepared seedbed at the Lincoln University, George Washington Carver Farm. The large seeded cultivars did not plant well with the #30-433 seed plates. POX-476 seed plates were purchased and the large seeded edamame cultivars were re-seeded on July 5th.

### Results

Two cultivars, Tamba Kuro Otsuba and Sayamusume, failed to adequately establish and no relative maturity data was collected for these cultivars.

Table1. Edamame cultivars included in the 2012 trails:

Cultivar	Cultivar	Cultivar
Bunker's Favorite	Tankuro	Shirofumi
Sunrise	Midori Giant	Sayamusume
MojoGreen	Lucky Lion	Be Sweet 292
Be Sweet 282	Kouri	Butterbean
Hakucho Early	Korean Black	Envy
White Lion	Tripple Play	Black Jet
Tamba Kuro Otsuba	Beer Friend	Tohoya

Table 2. Oilseed cultivars used as maturity group references in 2012 trial:

Cultivars	Relative Maturity
Stine 3522-4	3.5
Stine 3923-4	3.5
Stine 35RA02	3.8/3.9

The 2012 Growing season was especially trying. The study was impacted by drought, weed competition, and deer. The 2012 drought in the Midwest is well known. We attempted to mitigate the effects of the drought by aggressively irrigating the plots. We were unable to supply sufficient water to optimize plant

growth. The trial plot was in permanent tall fescue pasture prior to plowing for the study. Residual fescue was a weed problem at planting, and green foxtail became a severe issue as the weather warmed. A pre-plant application of Treflan® was ineffective in controlling these weeds. Deer were attracted to the soybeans and although deer damage was not severe, it did impact the plant numbers of some cultivars in various replicates.

On September 7th the first edamame plants reached the R6 stage of maturity. At this point we began semi-weekly evaluation of the cultivars to determine their maturity stage; five plants within each replicate were used to establish the relative maturity of the replicate. A cultivar was considered mature when the average relative maturity of two replicates was R6.

Cultivars were subjectively grouped into four maturity groups as shown in Table 3. The four groups correspond to seven day (week) intervals in maturity between groups.

To validate the subjective grouping of the edamame cultivars an analysis of variance was performed on the data. A Julian date was assigned based on the first recording of R6 for each replicate of each cultivar. The analysis of variance was highly significant ( $P < 0.001$ ) for variety effects. No replicate effects or interactions were significant. The result of the ANOVA is shown in Table 4.

Table 3. Subjective edamame maturity grouping for 2012.

Group1 (Earliest)	Group 2	Group 3	Group 4
White Lion	Bunker's Favorite	Midori Giant	Be Sweet 282
Kouri	Mojo Green	Shirofumi	
Beer Friend	Hakucho Early	Sunrise	
Envy	Tankuro	Butterbean	
	Tripple Play		
	Be Sweet 292		
	Black Jet		

### **Discussion**

The subjective grouping and least square means grouping of edamame cultivars aligned well. The oilseed cultivars provided good reference points, but all were later maturing than the edamame cultivars except Be Sweet 282, hence we can conclude that the 17 of the 19 edamame cultivars that produced beans are in the maturity group ranges less than 3.5 for Missouri conditions, planting edamame cultivars from groups 1 through 3 will provide season long edamame harvest. Be Sweet 282 may perform well in southern Missouri, where the onset of frost is delayed from that in central Missouri. In preparation for the 2013 study, the research plot was fall plowed, disked, and planted to a cereal rye cover crop. We expect that this will eliminate our residual tall fescue problem. We also expect to plant earlier in the season in 2013 and believe that early planting will suppress foxtail germination. The 30 inch row spacing suits our research needs, so narrower row spacing will not be changed.

For the 2013 trial we've secured oilseed reference varieties with a wider range of maturity dates than those used in 2013. Merchman Seeds supplied us with the reference soybeans. Currently, relative maturities of the oilseed cultivars range from 2.5 to 4.5. This will better enable us to match edamame maturity dates to known oilseed maturity groups. We are attempting to get some reference oilseed cultivars in the range of maturity group 2.5 and below from other sources.

Table 4. Edamame Maturity Groupings Based on Least Square Means

White Lion a*	Lucky Lion bc
Beer Friend a	Triple Play bc
Tohoya a	Mojo Green c
Kouri a	Midori Giant c
Bunkers Favorite a	Butterbean c
Envy a	Shirofumi c
Black Jet a	Sunrise cd
Hakucho Early a	Be Sweet 282 d
Tankuro b	3522-4 de
Be Sweet 292 b	3923-4 de
	35RA02 e

\* Cultivars having the same letter are not statistically different at the  $P < 0.001$  level of probability.

## Project 11: The Effect of Rapeseed Meal on Soybean Cyst Nematode Damage to Edamame

### Lincoln University

Dr. Todd R. Higgins

Final Performance Report

### Project Summary

The study was designed to determine if rapeseed (canola) meal or mustard flour could be used to effectively reduce the impact of soybean cyst nematodes (*Heterodera glycines*) (SCN) on edamame soybeans. A greenhouse study was set-up to evaluate the hypothesis. Six inch pots were filled with sand and received 0, 0.157, 0.302, 0.756, 1.1511, or 3.022 grams of canola meal or mustard flour. Four replications of each treatment were readied. Two edamame seeds (*Glycine max* cv 'Be Sweet 292' (Rupp Seeds)) were sown in each pot. A group of controls were also established. The control pots were planted to 'Williams' soybean, a variety known to be highly susceptible to SCN. Treatments were placed approximately 3 cm below the surface of the sand and covered with a thin layer of sand, the seeds were then placed in the sand and covered. SCN were obtained from the University of Missouri and were pipette into straws placed 3 cm into the sand adjacent to the seed. The seed germinated erratically over the course of 10-12 days. The plants were grown for four weeks, removed from the pots, and the roots washed into a # 20 (850  $\mu$ m) sieve. The material retained on the # 60(250  $\mu$ m) sieve was washed into plastic tubes and viewed under a stereoscopic microscope to count cysts. Cysts were observed in only two samples. A discussion of why the low number of cysts observed is presented.

Soybean cyst nematodes (SCN) are a significant pest problem for many soybean producers in the Southern Midwest. For a high value specialty crop like edamame, SCN pose a significant economic risk. The purpose of this study was to determine if two food processing by-products could be effective in managing SCN damage to edamame soybeans.

Canola meal and mustard flour were selected as the treatments for the study because of their potential as nematicidal agents. Rape (canola) and mustard are Brassica species that have been shown to repel nematodes. Both canola meal and mustard flour are by-products of the food industry. Canola meal is the

by-product of crushing canola seed to produce canola oil. Canola is an improved variety of rape and canola meal was easier to obtain in the US than rapeseed meal, as canola production has replaced virtually all rapeseed production in North America. A potential drawback of substituting canola meal for rapeseed is that the bitter taste has been essentially bred out of canola. If erusic acid is an essential part of the nematocidal effect, canola meal may not be effective in repelling nematodes. Mustard flour is made from dehulled and ground mustard seed that is ground to pass through a fine screen.

Both canola and mustard release substances known as glucosinates. It is believed that canola meal and mustard flour would also produce glucosinates as they break down. SCN do the most damage to juvenile roots. They feed on the young roots and they stunt the growth of the soybean plants. As roots mature they are less susceptible to SCN pressure, so the effects of the treatments need not extend season long, but for one to two weeks following germination.

## **Project Approach**

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The study was conducted in a hoop house at Lincoln University's Carver Farm. The hoop house is an open air structure covered with a shade cloth. The study start date was affected by temperature. We were unable to commence the study in spring 2013 due to the frequency of rainfall. Once the rains ceased, the temperature rose quickly and upon the guidance of Robert Heinz, Coordinator and Research Specialist, University of Missouri Nematology Lab, we postponed the start of the study, we believed that fall when warm, not hot, temperatures could be expected would be the best opportunity for success. The study was conducted beginning September 19, 2013 and completed November 17, 2013. Due to an earlier than normal onset of cold weather, a plastic enclosure was build around the greenhouse benches used during the study to retain heat an automatic watering system was installed to spray water on the pots every 6 to 8 hours.

Because SCN are parasites and soybean research is conducted at Carver Farm, we took appropriate bio-security measures to prevent contamination of the soil where the study was carried out. Our first bio-security measure was to construct a double-walled containment system around each of the greenhouse benches. The system consisted 2 x 6 inch frame the size of the bench that had a plastic sheet attached to the outside of the frame and placed on top of the bench, then a second plastic sheet was placed inside the frame. Both sheets were secured by construction staples. At the end of the study the plastic sheeting was removed and placed in a 55 gallon drum with other study wastes for transport to a dumpster for eventual land filling.

The greenhouse pots used in the study were 8 inches in diameter and 8 inches high and were filled with sifted construction grade sand to within 5 cm of the top of the pot. Fiberglass insulation (without backing) was cut and placed in each pot with a liner of waxed paper placed over it. This was done to prevent the sand from flowing out of the drainage holes of the pot and prevent the soybean plant roots from becoming tangled in the fiberglass mat. A piece of 5 cm (2 inch) diameter PVC pipe, 5 cm in length was placed in the center of each pot. The treatment was placed inside the PVC ring and covered with a ¼" (0.5 cm) layer of sand. Two edamame soybean seeds ('Be Sweet 292' (Rupp Seeds)) were then placed on top of the sand in the ring and covered with sand to the top of the PVC ring. Additional sand was added to the pot to secure the PVC ring in place. The pots were watered and the seed was allowed to germinate. The edamame seed was sown on September 10<sup>th</sup> to allow for germination and emergence to occur prior to inoculation with SCN eggs. Once rest of the pots displayed signs of seed germination, the SCN was obtained from the University of Missouri and the sand inoculated. A drinking straw was cut in half and inserted approximately 4 cm deep in the sand (see attached diagram) on the outside of the PVC ring. The SCN containing (2000 eggs/ ml) solution was pipette into the straw for introduction into the experimental pot on September 19, 2013. The straw was washed with a minimal amount of water to ensure the SCN were introduced into the sand.

The edamame plants were kept watered sufficiently to maintain moist sand, but we avoided overwatering that might flush the SCN eggs out of the rooting zone. Pots were fertilized using Miracle- Grow® soluble plant food on a weekly basis. If both seeds per pot germinated they were allowed to grow for a period before the weaker of the two was cut off at the soil surface. At termination, plants were carefully removed from the pots and gently dipped in a bucket of water to remove loose sand particles. The rinsed roots were then placed in the #20 sieve with the #60 sieve positioned directly below it. A strong stream of water was directed onto the roots and the roots were moved back and forth across the sieve and turned to remove soil particles (sand), cysts, and other material. The cysts would pass through the #20 and be retained on the #60 sieve. The #60 sieve was rinsed with less force and then the material remaining on the sieve was transferred to a 50 ml tube for storage until examined under a stereoscope.

## Goals & Outcomes Achieved

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Edamame germination was erratic occurring over a two-week period after the study was begun. The observation is similar to the germination habits of edamame observed in the field. Periodically, soybean plants would die off. Data was collected on which treatments showed signs of dying to consider if the treatments were affecting the growth of the soybean plants. Examination of the data collected showed no trends in premature plants death associated with either the treatments (canola meal, mustard flower, or control) or the rate of the treatment. Examination of the material retained on the #60 sieve under the stereoscope revealed that only two samples had cysts present.

The erratic germination presented a challenge in ensuring the juvenile roots were exposed to the SCN larvae as they hatched. Larvae that could not find a food source (young root) may have died. This may have contributed to the lack of cysts observed.

While we took precautions to not overwater the research pots, it is possible that a rainfall event washed the SCN eggs or larvae out of the pots (the hoop house the study was conducted in only had a shade cloth covering it at the start of the study). This is discounted because of the lack of significant rainfall event at the start of the study (the fall was very dry) and the pot lining system.

Plant growth was not as robust as was observed in a trial run of the potting system conducted in the spring. The climatic conditions in the spring were more conducive to soybean growth and root development. Thus, the lack of SCN cysts observed on the roots may have been a seasonal effect. We did not conduct the study during the spring due to heavy rains that transitioned into high temperatures that may have been conducive to soybean plant development, but not to SCN egg/ juvenile survivability. The cooler than normal fall temperatures also may have affected egg and juvenile survivability.

The treatment effectiveness cannot be judged based on the results of this study. Observations, although not statically supported, suggest that canola meal and mustard flour may have an effect on seed germination. In the preliminary study germination appeared to be suppressed when the seed was in direct contact with the treatment. This is something we may look at in the future.

The SCN egg containing solution was transported from the University of Missouri, where it was quickly used to inoculate the research pots. It is unlikely that any negative effects on the eggs were the result of transport.

The two most likely reasons for the failure of the SCN eggs to produce cysts in the majority of the pots are the erratic germination of the edamame soybean seed and the diurnal temperatures experienced during the conducts of the study. Were we to do the study again, we would plan to conduct the study in an environment where we can better control the temperature conditions to optimize them for SCN egg hatch. Furthermore, we would pre-germinate the seed before placing it into the research pots. Lastly, we

would conduct a preliminary study on treatment placement relative to the seed to determine if treatment placement affects seed germination and development.

Edamame soybean seed seems to have an extended germination window when compared to oilseed soybean. In a separate research study of edamame soybean varieties to determine relative maturities, we use oilseed soybean cultivars as our maturity group reference standards. When oilseed cultivars are sown alongside edamame cultivars, the oilseed cultivars come up as individual plants within the same cultivar over a period 3-4 days (first to emerge to last to emerge). Edamame varieties tend to spread emergence over a 7-10 day period within the same cultivar. This suggests that there may be considerable variation in the thickness, hardness, or permeability of the edamame soybean seed coat. Thus, for a greenhouse study on SCN either edamame seed should be pre-germinated, or oilseed cultivars used in the study, or both.

## **Beneficiaries**

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Our original plan was to share the results of the study with Missouri edamame producers, who would ultimately benefit from the results of this work. Since we did not have any conclusive results that we could share, we have not shared the results. We estimate that there are roughly 50-100 commercial edamame producers in the state. We have no hard evidence upon which to estimate the size of edamame operations, but we believe that the acreage devoted to edamame ranges from under an acre up to 25 acres. The latter acreage is likely to be in southeast Missouri where edamame can be more easily transported to a processing plant in Arkansas.

Had we obtained more definitive results we would have shared this information with edamame producers through an Extension bulletin or similar informational document. We would not recommend producers use mustard flour or canola meal at this time because there is too little evidence to support adoption. We would like to repeat the study under more controlled conditions and see if we can see a more definitive effect before sharing our findings on a broader scale.

## **Lessons Learned**

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In conclusion, although the results of this study are disappointing some learning and some positive outcomes were obtained. We learned that studies on SCN need a more controllable environment to posture the study for success. We learned that canola meal and mustard flour may have a retardant effect on seed germination and that it is worthy of further investigation to confirm or refute these suspicions. We developed a working relationship with the University of Missouri Nematology Laboratory personnel, especially Mr. Robert Heinz. We believe that this new relationship may be very beneficial in future research along the lines of biological nematicides.

## **Contact Information**

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## **Additional Information**

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We extend our appreciation to the Missouri Department of Agriculture and the USDA Specialty Crop program for supporting this research effort. Without external funding, research efforts such as this are unlikely to be supported, many thanks.

## **Project 12: Sweet Corn Production in Living Mulch**

### **Lincoln University**

Dr. Todd R. Higgins  
Final Performance Report

### **Project Summary**

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If sweet corn production can be successfully achieved in living mulch then we can reduce soil erosion, maybe reduce fertilizer requirements, and provide potential grazing following sweet corn harvest. The primary impetus was to determine if we can reduce soil erosion, weed control, and tillage. Other potential benefits include reduced fertilizer application, increased carbon sequestration, and reduced soil compaction.

Sustainable corn production requires producers to conserve their soils. Many Missouri soils are moderately to highly erodible and can benefit from conservation production practices. The living mulch provides year around cover to the soil and when clovers are used, allows some fixed atmospheric nitrogen to be available to the subsequent corn crop. We were aware of the ineligibility of grain corn in this program. However, sweet corn is an eligible specialty crop. We used NK199 sweet corn seed for the project. No funds were used on grain crops. This was clearly stated in the proposal and in the report.

This project was a repeat of a 2011 study funded by NRCS. We had similar weather-related issues with the 2011 study. The clovers used and experimental design used in the two studies was essentially the same. We used 15 inch rows in the NRCS study and used 30 inch rows in this study. We did this so we could use a 30" corn planter instead of a no-till drill to plant the sweet corn. We also used wider cultivator sweeps to do the strip till. The wider row width allowed us to use wider cultivator sweeps. We got good seed placement in 2012 and had better germination of the sweet corn seed in 2012 than in 2011; the drought impacted the growth and performance of the sweet corn plants.

### **Project Approach**

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We re-established clovers in the plots and prepared them for sweet corn planting by mowing to a height of two inches and using a field cultivator to strip rows through the clover in preparation for corn planting. Part of the each plot was strip tilled and the other part was left as is and no-till planted. The sweet corn was germination tested prior to planting and germination was found to be > 90%.

Sweet corn yield, in terms of number and weight of ears, was to be determined. After the corn was harvested, an assessment was to be made to determine the percentage of the soil remaining covered and this assessment was to be repeated until the project ended.

Tasks

- Field preparation. Site was already sown to the living mulch varieties. Some renovation and reseeded of the clover crops was done in the fall 2011/spring 2012. Site was staked out so we'd know the boundaries of each plot. The field cultivator was used to make the tilled strips. A John Deere 7000 eight-row no-till planter was used to plant the corn.
- Monitoring. The plan was to monitor the growth of the sweet corn to determine percent emergence over time for each treatment and plant heights over time for each treatment. We intended to harvest the sweet corn when it was ripe.
- Harvesting. We planned to harvest the sweet corn and measure the length of the ears and weight of ears harvested. Due to the drought affects of 2012 and in spite of our herculean efforts to irrigate the sweet corn, we did not get any sweet corn plants to produce harvestable ears.

## **Goals & Outcomes Achieved**

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We were not able to achieve our primary objective of determining the yield of sweet corn grown in living mulch due to the poor performance of the sweet corn under the drought conditions.

Residual clover at the end of the study was present. The red and white clovers were the most resilient. Kura clover, which is difficult to establish remained in the kura plots and was recovering nicely as the study concluded (however, the kura seed source was contaminated with red clover, so we may have been seeing red clover and not kura clover recovering). The subterranean clover appeared to be germinating in early October when the plots were rototilled and replanted. Subclover germination from seeds deposited in the spring was expected. We surmise that germination would have occurred earlier if precipitation had also occurred earlier. The crimson and ball clover plots may have been showing signs of germination and recovery as the study ended, but these plots had a significant amount of red clover present from dispersion.

## **Beneficiaries**

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The intent was to inform sweet corn producers of the effectiveness of using a living mulch to conserve soils. Unfortunately, the sweet corn portion of the study failed.

## **Lessons Learned**

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- We learned that cultivator sweeps do not work well for strip tilling.
- We also learned that under drought conditions, the living mulch doesn't suppress grassy weeds such as foxtail.
- We learned that under our production system, a herbicide will be required to suppress the annual warm season grasses.
- We need to plant the sweet corn a bit earlier in the year to allow it to close canopy before 1 July to shade the growth of any warm season grasses that escape our herbicide treatment. We also learned that mowing prior to planting is essential. In 2011 mowing was one of our treatments, we learned from it that mowing (or haymaking) prior to sowing the sweet corn is an essential management step. Our emergence percentage (observation, not measured) was improved this year over 2011, but still did not meet our expectations.
- The 30" strip tilled rows seemed to work better than the 15" rows used in 2011. Initial emergence was improved and more seed seemed to germinate. Using cultivator sweeps to strip the rows is not an effective means of performing strip tillage. The depth of tillage was inadequate and the destruction of the clover roots in the tilled area incomplete. We tried to secure a strip till machine,

but we were unable to make coordination in a timely manner. For the 2013 trial we have made arrangements for use of a strip trill machine.

- Some clover species survived in 2012, as discussed in the report. This may be positive, but getting the sweet corn to produce is the challenge we still face.

## Contact Information

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## Project 13: High Tunnel Tomato Variety Trials

### Lincoln University

Dr. Jaime Piñero  
Final Performance Report

## Project Summary

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High tunnels are used to extend the growing season earlier into spring and later into fall. Determinate and indeterminate tomatoes can be successfully grown in this production system, yielding a potentially profitable “out of season” crop. Other advantages to high tunnel production include: higher yields, improved fruit quality, fewer culls, and a reduction in pesticide applications. However, one factor hindering tomato production in high tunnels in Missouri is the lack of research-based information about appropriate tomato varieties to grow under high tunnels. This project was aimed at assessing the performance of new tomato hybrid and heirloom cultivars (both determinate and indeterminate types) in high tunnels located at Lincoln University (LU) Carver farm in Jefferson City and at the University of Missouri (MU) Southwest Research Center in Mt. Vernon, MO, and to promote the use of high tunnels among vegetable farmers.

For the 2012 season at Carver farm, the most productive determinate cultivars were Charger, Mt. Glory, and BHN589, whereas the best performing indeterminate cultivars were Arbason, Geronimo, and Rebelski. Results indicate that there is not a significant yield increase between tomatoes grown in single-layer tunnel and those grown in a double-layer tunnel. For the 2013 season, 21 tomato cultivars (14 determinate types, 5 indeterminate and 2 semi-determinate) were evaluated at both locations. The best performing determinate cultivars were Topanga, Charger, and Mountain Glory (Jefferson City) and GrowDena, HM8849CR, and Topanga (Mt. Vernon). For the 2014 season, cover crops were planted in the two high tunnels at LU Carver farm to improve soil quality. Over 1,900 farmers, within and outside Missouri, had access to the information that was generated by this project. Some of the impacts recorded include increased knowledge by farmers that participated in our educational activities, and increased number of farmers growing tomatoes in high tunnels (two success stories involving minority farmers are presented) and increased income as a result of the multiple activities that were conducted.

As stated in the original proposal, this is a collaborative effort between Lincoln University (LU) and University of Missouri (MU). Originally, Dr. Sanjun Gu served as the PD for this project. Upon his departure from LU in January 2013, Dr. Jaime C. Pinero, Assistant Professor and State Integrated Pest Management Specialist, agreed on serving as acting PD and committed about 5% of his time (donation to the project) to continue managing the whole project including planning, reporting, and disseminating

trial results. Mr. Steven Kirk, Vegetable Extension Associate of LU has spent more than 10% time in this project. Working together, the Commercial Vegetable Program and the IPM Program successfully organized multiple educational events such as the First Vegetable and IPM Festival at LU Carver farm (on August 28, 2013). This exemplifies the effective use of time and resources by LU. Results from the High Tunnel Tomato Variety Trial project, conducted over multiple years in two different regions, are expected to help growers in our region to make informed decisions in selecting cultivars that perform well under the variable weather conditions that characterize the Midwest.

Tomato production continues to increase in Missouri along with increases in the number of high tunnels (unheated structures protected with polyethylene plastic used to extend the season). In 2014, growers had the following intentions to grow tomatoes, as reflected by a survey conducted by the university of Missouri: "Farmers expressed that they will grow tomatoes commercially, the most frequently reported method was in a field, followed by in a greenhouse or heated high tunnel, and then by an unheated high tunnel" (sample size: 99 farmers).

This project was very timely and had excellent cost-benefit, as the economic returns for farmers are comparatively high, especially when tomatoes are produced in high tunnels. The new State Horticulture Specialist at Lincoln University will conduct additional research and extension on tomatoes.

## **Project Approach**

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Below we provide a synthesis of the research and outreach activities that were accomplished during the grant period. Nearly all activities proposed in the approved project proposal were accomplished. Significant results include the development of research-based data on best performing tomato cultivars for use in Missouri, thus helping specialty crop producers decide what may work best in their high tunnels. It is important to highlight that the costs associated with a project of this nature, which involved erecting a new high tunnel at the University of Missouri Southwest Research center in Mt. Vernon, MO, and the heavy work load associated with our evaluations (three tunnels, in all) were leveraged with supplementary funding provided by other sources. For example, this project was heavy on student labor / casual worker; even though only \$ 5,000 was allowed for salaries, any additional salaries were covered by Lincoln University. This exemplifies efficient use of resources by Lincoln University. The PI states that funds were used to solely enhance the competitiveness of specialty crops, in this case high tunnel tomatoes.

**I. Variety Trials (RESEARCH):** Our evaluations involved numerous steps, from ordering and sowing the seeds, growing the transplants, setting up black plastic and drip tape, transplanting, fertilization, etc. Below, we focus only on the main findings for the sake of brevity and clarity.

**Jefferson City, 2012:** The most productive determinate cultivars evaluated at LU Carver farm in 2012 were Charger, Mt. Glory, and BHN589, whereas the best performing indeterminate cultivars were Arbason, Geronimo, and Rebelski. Results indicate that there is not a significant yield increase between tomatoes grown in single-layer tunnel and those grown in a double- layer tunnel. Additional / more detailed information can be found in the poster (see Additional Information section) that was presented at one conference.

**Jefferson City, 2013:** For the 2013 season, 21 tomato cultivars (14 determinate types, 5 indeterminate and 2 semi-determinate) were evaluated at LU Carver farm. The top three tomato cultivars in the single-layer tunnel were Topanga, Charger, and Mountain Glory, whereas the best performing cultivars in the double-layer tunnel were Topanga, GrowDena, and Red Mountain.

Jefferson City, 2014: Starting in the fall of 2013, and throughout 2014, these two high tunnels were used to demonstrate conservation and enhancement of soils, an important aspect of production that farmers need to consider when growing tomatoes for several consecutive seasons. One relevant activity concerning this objective was the planting of cover crops inside the high tunnels, which is something that tomato producers would normally not do.

Mt. Vernon, 2013: This represented the first tomato-growing season at the MU Southwest Research Center. The same 21 tomato cultivars tested in Jefferson City were evaluated in Mt. Vernon. The most productive determinate tomatoes were GrowDena, HM 8849CR, and Topanga.

Mt. Vernon, 2014: In 2014, the high tunnel was used strictly for demonstration purposes and also served as a focal point for a tomato field day that was held at the Southwest Research Center. Unfortunately, the tomato plants were exposed to a broad leaf herbicide (most likely a 2-4-D product). This happened between the dates of June 26-30, 2014. After sending pictures and samples to Patrick Byers- MU Regional Horticulture Specialist, and Andrew Thomas- Horticultural Specialist, Southwest Research Center, the conclusion was reached that most likely a herbicide product primarily comprised of the 2-4D formulation was the cause of the physical damage to the plants. At this point, a decision was reached by Nahshon Bishop to keep the plants alive only for a visual reference in the coming tomato field day. Fertilizer and fungicide spray programs were applied in order to attempt to save the plants for the tomato field day, but plant showed no improvement and therefore no yield data could be recorded. This type of situation is representative of the types of challenges and unexpected situations that commercial farmers face every year.

## **II. High Tunnel Hands-On Workshops (EXTENSION / OUTREACH):**

2012: On Mar. 9<sup>th</sup>, a high tunnel workshop took place at Ms. Jessie Cox's farm. Seven individuals met beginning at 9:00 AM in the morning to raise a 30' x 72' Zimmerman cathedral style high tunnel. The high tunnel was in part, a result of a grant received through NRCS's 2011 High Tunnel Initiative. Jessie Cox, a local organic producer was the recipient of the grant and had approached me several months prior to securing the grant; asking if we would be interested in helping her raise the high tunnel.

2013: On Feb. 8-9, 2013, a high tunnel workshop was conducted in Mt. Vernon, MO with the goal of setting up a new 30' x 96' Zimmerman high tunnel. As stated in the proposal, this workshop was offered in partnership with the MU Southwest Agriculture Research Center. Twenty participants learned about the benefits of having a high tunnel for commercial tomato production, learned about the various components and acquired hands-on experience by helping set up the high tunnel.

## **III Dissemination of information through workshops, seminars, conferences, and field days (EXTENSION / OUTREACH):**

From 2012 to 2014 the Lincoln University Commercial Vegetable program led the High Tunnel Workshops. Attendance to these workshops has been high: 2012: 400+, 2013: 133, 2014: 84.

2012: On Nov. 1-3, 2012, the former PI, Dr. Sanjun Gu, presented the heirloom tomato trial results at the National Small Farm Forum and Trade Show held in Columbia, MO. More than 125 farmers participated in the two seminars where information was delivered.

On Jan. 10, 2012, Dr. Sanjun Gu presented the variety trial results at the Great Plains Growers Conference, which took place in St. Joseph, MO, Jan. 10-12. More than 150 farmers and educators received this new information.

2013: On Mar. 15<sup>th</sup>, 2013, Dr. Sanjun Gu gave a presentation on “Basics of High Tunnel Production” which included an overview of tomato cultivars that are most commonly grown in high tunnels. This was done as part of the 2013 Missouri Minority and Limited-Resource Farmers Conference. Attendance: 48.

On Jul. 22-25, 2013, Dr. Sanjun Gu presented a poster titled: “Grafting and Number of Polyplastic Film Layers Affect Yield of High Tunnel Tomatoes” at the 2013 Conference of the American Society for Horticultural Science held in Palm Desert, CA.

On Aug. 9, 2013, a tomato field day was held at the MU Southwest Research Center with Lincoln University acting as the leading institution. This workshop focused on high tunnel tomato production and relevant issues for the Midwest. For this workshop, educational tracks were held in a classroom setting followed by a tour of the high tunnel. All 21 tomato cultivars being grown were available for tasting so that workshop attendees could pick and choose cultivars to grow themselves. More than 65 individuals were present for this workshop, that received overwhelmingly positive feedback.

On Aug. 28, 2013, LU hosted the First Vegetable and Integrated Pest Management Festival at Carver farm in Jefferson City, MO. Attendance: ~150 farmers. The field day consisted of several “stops” that attendees could explore and ask questions. One of the stations was the two high tunnels, and a person answered questions that commercial growers might have about best methods for growing tomatoes. Farmers were explained the high tunnel research being conducted involving tomato cultivar trials. Demonstrations of tomato tasting were also included. Participants had the opportunity to compare the organoleptic properties e.g., flavor, texture, aroma, of 21 tomato cultivars.

2014: On Jan. 9-10, two posters were presented at the GPGC: (1) “*Pumpkin, Pepper and Tomato Variety Trials in Central Missouri*” by Steven Kirk, Catherine Bohnert, and David Johnson, and (2) Grafting and Number of Polyplastic Film Layers Affect Yield of High Tunnel Tomatoes by Sanjun Gu, Catherine Bohnert, and Steven Kirk. While a precise number of people that read the posters cannot be provided, total number of attendees of the 2014 GPGC, and hence the potential number of people that may have seen the posters, was 613 (combining farmers, exhibitors, and presenters / coordinators).

On Jan. 9<sup>th</sup>, 2014, Mr. Steven Kirk gave a presentation titled “Building Better Soil at LU’s Carver farm”, at the 2014 Great Plains Growers Conference. This presentation included information about the performance of Brassica cover crops that were planted in the fall of 2013. Attendance: 83.

On Mar. 21<sup>st</sup>, 2014, Mr. Steven Kirk gave a presentation titled “High Tunnel Research and Soil Health” and toured the high tunnels as part of the 2014 Missouri Minority and Limited Resource Farmers Conference, organized by Lincoln University and held on March 20-22, 2014 at LU Carver farm. Attendance: 30.

## **Goals and Outcomes Achieved**

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RESEARCH OUTCOMES AND IMPACTS: Results generated as part of this project generated new research-based information concerning (i) most productive tomato cultivars that can be grown in high tunnels, this information will help growers in our region make informed decisions in selecting cultivars that perform well under variable weather conditions, (ii) the effects of grafting - grafting heirloom varieties has the potential to enhance early yield and increase overall yield in single or double-layer polyplastic high tunnels, while being a first line of defense against soil-borne diseases; however, rootstocks did not reduce incidence of the blossom end rot disorder, (iii) findings indicate that there is

not a significant yield increase between tomatoes grown in single-layer tunnel and those grown in a double-layer tunnel.

#### EXTENSION (OUTREACH) OUTCOMES AND IMPACTS:

Over a 3-year period at least 1,900 farmers received information generated by this project. Farmers that attended the workshops reported an increase in knowledge concerning soil fertility and management in high tunnels, identification and management of common tomato diseases, monitoring and management of key insect pests, and general knowledge of high tunnel tomato production.

A survey intended to document impacts of the high tunnel workshop was implemented at the GPGC 2012. When farmers were asked about the decision they made to purchase a high tunnel, 60% of the responses indicated that the workshops helped them a lot, or what they learned at three workshops made the critical difference for their decision. While Lincoln University cannot take full credit for this, the leadership of the former and new PIs and project participants when coupled with critical information presented about the performance of tomato cultivars in high tunnels contributed to this success.

A survey will be implemented by the Lincoln University Vegetable program targeting tomato producers. We will be asking specific questions that can shed light to what extent they benefited from information generated by this project. We will also gather more personalized statements based on interviews. Various factors are known to influence farmers' decision on which tomato cultivar to grow, including productivity. Based on the tomato survey conducted by the Univ. of Missouri, the three factors the survey prompted respondents to choose were: - Marketability (e.g., taste, fruit size), - Productivity (e.g., growth, yield), - Hardiness (e.g., resistance to leaf mold or pests, heat tolerance). This means that the decision of growing specific tomato varieties would not only be based on information produced by this project.

Two success stories from minority and/or limited-resource farmers were documented.

- 1) **Hispanic farmer from St. Peters, MO.** This farmer and his family moved to Missouri from California in the early 1990s. The family now operates a 30 acre farm and specializes in direct-to-consumer sales at a roadside stand and multiple farmers markets. In the fall of 2012, the farmer set up a high tunnel using the cost-share EQIP program of NRCS. When specifically asked about his decision of erecting a high tunnel, He replied that he decided to grow tomatoes in a high tunnel as a result of his interactions with Lincoln University. His first season was in 2013, the tomato cultivars the farmer grew in the high tunnel were Goliath and Geronimo. This first season was "excellent" as indicated by him. His second high tunnel season was in 2014, and the main tomato cultivars were Brandy Wine, Cherokee Purple, and Red Deuce. Production and marketing was again excellent. This farmer indicated that he believes that 200 plants inside a high tunnel are as productive as 1,000 plants grown in the field. He shared with us some information about his income:

- Total income high tunnel tomatoes (200 plants only): \$ 7,000 (his estimate)
- Total income field-grown tomatoes (1,000 plants): \$ 4,000 (his estimate)

The difference in income high tunnel tomatoes vs. field-grown tomatoes is: \$ 3,000 in favor of high tunnel tomatoes, even though he had only 20% of the plants in the high tunnel compared to the field. He also had more expenses for tomatoes grown in the field e.g., weeding; however, he didn't provide information about costs). Bottom line: this farmer made more money and worked less by growing tomatoes in a high tunnel. In addition, fruit quality and price of tomatoes grown in his tunnel were better than those of field-grown tomatoes.

- 2) **Hmong vegetable farmer from Anderson Missouri.** This Hmong farmer has become an important connection between the Hmong culture and Lincoln University in Southwest Missouri.

Our first contact was on June 6, 2010. Initially, he was farming three acres of vegetable crops and had one 20' X 40' greenhouse, which he used to start most of his vegetable transplants. His immediate concerns were supplemental irrigation, equipment and storage facilities. As a result of frequent advice provided by Lincoln University, this Hmong farmer now has a working well for irrigation.

He owns a raised bed/plastic mulch-laying implement that allows him to grow on plastic and reap a multitude of labor-saving benefits as well as a "Cool-Bot" storage room, so he is able to store his produce safely while retaining its nutritional value. He was recently qualified for the NRCS-EQIP High Tunnel Initiative. The high tunnel was put together in 2013 under Lincoln University's supervision. He agreed to open his farm for the high tunnel construction, allowing us to sponsor a high tunnel workshop specifically directed toward Hmong growers in the region.

The approved project included the following expected outcomes / impacts:

- Number of workshops/field days
- Number of farmers visited the research sites (Carver Farm in Jefferson City and the Southwest Research and Education Center in Mt. Vernon).
- Number of publications (fact sheets) based on trial data.

Measurable outcomes to growers include:

- Number of farmers participated in field days and workshops.
- Knowledge gain by farmers on reports of tomato variety trials.
- Information on number of farmers who tried recommended varieties by end of the trials.

Results from the variety trials were disseminated at High Tunnel Workshops of the Annual Great Plains Vegetable Growers Conference (2013 & 2014). Over 240 participants received the updated information of new tomato varieties.

Information included in the present report shows that the above expectations were met and even surpassed. By requesting a no-cost extension until August 30, 2014 we were able to conduct additional outreach thereby more farmers received the information that this project generated.

The tomato cultivars that consistently performed best were Topanga, Charger, Geronimo and GrowDena. These cultivars need to be promoted for growing inside high tunnels. Lincoln University just hired a new State Horticulture Specialist, Dr. Touria Eaton. Dr. Eaton has already begun planning research and outreach on high tunnel tomatoes using information that this MDA SCBGP provided. Thus, information collected will serve as the basis for new research and extension activities that will take place beyond the scope of this project.

Based on the survey conducted by the University of Missouri, from a list of 15 tomato varieties often grown in fields, growers were asked to select what varieties they intended to grow commercially in their field this season. Some of the cultivars listed were tested by Lincoln University as part of this grant. While this information is very useful, we cannot claim that farmers selected those varieties based solely on information provided by Lincoln University, as no survey specific to this grant could be conducted. However, with the incorporation of a new Horticulture specialist at Lincoln University we are planning on conducting our own survey that will include questions aimed at addressing the impact of this project. The survey will be implemented by the end of 2015. Results will be posted at the Lincoln University website and will also be disseminated among growers. USDA will also be provided with a summary of findings related to outcomes".

Interestingly, an independent survey conducted by Mr. James Quinn, from University of Missouri Extension revealed some information about tomato varieties that growers were intending to grow in high tunnels in 2014. It shows that some of the tomato cultivars that farmers are choosing are in fact among the best performing cultivars that the present project evaluated. As an example, please see below a table that was taken directly from that survey (full name of the document, for credit: MISSOURI TOMATO GROWERS Survey Report, January 31, 2014. Prepared for University of Missouri Extension, James Quinn, Regional Horticulture Specialist - Central Region. Prepared by: Paula McFarling, Senior Coordinator, John Christiansen, Coordinator, Assessment Resource Center, College of Education, University of Missouri, 2800 Maguire Blvd. Columbia, MO 65201).

### Greenhouse or Heated High Tunnel Tomato Varieties

From a list of 12 tomato varieties often grown in a greenhouse or high tunnel, growers were asked to select the varieties they intended to grow commercially in a greenhouse or heated high tunnel this season. A final choice was "Other." The most frequently reported variety was Big Dena (Table 4). Varieties are listed in the table from the most often selected to the least-often selected varieties.

**Table 4: Varieties for Greenhouse or Heated High Tunnel**

Tomato Variety	Count
Big Dena	26
Rocky Top	10
Goliath	8
Big Beef	7
Scarlet Red	7
Red Deuce	7
Geronimo	4
Mountain Fresh	4
Mountain Spring	3
Primo Red	3
Torero	2
Trust	2
Other	10

Note: Table includes responses from 58 growers.

A mid-term outcome of this project is the change in behavior by two minority farmers who after learning about the advantages of high tunnel production applied for the NRCS EQIP High Tunnel program, received the funding, erected the high tunnels and grew tomatoes successfully over at least 2 growing seasons. No long-term outcomes were proposed in the approved project proposal and no long-term data could be obtained as a result of this project.

## Beneficiaries

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Specialty crop groups that directly benefited are vegetable (tomato) farmers. However, by learning about the benefits provided by high tunnels, other specialty crop farmers such as berry producers became interested in high tunnels.

One main method of disseminating the information that was collected was the Great Plains Growers Conference. The original project narrative listed 240 participants as recipients of the information of new tomato varieties. At the end of the project, this goal was surpassed, as at least 840 people that attended the GPGC received the new information.

The two success stories presented show that two minority farmers became interested in high tunnels and as a result of information generated and disseminated as part of this project started growing tomatoes in high tunnels.

## **Lessons Learned**

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The departure of the former PI, Dr. Sanjun Gu, prevented the publication of the information in the Midwest Vegetable Trial Reports. The original proposal stated “Results will be published at the Midwest Vegetable Trial Reports (annually) which has an audience of over 300, including vegetable research and extension professionals and vegetable growers”. To compensate for this drawback, the new PI increased efforts to disseminate the information that was generated through workshops and field days.

Conducting variety trials involves a collective effort by horticulture specialists, plant pathologists, entomologists as well as technicians, casual employees and students. This project provided a small amount of money that could be used for salaries. This situation was solved by Dr. Sanjun Gu with leveraging funds from other sources. The message here is that other researchers trying to conduct studies in at least two high tunnels (we used three in this project) need to consider the heavy labor (and salaries associated) that is involved.

## **Contact Information**

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Dr. Jaime C. Piñero  
573-681-5522  
[pineroj@lincolnu.edu](mailto:pineroj@lincolnu.edu)

## **Additional Information**

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**Dr. Sanjun Gu (former PI of this project) gave a presentation at the 2013 Missouri Minority and Limited-Resource Farmers Conference held on March 14-16, 2013 at LU Carver farm.**

**2013 MISSOURI MINORITY AND LIMITED RESOURCE FARMERS' CONFERENCE  
LINCOLN UNIVERSITY IN MISSOURI**

**THURSDAY, MARCH 14**

Pre-Registration Required

4:00 – 7:00 pm      **PRE-CONFERENCE FARM TOUR AND DINNER AT THE SALAD GARDEN FARM**  
16303 S. HAWKINS ROAD, ASHLAND, MO 65010  
*Meet in Capitol Plaza Lobby, 415 W. McCarty Street, Jefferson City, MO 65102*  
*Depart at 3:30 pm*

**FRIDAY, MARCH 15**

8:00 – 9:00 am      **Exhibit Set-Up, Scruggs University Center Ballroom**

8:00 – 9:00 am      **Registration**  
Scruggs University Center, 819 Chestnut Street, Jefferson City, MO 65101

9:00 am – 5:00 pm      **Vendor Exhibits, Scruggs University Center Ballroom**

**General Session Ballroom** (Dr. Sanjun Gu, presiding)  
9:00 – 9:30 am      Welcome—Ms. Yvonne Matthews (LUCE), Michael Warrick and Reggie Stockman (MDA)  
9:30 – 10:30 am      Keynote Address: *Small Farms in Missouri: What the Future Holds?*—Dr. K.B. Paul

**10:30 – 11:00 am      BREAK FOR NETWORKING, VISITING VENDORS AND SELF-GUIDED TOUR OF LU CAMPUS**

11:00 am – 12:00 pm      *Updates of Programs Pertinent to Small Farms from USDA* (Brad McCord, presiding)

**12:00 – 1:00 pm      LUNCH IN BALLROOM**

Concurrent Sessions	<b>Track A Founders Hall Room 135</b> (Katie Nixon, presiding)	<b>Track B Founders Hall Room 238</b> (Shon Bishop, presiding)
1:00 – 1:45 pm	<i>High Tunnel Production Basics</i> Dr. Sanjun Gu	<i>Beekeeping as a Side Line Business</i> Miranda Duschack
1:45 – 2:30 pm	<i>Growing Vegetables in a High Tunnel: A Farmer's Learning Experience</i> Liz Graznak	<i>Planning for Pollinators and Other Beneficial Insects</i> Dr. Nadia Navarrete-Tindall

**2:30 – 3:00 pm      BREAK FOR NETWORKING, VISITING VENDORS AND SELF-GUIDED TOUR OF LU CAMPUS**

3:00 – 4:00 pm	<i>Soil Health: Key to Gaining Agricultural Productivity, Environmental Quality, &amp; Sustainability</i> Steven Hefner	<i>Small Ruminant Health</i> Dr. Charlotte Clifford-Rathert
4:00 – 5:00 pm	<i>Basics of Irrigation System Design &amp; Maintenance</i>	<i>Making Plans for a Successful Aquaculture Enterprise in the North Central States</i>

**A  
P  
P**

Poster presented by Dr. Sanjun Gu at the 2013 Conference of the American Society for Horticultural Science held in Palm Desert, CA (July 22-25, 2013).



# Grafting and Number of Polyplastic Film Layers Affect Yield of High Tunnel Tomatoes



Sanjun Gu<sup>1</sup>, Catherine Bohnert<sup>2</sup> and Steven Kirk<sup>2</sup>

<sup>1</sup>Cooperative Extension, North Carolina A&T State University, Greensboro, NC 27411

<sup>2</sup>Cooperative Research and Extension, Lincoln University in Missouri, Jefferson City, MO 65102

### Abstract

High tunnel tomatoes play an important role in season extension in the Midwest. Farmers always request the latest information on high tunnel tomato varieties and management techniques. The objectives of our trials were to evaluate new hybrid tomato varieties and to investigate the grafting effects on heirloom tomatoes grown in 30' x 96' Zimmerman high tunnels covered with either single-layer or double-layer polyplastic film at Lincoln University's Carver Farm in Jefferson City, Missouri. In 2012, four determinate varieties (Mt. Glory, BHN-589, Charger, and Rocky Top) and seven indeterminate varieties (Arbason, Bigbeef, Bigdena, Geronimo, Panzer, Rebeleski and Trust) were tested. Heirloom tomatoes German Pink and Ananas Noire were grafted onto rootstocks Maxifort, Beaufort, Multifort, Colosus and RST04-106-T, with own-rooted scions as controls. Grafting was done in a greenhouse using the Tube Grafting method. All trials in the high tunnels were conducted in a completely randomized-block design with four replications per variety and four plants per replication. Plants of indeterminate varieties and grafted heirlooms were trained to a single leader. Determinate varieties were pruned up to the first fruit cluster. All other management techniques were similar to local high tunnel tomato production standards. Data showed that yield and number of fruit were similar among determinate varieties. For indeterminate varieties, Geronimo yielded the most, while Trust yielded the least. Mt. Glory, BHN-589, Rocky Top and Geronimo yielded higher in the single-layer high tunnel than in the double-layer high tunnel. Yield was higher for grafted heirloom varieties in the double-layer high tunnel than in the single-layer high tunnel. Colosus rootstock greatly enhanced the early yield of the German Pink variety. All varieties experienced severe blossom end rot with the worst incidence occurring on Ananas Noire. Rootstocks did not reduce the incidence of blossom end rot disorder.



### Introduction

More and more Missouri farmers are constructing high tunnels to extend the growing season. Tomatoes continue to be a popular high tunnel crop. The objectives of our trials were to evaluate new hybrid tomato varieties and investigate the grafting effects on heirloom tomatoes grown in high tunnels covered with either single-layer or double-layer polyplastic film.

### Methods

Below are hybrid tomato varieties tested in 2012.

- |                       |                         |            |             |
|-----------------------|-------------------------|------------|-------------|
| Determinate varieties | Indeterminate varieties |            |             |
| • BHN-589             | • Mountain Glory        | • Arbason  | • Panzer    |
| • Charger             | • Rocky Top             | • Bigbeef  | • Rebeleski |
|                       |                         | • Bigdena  | • Trust     |
|                       |                         | • Geronimo |             |

Below are heirloom tomatoes and rootstocks for the 2012 grafted trial.

- |                    |                     |               |
|--------------------|---------------------|---------------|
| Heirloom varieties | Rootstock varieties |               |
| • German Pink      | • Beaufort          | • Multifort   |
| • Ananas Noire     | • Colosus           | • RST04-106-T |
|                    | • Maxifort          |               |

- Transplants for the hybrid tomato variety trial were started from seeds in mid-March in the Dickenson Greenhouse.
- Transplants for the grafted heirloom trial were started from seeds in mid-February. Grafting was performed in early March using the Tube Grafting method.
- Prior to laying the black plastic, fertilizer was applied and cultivated into the soil at a rate of 50 lb. N per acre.
- On April 17, transplants were planted into raised black-plastic beds in Carver Farm's two Zimmerman 30' x 96' high tunnels equipped with an automated ventilation system. Irrigation was provided using 8 mil drip tape with emitters spaced at 12" rated at 100 GPM per 100 ft.
- Plant spacing was 1.5 feet within a row for the determinate varieties and 2 feet apart for the indeterminate and grafted plants.
- Plants were irrigated 6 to 8 hours per week depending on need. Additional water-soluble fertilization (Chem-Gro 4-15-35 & Calcium Nitrate, tank mixed 8 oz. each per 100 gal. of water) was applied weekly using a fertilizer injection system.
- Determinates were pruned up to the first fruit cluster and the indeterminate and grafted plants were trained to a single leader.
- All other management techniques were similar to local high tunnel tomato production standards.
- All trials in the high tunnels were conducted in a completely randomized-block design with four replications per variety and four plants per replication.
- Harvests began on June 18 and continued weekly until August 30. Harvesting consisted of picking all mature fruit from the 4-plant blocks and weighing the marketable and unmarketable fruit separately. All harvests were combined to reflect the total yield for each cultivar.

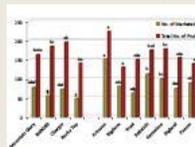


Figure 1. Yield (No. of fruit) of hybrid varieties in the double-layer high tunnel (n=2000, n=200).

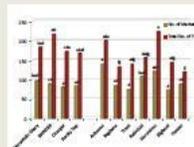


Figure 2. Yield (No. of fruit) of hybrid varieties in the single-layer high tunnel (n=2000, n=200).

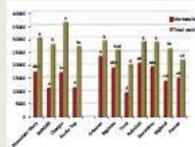


Figure 3. Yield (g) of grafted German Pink in the double-layer high tunnel (n=1000, n=20).

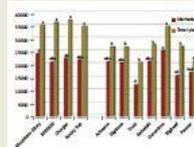


Figure 4. Yield (g) of grafted German Pink in the single-layer high tunnel (n=1000, n=20).

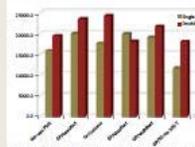


Figure 5. Yield (g) of grafted Ananas Noire in the double-layer high tunnel (n=1000, n=20).

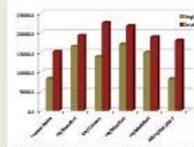


Figure 6. Yield (g) of grafted Ananas Noire in the single-layer high tunnel (n=1000, n=20).



Figure 7. Cross sections of hybrid varieties that grafted scions in the single-layer high tunnel (left) to the double-layer high tunnel (right).

### Results

#### Hybrid Tomato Trial (Figures 1-4)

- Number of fruit and total yields were similar among the determinate tomato varieties.
- For indeterminate varieties, Geronimo yielded the most in the single layer polyplastic tunnel (25,400 g), while Arbason yielded the most in the double-layer polyplastic tunnel (23,279 g). Trust yielded the least in both high tunnels (single-layer 12,206 g, double-layer 9,358 g).
- No difference was observed between the single and double-layer polyplastic tunnels, although Mountain Glory, BHN589, Rocky Top and Geronimo had higher yields in the single-layer high tunnel (Figure 7).
- Most varieties had blossom end rot disorder (Figure 8).

#### Grafted Tomato Trial (Figures 5, 6 and 9)

- Yield was enhanced by grafting in most cases for German Pink and in all cases for Ananas Noire.
- Double-layer polyplastic increased yield in most cases.
- Rootstock Colosus greatly enhanced early yield of German Pink.
- Both heirloom varieties experienced blossom end rot disorder (especially Ananas Noire) (Figure 8).

### Conclusions

- Results from the 2012 tomato hybrid variety trial, should help growers in our region make informed decisions in selecting cultivars that performed well under the extreme heat and drought conditions that pervaded the Midwest.
- Grafting heirloom varieties has the potential to enhance early yield and increase overall yield in single or double-layer polyplastic high tunnels, while being a first line of defense against soil-borne diseases. However, rootstocks did not reduce incidence of the blossom end rot disorder.
- Results indicate that there is not a significant yield increase between tomatoes grown in single layer tunnel and those grown in a double layer tunnel.



Figure 8. Cross-sections of heirloom varieties from the 2012 grafted trial.



Figure 8. A high incidence of blossom end rot disorder in both high tunnels reduced marketable plants.

### Acknowledgements

Financial support for the trials was made possible through the MDA Specialty Crop Block Grant and the Commercial Vegetable Program through Lincoln University Cooperative Extension.

First Vegetable and IPM Festival held at LU Carver Farm on August 14, 2014



LINCOLN UNIVERSITY COOPERATIVE EXTENSION

invites you to the

**1st VEGETABLE and INTEGRATED PEST MANAGEMENT**

# FESTIVAL

4:00 – 7:00 pm, Wednesday, August 28, 2013

Lincoln University George Washington Carver Farm

3804 Bald Hill Road, Jefferson City, MO, 65101

Missouri's agriculture is diverse and vibrant, and this is being celebrated at the "*First Vegetable and Integrated Pest Management Festival*", hosted by Lincoln University Cooperative Extension (LUCE). This free event will showcase vegetable production and pest management tools that are effective and help conserve beneficial arthropods. Three LUCE Programs (Vegetable Program, Native Plants Program, and Integrated Pest Management Program) joined efforts to provide small- and mid-scale farmers and gardeners with educational displays, informative demonstrations and short talks on various aspects of agriculture.

## Demonstrations & Presentations

High Tunnel Tomato Production ~ Research Update on Trap Cropping ~ Cover Crops for Vegetables ~ Elderberry as an Edible Native Plant ~ Native Plants for Native Pollinators ~ Weed and Insect Pest Management in Jack-o'-lantern Pumpkin Production ~ Field Sweet / Chile Pepper Production ~ Integrated Disease Management of Watermelon ~ Monitoring and Management of Invasive Insects including Spotted Wing Drosophila (SWD)– free bait and traps.

*SWD is a very serious new invasive pest that attacks small fruit crops, some stone fruits (cherry, nectarine, peach), high tunnel tomatoes, and wild hosts (including pokeweed, autumn olive, crabapple, nightshade, Amur honeysuckle, and wild grape). Raspberries, blackberries, blueberries, and grapes are at the greatest risk. Learn how to identify, monitor, and manage this injurious pest.*

**PEPPER AND TOMATO TASTING!**

## Tomato Field Day held on September 5, 2013 at the MU Bradford Farm



**Bradford Research Center**  
**9TH ANNUAL**  
**TOMATO FEST**

4-7 p.m.  
Thursday, September 5, 2013



4968 Rangeline Road  
Columbia, MO 65201

For more information, contact  
Tim Reinbott or Thresa Chism:  
573-884-7945  
or visit our website at:  
[aes.missouri.edu/bradford](http://aes.missouri.edu/bradford)

**New for 2013!**  
Chef competition  
Kids' Corner

**Presentations on the hour from 4-7 p.m.**  
Informative presentations from Dr. David Trinklein (University of Missouri), Dr. Jaime Piñero (Lincoln University), and James Quinn (University of Missouri).  
Wonderful World of Chili Peppers, Steven Kirk (Lincoln University)

**Free and open to the public! 200 varieties of tomatoes and peppers!**

  
Bradford Research Center  
College of Agriculture, Food and Natural Resources



# Tomato Insect Pests:

## *What bugged you in 2013?*



### Jaime Piñero

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Poster presented by Mr. Steven Kirk (Lincoln University Cooperative Extension) on pumpkin, pepper, and tomato variety trials conducted at LU Carver farm at the 2014 Great Plains Growers Conference. It presents information on the high tunnel tomato variety trial supported by MDA.

## Pumpkin, Pepper and Tomato Variety Trials in Central Missouri

Steven Kirk, Catherine Bohnert and David Johnson  
Lincoln University Cooperative Extension, Jefferson City, MO 65101

**ABSTRACT.** Twenty-one tomato, 14 sweet pepper, 16 chili pepper and 16 Jack-O-Lantern pumpkin cultivars were evaluated at the George Washington Carver Research Farm in Jefferson City, MO during the 2013 growing season. Replicated trials analyzed cultivars for both 'marketable per plant yield' and as well as individual fruit characteristics of 'weight', 'length' and 'width'. The highest yielding tomato cultivar in both the east and west high tunnel was 'Topanga' (4362 g/4576 g/plant) respectively. The highest chili pepper marketable grams/plant yields were 'Magno' Jalapeno (2289.0g), 'Sequoia' Poblano (1878.6 g) and 'Highlander' Big Chili (2231.2 g) and 'Gran Camino' Serrano (2193.5g). Highest marketable sweet pepper per-plant yields include 'JFR 632' medium sized bell pepper (1315.8 g) 'JFR 985' large sweet Como di Toro (2579.6 g) 'JFR 993' small Como di Toro (1962.3 g) and 'JFR 639' sweet Pimiento pepper (1064.2 g). The highest yielding pumpkin cultivar was 'Rival PMR' (119.6 kg) and the largest pumpkin was 'Polar Bear' (11.7 kg).

**Materials and Methods**

Sixteen Jack-O-Lantern pumpkin cultivars (Table 1), 21 tomato cultivars (14 determinate types, 5 indeterminate and 2 semi-determinate; Table 1) 14 sweet pepper (4 medium bell, 4 small and 4 large Como di Toro, and 2 pimiento; Table 2), and 16 chili pepper cultivars (4 each of Jalapeno, Poblano, Serrano and Big Chili; Table 2) were chosen for these trials. Seeds of tomatoes and peppers were sown into germination ribbon flats on April 9<sup>th</sup> and 15<sup>th</sup> in the greenhouse. Resulting seedlings of 1-1.5 inches tall were transplanted into 504 insert 4-cell packs. Pumpkins were sown directly into 4-cell packs.

On May 9<sup>th</sup>, 2013, tomato plants with 3-4 true leaves were transplanted into two 30' x 96' high tunnels. Planting design consisted of five raised 3-foot wide beds covered in black plastic with plants spaced in a zigzag pattern at 2' intervals within rows for both tunnels. Each block consisted of four plants of the same cultivar and replicated 4 times. On June 4<sup>th</sup>, 2013, pepper plants with 3-4 true leaves were transplanted outside into raised beds covered in white plastic. Each block consisted of four plants of the same cultivar and replicated 4 times. Pepper plant spacing was two feet within a row and nine feet on center between rows. On July 12<sup>th</sup>, 2013, pumpkin plants were transplanted into raised beds covered in black, bio-degradable plastic mulch at Carver Farm. Pumpkin plant spacing was three feet within a row and nine feet on center between rows.

Prior to laying the plastic mulch, fertilizer was applied and cultivated into the soil at rates recommended by Kinsey Agricultural Service's analysis of soil samples specific to each crop and plot. Irrigation for the tomatoes and peppers was provided using two 8 mil drip tapes per row with emitters spaced at 12" and rated at 0.5 GPH per 100 ft. The pumpkin plots only had one irrigation line. All were irrigated 6 to 8 hours per week. Additional water-soluble 'Aqua' was applied weekly to the tomatoes and peppers using a Domatic Superdop 30 Mobile fertilizer injection system at a rate of 0.5 lb per 8 gallons. Pesticide control for the tomatoes and peppers consisted of 1 application of Dipel (Bacillus thuringiensis) in mid July. Blue Hubbard and Red Kuri squash were planted at the end of each pumpkin row as trap-crops to attract squash bugs. Dipel was applied to all cucurbits on 7/19. On 7/2, Azera insecticide (Pyrethrin + Azadirachtin) was applied to the trap-crops on 7/19, 8/1, 8/7. On August 15<sup>th</sup>, Azera was applied to all the trap crops and to the eastern most row of the cultivar trial.

The high tunnels were harvested weekly from July 30<sup>th</sup> thru September 9<sup>th</sup> for a total of seven harvests. Both sweet and chili peppers were harvested 4 times during the growing season from July thru October. Harvesting consisted of picking all mature fruit from the 4-plant blocks and weighing them together. Pumpkins were harvested on September 19<sup>th</sup>. Data collection consisted of following each vine in each block, collecting all ripe fruit, placing them together on the raised plastic mulch bed and weighing each individual pumpkin. Four fruit per cultivar, one representative pumpkin from each block, were measured to establish individual fruit characteristics including circumference at the equator and at the pole.

Individual tomato and pepper fruit measurements (weight, length and width) were taken at each harvest to determine the average size of each cultivar. Individual fruit data was collected by randomly selecting 3 mature chilies per block for a total of 12 fruit per cultivar, per harvest. Additional data was taken on the sweet peppers including 'disease/rot', 'fruit appearance' and 'wall thickness' (bell peppers only) was taken twice on September 16 and October 7.

The western high tunnel with the double layer of 6-mil poly consistently out produced the eastern high tunnel with only one layer of 6-mil poly. Marketable yield for the west high tunnel tomatoes ranged from 339 grams/plant for 'San Marzano' to 4576 grams/plant for 'Topanga'. The single fruit weight of tomato cultivars in the west high tunnel averaged from 104.2 grams for 'Homeless Imperial' to 3313 grams for 'Charger' (Figure 1).

Marketable yield of jalapeno cultivars ranged from 1625.7 grams/plant for 'Eufonia' to 2289.0 grams/plant for 'Magno'. Big Chili yields ranged from 1470.6 grams/plant for 'Chili 676' to 2231.2 grams/plant for 'Highlander', and Poblano chilies ranged from 1330.5 g for 'Caballero' to 1978.0 g for 'Sequoia'. The yield per plant yield of Serrano chilies ranged from 1106.5 grams/plants for 'Serrano Del Sol' to 2193.5 grams/plant for 'Gran Camino'.

Marketable per plant yield of medium sized sweet bell pepper cultivars ranged from 588.2 g for 'Gourmet' to 1315.8 g for 'JFR 632'. The yield for small Como di Toro peppers ranged from 1078.8 g/plants for 'JFR 1309' to 1962.3 g/plant for 'JFR 993'. Large Como di Toro pepper per plant yields ranged from 1733.1 g for 'JFR 211' to 2579.6 g for 'JFR 985'. The yield of sweet Pimiento peppers ranged from 756.5 g/plants for 'Lipstick' to 1064.2 g/plant for 'JFR 639'.

The highest yielding pumpkin cultivar was 'Rival PMR' (119.6 kg) and the largest pumpkin cultivar was 'Polar Bear' (11.7 kg) (Figure 2).

**Results and Discussion**

**Table 1: Pumpkin and Tomato Cultivars**

Cultivar	Yield (g/plant)
Topanga	4362
Charger	4576
Mango	3313
Sequoia	1878.6
Highlander	2231.2
Gran Camino	2193.5
Pumpkin Harvest	119.6
Pepper Harvest	1315.8

**Table 2: Sweet and Chili Pepper Cultivars**

Cultivar	Yield (g/plant)
Magno	2289.0
Sequoia	1878.6
Highlander	2231.2
Gran Camino	2193.5
Rival PMR	119.6
Polar Bear	11.7

**Figure 1. 2013 High Tunnel Tomato Variety Trial**

**Figure 2. 2013 Jack-O-Lantern Pumpkin Cultivar Trial**

**Acknowledgements:** This trial was funded by Lincoln University Cooperative Extension. The authors would like to thank the Commercial Vegetable Program, the Vegetable IPM Program and the staff at George W. Carver Research Farm for their assistance on these projects.

Mr. Steven Kirk (Lincoln University Cooperative Extension) gave a presentation at the 2014 Missouri Minority and Limited-Resource Farmers Conference held on March 20-22, 2014 at LU Carver farm.

## 2014 MISSOURI MINORITY AND LIMITED RESOURCE FARMERS' CONFERENCE LINCOLN UNIVERSITY IN MISSOURI (LU)

THURSDAY, MARCH 20			
Pre-Registration Required			
4:00 – 6:30 pm	<b>PRE-CONFERENCE FARM TOUR AND DINNER AT TRINKLEIN BROTHERS GREENHOUSES</b> <i>(Meet at the LUDickinson Greenhouse Parking Lot 1219 Chestnut St, Jefferson City, MO 65101)</i>	<b>EXTENDING THE SEASON THROUGH A CERTIFIED KITCHEN (TOUR AND APPETIZERS)</b> <i>(Meet at the LUDickinson Greenhouse Parking Lot 1219 Chestnut St, Jefferson City, MO 65101)</i>	
FRIDAY, MARCH 21			
8:00 – 9:00 am	<b>Registration / Display Set-up</b> <i>Carver Farm: 3804 Bald Hill Road, Jefferson City, MO 65101</i>		
9:00 – 6:00 pm	<b>Exhibits Open Room 105</b>		
<b>General Session Room 103 &amp; 104 (Dr. K.B. Paul, presiding)</b>			
9:00 – 9:10 am	<i>Welcome—Yvonne Matthews (LU)</i>		
9:10 – 9:30 am	<i>Dr. Kevin Rome (LU President)</i>		
9:30 – 10:00 am	<i>Cultivating Potential—Reginald Stockman (MDA)</i>		
10:00 – 10:30 am	<i>Overview: 2501 Program—Dr. K.B. Paul (LU)</i>		
10:30 – 10:40 am	<b>BREAK, NETWORKING AND VISITING VENDORS</b>		
10:40 – 11:50 am	<i>Food Systems and Safety—Charlie Hopper (MDA)</i>		
<b>LUNCH</b>			
11:50 am – 1:00 pm	<b>LUNCHEON KEYNOTE—BOB GARINO, USDA NATIONAL AGRICULTURAL STATISTICS SERVICE</b>		
Concurrent Sessions	<b>Livestock Track Room 103</b> (Miranda Duschack, presiding)	<b>Horticulture Track Room 104</b> (Katie Nixon, presiding)	
1:00 – 1:50 pm	<i>Grazing Wedges</i> Dr. Justin Sexten (MU)	<i>Native Seed Production</i> Jerry Kaiser (Plant Materials Center Elsberry)	
1:50 – 2:40 pm	<i>How to Bring Your Meat to Market</i> John Jordan (MDA)	<i>Growing Strawberries for Profit: A Farmer's Perspective</i> Ron Rushly (Little Dixie Family Farm)	
2:40 – 3:10 pm	<b>BREAK, NETWORKING AND VISITING VENDORS</b>		
Concurrent Sessions	<b>Livestock Track Room 103</b> (Susan Jaster, presiding)	<b>Aquaculture Track Aquaculture Building</b> (Reneesha Auboug, presiding)	<b>Horticulture Track Room 104</b> (Shon Bishop, presiding)
3:10 – 5:30 pm	<i>Integration of Silvopasture for Livestock and Maintaining Wildlife Biodiversity</i> Dr. Dusty Walter (MU)	<i>Cage Culture of Food Fish in Existing Ponds</i> Dr. James Wetzel (LU) and Jacob Wilson (LU)	<i>Growing Vegetable Seed For Market</i> Art Davidson (Baker Creek Heirloom Seeds)
	<i>Small Ruminant Herd Management</i> Dr. Charlotte Clifford-Rathert (LU)		<i>LUCE Commercial Vegetable Program- An Overview</i> Steven Kirk (LU)

2014 tomato field day held at the Univ. of Missouri Southwest Research Center (Mt. Vernon, MO), led by Lincoln University.



2501 Program



Tuesday, July 15, 2014

## Tomato Field Day

5:00 - 7:00 PM

Southwest Research Center, Mt. Vernon, MO

### Directions

**I-44 West:** take exit 44, turn left onto County Road 1100, travel 2 miles following Highway H, Research Center will be located on your left

• • •

**I-44 East:** take exit 38, turn right onto Highway 97 and an immediate left onto County Road 2140 (turns into Highway H), travel 4 miles, Research Center will be located on your right

High Tunnel tomato production in southwest Missouri can be a lucrative venture for vegetable farmers. Please join us for an informative evening with presentations and a tomato tasting!

This workshop will be led by:

- **Patrick Byers**, University of Missouri: Soil Fertility and Management
- **Dr. Zelalem Mersha**, Lincoln University: Identification and management of Common Tomato Diseases
- **Dr. Jaime Pinero**, Lincoln University: Monitoring and Management of Key Pests in High Tunnel Tomatoes
- **Nahshon Bishop**, Lincoln University : High Tunnel Tour and Tomato Tasting

Second Vegetable and IPM Festival held at LU Carver Farm on August 14, 2014



# VEGETABLE

and **INTEGRATED PEST MANAGEMENT**

# FESTIVAL

4:00 – 7:00 pm, Thursday, August 14, 2014

Lincoln University George Washington Carver Farm

3804 Bald Hill Road, Jefferson City, MO, 65101

This free event will showcase various aspects of crop production including vegetables, cover crops, and pest management tools that are effective and help conserve beneficial arthropods.

Small- and mid-scale farmers and gardeners will receive research-based information / demonstrations on various aspects of sustainable agriculture.

### Demonstrations and Presentations

Cover Crops for Vegetables ~ Sweet / Chili Pepper Production ~ Integrated Disease Management of Watermelon ~ Research Update on Trap Cropping ~ Weed and Insect Pest Management in Jack-o'-Lantern Pumpkin Production ~ Native Plants as Specialty Crops ~ Native Plants for Native Pollinators ~ Aquaculture: friends and pests ~ Missouri aquaculture eats ~ Cover Crop Grazing by Goats / Sheep ~ Edamame / Soybean variety trial ~ Living Mulch with Sweet Corn / Green Beans ~ Monitoring and Management of Invasive Insects including Spotted Wing Drosophila (SWD) – *free bait and traps*.

### **WATERMELON AND TOMATO TASTING!**

This is a FREE event, registration is not required but encouraged. To register, contact Vonna Kesel at [keselv@lincolnu.edu](mailto:keselv@lincolnu.edu) or (573) 681-5312. Please let us know if you require special accommodations.

*Lincoln University is an equal opportunity provider and employer*

## **Project 14: River Hills Elderberry Producers Market Enhancement and Continuing Grower Education Project**

### **Missouri River Hills Elderberry Producers**

Terry Durham  
Final Performance Report

#### **Project Summary**

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This proposal's objective is to support and further the education of farmers and agricultural landowners who have committed acreages to elderberries, to attract more elderberry growers, and to provide a ready market for berries through retail product development that supports growers.

Previous projects, upon which the **Market Enhancement and Continuing Grower Education Project** was built, include **Grower Support & Value-Added Education Project (2011)**; the **Grower Recruitment Project (2010)**, which launched an education module to encourage elderberry production, resulting in many new growers and additional acreage; and **New Crop for a New Age: Innovation and Marketing of Elderberry Plantations and Value-Added Products (2009)**, which built on the project by providing potential growers with information on the marketing advantages and crop production of elderberry plantations. Elderberry is under-produced in the United States, resulting in 95% imports of elderberry ingredients, usually in the form of juice.

Elderberry's reputation as a "super-fruit" containing excellent antioxidant and anti-viral components continues to grow. It is highly sought after by a large number of food and beverage manufacturers, and consumers are becoming better educated, seeking more natural sources of daily consumption.

#### **Project Approach**

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The project used the following objectives to reach out to established and new elderberry producers, and to increase market potential for elderberry products:

Marketing: factors affecting marketing, from distribution and supply chain to targeting consumer interest and working directly with retailers was researched and implemented. Marketing materials were redesigned to create a more cohesive and attractive message.

Education: Speaking at conferences, education booths at trade shows, tasting at retail establishments and advertising in key publications promoted the third Comprehensive Elderberry Workshop and Farm Tour, a farmer-oriented intensive education event.

Web presence: The River Hills Harvest web site was enhanced for general education, grower access to the community of elderberry growers and experts, and for promotion of elderberry as a cash crop option for farmers. Consumers are also driven to the website through marketing materials available at local retailers and distributed at public tasting opportunities.

#### **Goals & Outcomes Achieved**

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**Goal**: To encourage elderberry production and value-added processing.

**Performance Measure**: Increase in number of growers and acres.

**Benchmark:** Five growers committed to growing 80 acres of elderberries for RHEP. Independent growers have planted large acreages: 40A, 25A, 12A, 12A = 89A for four growers, with dozens of 1A patches.

**Target:** 20 to 30 growers supporting 125 or more acres. According to our count, the number of growers more than doubled from 2011 to 2012 growing seasons, from about 59 to about 130. From 2012 to 2014 another 180-plus growers were added.

- 1) Distribution and supply chain was expanded into cooperative grocery stores employing grower/marketers. In addition, a wholesale system was established to distribute to grocers and health specialty retailers. Currently over 200 retail entities carry River Hills Harvest brand products, and four wholesale distribution points have been activated, all in the Midwest, which can ship to anywhere in the U.S. Online sales also continue on an individual case basis. (In 2014 an additional 200 stores are projected to be added due to increased quantities of berries provided by increased crop yields from more farmers, more acreage and more mature plantings.)
- 2) On-site display and education offerings at local and regional farm conferences and exhibitions: Terry Durham spoke at six events on behalf of MoRHEP; presented information at eight local and regional conferences and trade shows; showcasing to 15,000 potential growers and adding 505 names to email list; distributing 4,000 pieces of information from these meetings.
- 3) Comprehensive Elderberry Workshop and Farm Tour – 160 farmers with over 90 unique potential growers, attended the workshop and farm tour held June 7-8, 2012. From that number, 59 Missouri growers attended the MoRHEP cooperative organizational meeting.
- 4) In addition to the trade show contract results, we prepared an on-site simple questionnaire that asked:
  - a) Have you been aware of elderberries as a farm crop prior to receiving this information?  
Yes: 95 No: 25
  - b) Having this information, are you considering raising elderberries as a farm crop?  
Yes: 75 Not at this time: 45
  - c) Would you like to receive additional information or participate in a farm day or attend an event that targets learning more about elderberry production and processing?  
Yes: 120 No: -0-
- 5) Over 600 farmers attended farm tours and education events at Terry Durham's Hartsburg fields.

## **Beneficiaries**

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Connections and relationships between farmers have increased options and opportunities. MoRHEP growers have created new products and also supply ingredients for other products, including spirits and wine, chocolate, ice cream, and yogurt to date. Organic elderberry growers are planning to start an organic processing facility in Missouri.

Growers have increased the value of their farms by planting elderberry, and subsequently harvest a new high-value specialty crop that increases farm income. According to our count, the number of growers more than doubled from 2011 to 2012 growing seasons, from approx 59 to approx 130. From 2012 to 2014 another 180-plus were added. As of 2014, an estimated 300 elderberry growers, produced and harvested the largest crop, most from three-year-old fields. Farmers' communities benefit from increased

farm value and income, as well as from increased employment opportunities in the form of farm labor and processing employment.

University of Missouri health researchers utilized RHEP pure elderberry juice from *Sambucus Canadensis*, the American elderberry, the first research of its kind conducted on elderberries that did not originate in Europe. This research is expected to encourage use of elderberry products in the future as more is learned about benefits of consuming elderberry.

With the aid of this funding opportunity, MoRHEP has come one step closer to educating growers and securing the number of acres necessary to pursue organization as a cooperative. The 2014 crop yields and number of growers involved indicates the time to create a cooperative is at hand.

## **Lessons Learned**

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All outcomes were achieved satisfactorily.

- 1) Marketing efforts have been successful, increasing the number of stores and distribution channel.
- 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) The destemmer and custom tools are necessary, mandated by FDA, which drives costs up for farmers, but also increases value of crop and safety for the consumer.
- 4) The growing environment is changing due to crop increases. Dynamic changes (new pests, climatic differences from year to year) require growers to respond quickly, so ongoing research into culture and safety considerations require additional education from professional technicians as well as other farmers. All entities need support to learn best cultural practices.
- 5) More rural areas are implementing internet access and growers are beginning to use the services available through the internet, including communication, research, and purchasing.
- 6) Consumers respond best when the 'face of the farmer' is present at tastings, retail opportunities and events/festivals.
- 7) While farmers and landowners are interested in on-site reference tools; being able to see and discuss the problems, solutions and best practices involved in elderberry production with experts and other growers adds value to their education. Farmers will travel to exhibitions, small group intensive educational activities, and farm tours, to acquire educational experiences.

## **Contact Information**

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## **Project 15: Missouri Wine and Grape Board Consumer Behavior Research**

### **Missouri Wine and Grape Board**

Jim Anderson and Teah Hopper  
Final Performance Report

### **Project Summary**

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Seeking to increase sales, volume and market share, the Missouri Wine and Grape Board (MWGB) conducted a telephone survey of Missouri wine drinkers in 2010 to determine brand awareness. The results yielded high brand awareness and high quality ratings, yet purchases of Missouri wines did not correlate. Reporting a low awareness to consumption conversion, the MWGB conducted additional research to probe further to understand the psychological and behavioral factors that lead to any barriers that are impacting consumption and purchase of Missouri wine and grape products. The specific issue this research hoped to resolve was a lack of knowledge about the behavior of wine consumers in Missouri.

The consumer behavior research consisted of a quantitative online survey and qualitative focus groups to gain a deeper understanding of purchase decisions of Missouri wine. The MWGB decided the research was necessary before moving forward with goal setting and determining marketing strategies. The research was conducted in a timely manner so that new marketing strategies could be developed and promptly put in place to assist Missouri wineries in increasing sales and the overall economic impact of the Missouri wine industry. This project was not built on a previously funded project.

### **Project Approach**

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The consumer behavior research began in late 2011 with the distribution of a quantitative online survey administered by Wine Opinions. A summary of the research findings is attached. Findings from the survey and an initial report were given to the MWGB staff so that planning could be made for the follow-up focus group research. Focus group planning consisted of identifying markets for conducting focus groups, selecting focus group candidates and developing research questions and a script for the moderator. Qualitative focus groups were conducted throughout the state (St. Louis, Kansas City, Columbia and Springfield) by the Prell Organization in the weeks following and all research results and recommendations were presented to the MWGB in January of 2012. A summary of the Prell research findings and recommendations are attached. In early spring, the Board met to reevaluate their goals and identify new strategies based on the research findings. The following months were spent selecting a new advertising agency to help the Board reach their goals and develop marketing strategies. Paradowski Creative was awarded the state contract and was named the Board's new agency in July of 2012. Since then, a new brand platform and campaign have been developed and tested and will launch in January of 2013.

The MWGB worked with Hughes, their previous advertising agency, and subcontractors, Wine Opinions and the Prell Organization to conduct a consumer behavior research study that implemented both quantitative and qualitative methods. Both subcontractors were knowledgeable in their own field of research and had previous experience with the wine industry. The research results and recommendations were accurate and relevant due to their professional experience.

## **Goals & Outcomes Achieved**

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The goal of the project was to conduct research that would provide a specific marketing and messaging direction targeted at the core wine drinker to increase Missouri wine consumption. Quantitative and qualitative research was conducted and the results of the research were used to not only develop a new marketing direction and programs, but a whole new brand platform, as well. The findings from both the quantitative online survey and the qualitative focus groups are attached for review.

While a new marketing campaign and programs have been developed and will be launched in 2013, the long term goal of increasing wine sales and the economic impact of the Missouri wine industry will not be measurable until the new strategies have been executed and in the market place long enough to have an impact.

Actual accomplishments align with the goals established for this project as the research was conducted and findings were used to conduct additional research and ultimately develop a new brand architecture, marketing campaign and programs.

As communicated above, the research project has been completed and the results of the research were used to develop a new brand, a new marketing campaign and new marketing programs (such as the varietal of the month program). Evidence of these three outcomes are attached to show the progress being made toward achieving the ultimate long term goal of increasing wine sales and the economic impact of the Missouri wine industry. Additionally, a wholesale subcommittee has been formed to increase distribution of Missouri wines in the wholesale market. A quality subcommittee has been appointed and a sweetness scale has been developed to help improve the perception of wine quality. Lastly, an education subcommittee was formed and a varietal of the month program has been developed to educate consumers on our grape varieties and increase familiarity of their names.

## **Beneficiaries**

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The beneficiaries of this research are the 118 winery owners and many more grape growers across the state. The results of the research were presented to industry leaders at Marketing and Board meetings. Hard copies of the report findings are available to wineries upon request.

The results of the quantitative and qualitative research findings helped the Board develop marketing strategies, educational programs and a new brand platform and campaign that will promote Missouri wine and attract wine consumers to purchase Missouri wine. Several new programs will help clear up confusion in the market place and increase the economic impact of the Missouri wine industry.

## **Lessons Learned**

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While much helpful information was gained from the research, there was no clear answer or solution. Research, especially qualitative research, brings much data and often more questions. After the findings were reported, it was clear there were many directions the Board could go. The MWGB is made up of a group of 11 individuals. Getting everyone on the Board to agree the best action to take and make a decision was challenging and was more timely than originally anticipated.

As mentioned above, research findings can often cause one to ask more questions. The results of the research spurred the Board to spend time re-evaluating their brand foundation and core values and ultimately led to additional testing of the current logo and consumer reactions. An appreciation of research has spurred from the project and much insight has been gained.

## Contact Information

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### **Project 16: Chestnut Weevil Monitoring: Developing a Comprehensive Strategy for Pest Management**

#### **University of Missouri, Center for Agroforestry**

Dr. Bruce Barrett and Dr. W. Terrell Stamps  
Final Performance Report

## Project Summary

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The most important economic pests of chestnut in the United States are the larger chestnut weevil (*Curculio caryatrypes*) and the lesser (or small) chestnut weevil (*Curculio sayi*). In Missouri, the lesser chestnut weevil is the dominant species. Chestnut weevils are re-emerging pests of the rapidly growing chestnut industry, and Missouri is an ideal location for chestnut production; but the lack of basic biological knowledge and appropriate monitoring techniques have led to calendar-based pesticide applications to control these highly destructive weevils. Very little is known of the biology and chemical ecology of the native species of chestnut weevils. The overall goal of our proposal was to expand on our previously funded project in determining possible key weevil attractant plant volatiles for use in pest monitoring schemes. From the prior project, we determined a number of likely volatile organic compounds (VOCs) from chestnut burs, nuts and catkins. Chestnut weevils exhibited physiological responses to the compounds through electroantennography (EAG) and behavior responses through y-tube olfactometer bioassays.

To build upon these findings, this project proposes to examine the VOCs exhibiting the greatest physiological and behavioral responses through further EAG and bioassay experiments.

Objective 1 - Evaluate adult chestnut weevil behavioral dose-response to chestnut volatiles through laboratory bioassays using VOCs previously identified as promising; Objective 2 - Evaluate adult chestnut weevil physiological dose-response to chestnut volatiles through electroantennography. This project also attempted to examine weevil response to possible sex pheromones. Objective 3 - Evaluate adult chestnut weevil behavioral response to possible sex pheromones. Objective 4 - Evaluate adult chestnut weevil physiological response to possible sex pheromones through electroantennography). Dose-response and ratios of more than one VOC can be important in insect host location and attraction. Different doses and ratios of compounds can dramatically affect their attractiveness to the target insect. The project's main goal was to develop a comprehensive picture of the chestnut weevil's chemical ecology as it pertains to host and mate location. It is hoped that such information will aid in the development of an effective monitoring tactic.

## Project Approach

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Weevil behavioral bioassays to VOCs (dose-response). Bioassays examined the behavioral response of adult weevils exposed to four previously identified chestnut VOCs: 2-heptanol, (E)-2-hexenal, ethyl

butyrate, and ethyl isobutyrate. These compounds were each tested at four dose ratios (compound/solvent mineral oil): 0.1, 0.01, 0.001, and 0.0001, using a Y-tube olfactometer apparatus. Each plant VOC was assayed with at least 10 weevils (for both male and female). Different dose-ratios elicited different responses in weevil behavior, especially in male weevils. For the 2-heptanol treatment, the males were attracted most to the 0.01  $\mu\text{L}$  dose, but repelled at the 0.001  $\mu\text{L}$  dose (Figure 1). No males found that compound attractive at the 0.1  $\mu\text{L}$  dose. For female weevils, there appeared to be no strong attraction at any of the doses. For the (E)-2-hexenal treatment, the male weevils showed strong attraction towards the 0.1, 0.001 and 0.0001  $\mu\text{L}$  doses. Interestingly, the female weevils did not display a strong attraction to this VOC at any of the doses. For the ethyl butyrate treatment, the males were most attracted to the 0.1  $\mu\text{L}$  dose (Figure 1). The females did not display a strong preference for this VOC. For the ethyl isobutyrate treatment, the males were most attracted to the 0.1  $\mu\text{L}$  dose. Female weevils showed some attraction to this VOC, especially at the 0.1 and 0.001  $\mu\text{L}$  doses. Data from both periods of adult emergence were combined in to bolster repetitions and show the consistent significant avoidance of female *C. sayi* to trans-2-hexenol at 0.1  $\mu\text{L}$  (Figure 3). Trans-2-hexenol, trans-2-hexenal, 2-heptanone, and ethyl butyrate all showed responses at different doses that require further explanation. The results strongly suggest that each of these four VOCs, at the 0.01  $\mu\text{L}$  and 0.1  $\mu\text{L}$  doses, show promise as a component (or one of several components) in a plant VOC-based monitoring lure for *C. sayi*.

Weevil physiological bioassays to VOCs (dose response). The same four VOCs used in the first objective were tested at the same dose-ratios in experiments involving EAG. For the 2-heptanol treatment the largest EAG amplitude response occurred when the antennae were exposed to the VOCs at the 0.01  $\mu\text{L}$  dose. For female antennae, they were most sensitive to the VOC at the 0.01 and 0.1  $\mu\text{L}$  doses (Figure 2). For the (E)-2-hexenal treatment, the largest EAG responses from male and female antennae occurred at the 0.01  $\mu\text{L}$  dose. For ethyl butyrate, the male antennae showed the greatest EAG response at the 0.01 and 0.1  $\mu\text{L}$  doses, whereas the female antennae were most sensitive at the 0.1  $\mu\text{L}$  dose. For the ethyl isobutyrate treatment, the greatest responses from the male and female antennae came from the 0.01  $\mu\text{L}$  dose, but these responses (for both sexes) probably were not significantly greater than the EAG responses at the 0.0001 and 0.1  $\mu\text{L}$  doses (Figure 2). When comparing weevil responses from emerging adults from the two emergence periods, adult weevils (of both sexes) that emerged during the spring period responded to all four compounds at the 0.1  $\mu\text{L}$  dose (except for ethyl butyrate). Male weevils collected in the spring also responded to trans-2-hexenol at the 0.0001  $\mu\text{L}$  dose. Male weevil responses also tended to be larger than emerging females in the spring, especially at the 0.01  $\mu\text{L}$  dose for trans-2-hexenal (Figure 4). Adult weevils emerging during the fall period of both sexes similarly responded to all compounds at 0.1  $\mu\text{L}$ . Male weevils did however respond at 0.01  $\mu\text{L}$  for trans-2-hexenol and 2-heptanone. Also both sexes responded at 0.001  $\mu\text{L}$  to trans-2-hexenol and females responded to trans-2-hexenal at 0.001  $\mu\text{L}$ . The male response to 2-heptanone was particularly large with almost twice the amplitude of other VOC responses (Figure 5). In summary, both male and female antennae responded to all of the compounds tested. Weevil antennae appeared to have the greatest response to the higher doses, 0.01 and 0.1 ratios.

## Goals & Outcomes Achieved

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The goals of Objectives 1 and 2 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. Due to the very variable (and low) numbers of weevils that emerged from the field site during the project period, Objectives 3 and 4 of the proposal were not conducted (see Lessons Learned section).

Additionally, several papers and poster presentations were produced during the project period. For example, data from the project was presented at the Entomological Society of America Annual meetings in Reno, NV, Knoxville, TN, and Austin, TX, as well as at Missouri Life Sciences week at the University of Missouri (see Additional Information section for complete listing).

The data from the project was primarily presented/reported as "several papers and poster presentations" given at scientific and professional meetings. How many participants at these meetings actually read the posters or listened to talks is unknown. However, I estimate that the total number of people at such meetings and were interested in the data to be about **200-300 people** (total over the course of the project).

## Beneficiaries

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Primary beneficiaries from this project have been fellow scientists in the field of chemical ecology and chestnut growers. The initial information garnered is foundational in nature. I do not know how many fellow scientists have utilized our data to help further their own research. Just as important, chestnut growers will benefit from the information built upon the data from this project. Data from our project has been included in many state, regional and national presentations covering the overall chestnut program at the University of Missouri, and it is estimated that during the project time period that approximately **300 chestnut growers and potential chestnut growers** have been exposed to data from our project.

Additionally, the ultimate utilization of the project's data would be to "aid in the development of an effective monitoring tactic" for the chestnut weevil. However, I am not aware of any individual/group that has used our data to develop such a monitoring tactic. Hence, I cannot provide a potential economic benefit of the project.

The continued refinement of dose-response for specific attractive VOCs and investigation of the most attractive mixtures of VOCs will be the basis for the creation of 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.

## Lessons Learned

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Due to the variable (and often low) numbers of weevils that emerged from the field site during the project period (especially in 2013), the laboratory bioassays designed to examine weevil responses, behaviorally and physiologically, to potential *Curculio sayi* sex pheromones (Objectives 3 and 4) were not conducted. Weevils can only be captured during the spring and fall periods (with each period lasting only about 3-4 weeks). In addition, the number of beetles that emerge at these times may vary greatly from year to year. Unfortunately, we had only sufficient numbers of weevils available during 2012 (and to some extent during 2013) to complete Objectives 1 and 2.

## Contact Information

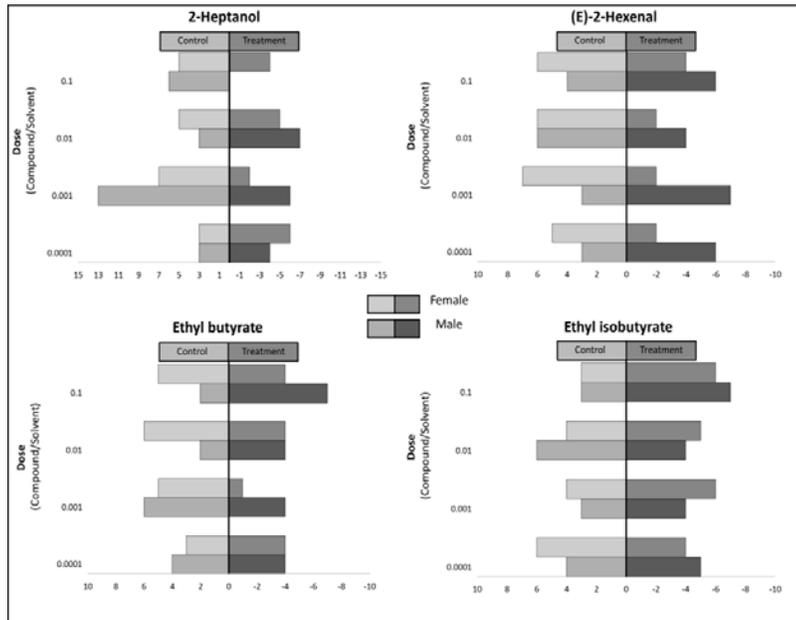
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Dr. Bruce A. Barrett  
(573) 882-3446  
[barrettb@missouri.edu](mailto:barrettb@missouri.edu)

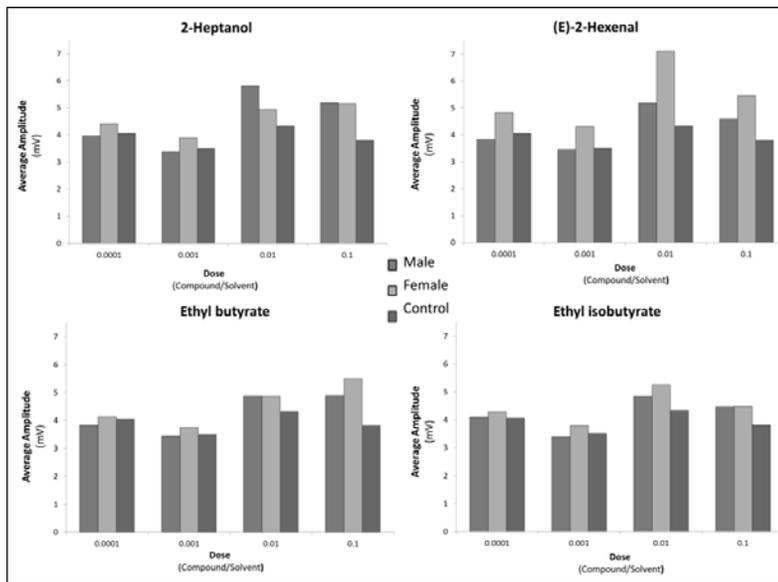
## Additional Information

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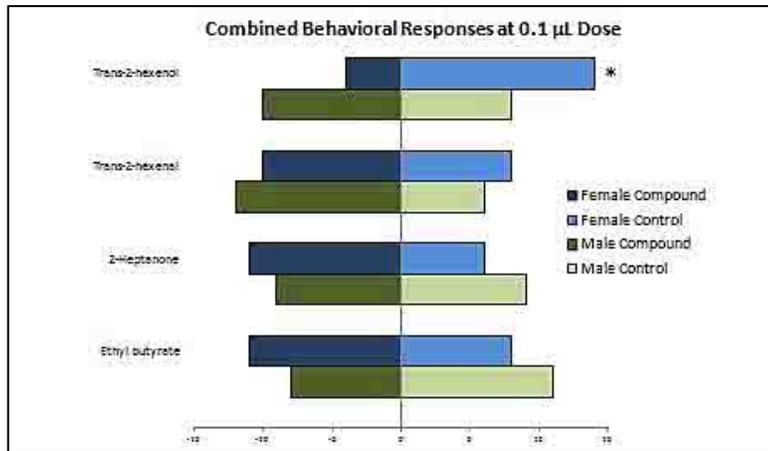
**Figure 1.** Responses of *Curculio sayi* in a Y-tube olfactometer choice test using adults collected during the spring emergence period. Data are represented as percentage of beetles, per sex, responding toward the control or treatment arm of the olfactometer per chestnut VOC at four doses.



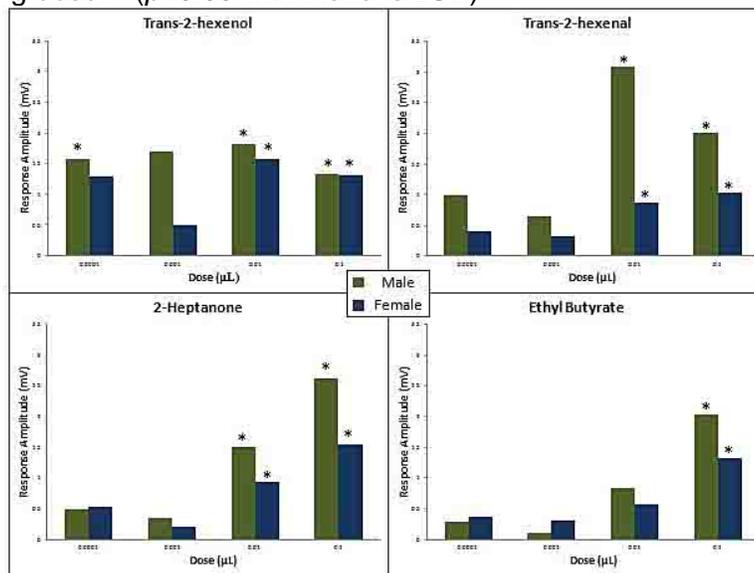
**Figure 2.** Average EAG antennal responses (mV) of male and female *Curculio sayi* adults collected during the spring emergence period to odors emanating from Chinese chestnut (*Castanea mollissima*) VOCs per dose.



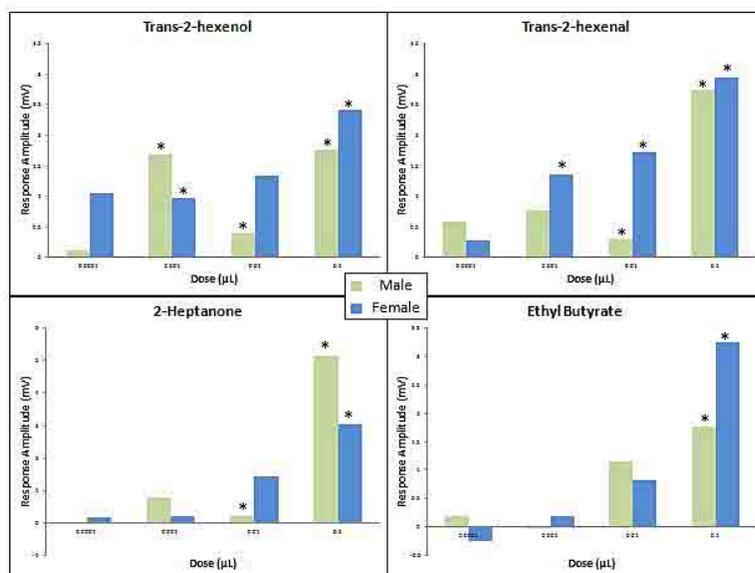
**Figure 3.** Responses of *Curculio sayi* in a Y-tube olfactometer to a two-choice test with the number of choices being represented for male and female adult weevils. \*( $p < 0.05$  with Pearson's Chi-squared)



**Figure 4.** Average EAG antennal responses (mV) of spring emerging *Curculio sayi* normalized by subtraction of average control amplitude per dose. Significance represented between each response and its accompanying dose. \* ( $p < 0.05$  with Fisher's LSD)



**Figure 5.** Average EAG antennal responses (mV) of fall emerging *Curculio sayi* normalized by subtraction of average control amplitude per dose. Significance represented between each response and its accompanying dose. \* ( $p < 0.05$  with Fisher's LSD)



## 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.

Preliminary data on the physiological and behavioral dose-responses of the lesser chestnut weevil (*Curculio sayi*) to volatile organic compounds from its host plant. Andrew Fill, Bruce A. Barrett and Ian W. Keesey (University of Missouri); Entomological Society of America Annual Meeting, Knoxville, TN, November 13, 2012.

Physiological and behavioral dose-responses of the lesser chestnut weevil, *Curculio sayi*, to host plant volatile organic compounds. Andrew Fill and Bruce A. Barrett (University of Missouri); Entomological Society of America Annual Meeting, Austin, TX, November 11, 2013.

## Peer-Reviewed 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.