Oklahoma Department of Agriculture, Food, and Forestry

(ODAFF)

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Final Report

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DOES CATTLE GRAZING INCREASE THE FOOD SAFETY RISKS OF NATIVE PECAN

Project Summary:

Recent foodborne illness outbreaks associated with tree nut consumption highlight the need for a basic understanding of the natural occurrence of foodborne pathogens and the potential contributing factors, including cattle grazing, which may lead to tree nut contamination. The goals of this project were to assess the natural occurrence of two major foodborne pathogens, shiga-toxin producing Escherichia coli (STEC) and Salmonella, in native pecan production and to determine the influence of cattle grazing in such incidence. Samples of soil, water, cattle feces, pecans (from the ground and processed), and wild animal fecal swabs were collected from eight pecan orchards (four grazed by cattle and four without) at pre-harvest (two months before harvesting) and during harvest. Swabs from harvesting equipment surfaces were also collected during harvest. Isolation and detection of STEC and Salmonella were performed by enrichment, selective isolation/enrichment, and multiplex PCR. Molecular typing of isolates was conducted by pulsed-field gel electrophoresis (PFGE) and serotyping was performed by Lumina xMAP®. While both pathogens were detected in both types of pecan production fields, STEC was more common than Salmonella. Salmonella was detected in pre-harvest and harvest soil samples from an orchard without cattle grazing as well as cattle feces on grazed orchards at pre-harvest; however, no Salmonella was detected in ground or processed pecans during harvest or pre-harvest, regardless of cattle grazing. The percentages of STEC-positive pecans (from the ground or processed) were significantly different between orchards with (7.5%) and without cattle grazing (1.7%). A possible contamination route for STEC contamination was identified from cattle feces to harvesting machinery after PFGE profiling of STEC isolates. The results of this project show the presence of human pathogens, STEC and Salmonella, in native pecan production and the complicated contamination sources that contribute to such contamination, including cattle grazing and other potential factors

Project Approach:

Most of the samples collected in this project were environmental samples, such as soil, ground cover, and animal feces. The challenge in detection of human pathogens in these samples by polymerase chain reaction (PCR) is the presence of PCR inhibitors in such matrices. Therefore, we initially conducted series of experiments to develop a simple, rapid, sensitive, and cost-effective method for the detection of Salmonella in environmental samples. Using the same strategy, we then conducted series of experiments to develop a similar method for the detection of STEC in environmental samples. The developed methods were used in the subsequent analysis of collected samples throughout the project.

Native pecan orchard selection (4 grazed orchards and 4 without), sample collection from pecan orchards at preharvest (August-September, 2013), harvest, and handling stages (October, 2013-February, 2014), microbiological analysis (culture-based and molecular) of collected samples were conducted in a timely manner (once the samples were collected from each orchard). The characterization of isolates of STEC and Salmonella were performed at the later stages of the project

Goals & Outcomes Achieved:

We have developed simple, rapid, sensitive, and cost-effective multiplex PCR methods for the detection of *Salmonella* and shiga toxin-producing *E. coli* in environmental samples (one article published and one in preparation) that could be used in similar projects.

In total, 275 samples were collected including soil, irrigation water, pecans (immature fruit and matured pecans), cattle feces, wild animal fecal swabs, and harvesting equipment surface swabs. Among the two pathogens tested, STEC was more prevalent than *Salmonella*, with 8.0% of samples positive for STEC comparing to 2.9% positive for *Salmonella* (Table 1). The majority of STEC-positive samples were cattle feces, along with soil, equipment surface, pecans (collected from orchards with and without cattle grazing). *Salmonella* was detected in pre-harvest and harvest soil samples from an orchard without cattle grazing as well as cattle feces on grazed orchards at pre-harvest; however, no *Salmonella* was detected in ground or processed pecans during harvest or pre-harvest, regardless of cattle grazing. The percentages of STEC-positive pecans (from the ground or processed) were significantly different between orchards with (7.5%) and without cattle grazing (1.7%), suggesting an increased food safety risk associated with cattle grazing.

Table 1. Occurrence of *Salmonella* and shiga toxin-producing *E. coli* in samples collected from native pecan orchards

Source	Number (%) of samples positive			
	Salmonella		STEC	
Orchards without grazing cattle				
Soil (n = 24)	3	(12.5%)	0	(0%)
Pecan (n = 56)	0	(0%)	1	(1.7%)
Water (n = 4)	0	(0%)	0	(0%)
Wild animal (n = 11)	0	(0%)	0	(0%)
Equipment (n=38)	0	(0%)	0	(0%)
Orchards with grazing cattle				
Soil (n = 24)	0	(0%)	2	(8.3%)
Cattle feces (n = 24)	4	(16.7%)	14	(58.3%)
Pecan (n = 53)	0	(0%)	4	(7.5%)
Equipment (n=41)	1	(2.4%)	1	(2.4%)
Total positive samples (n=275)	8	(2.9%)	22	(8.0%)

DNA fingerprinting of the orchard isolates of STEC and *Salmonella* had revealed identical patterns between the isolates from cattle fecal sample and the harvest equipment surface in a same grazed orchard (grazed #2, G2), suggesting a possible contaminating route from cattle to the equipment (Figure 1).

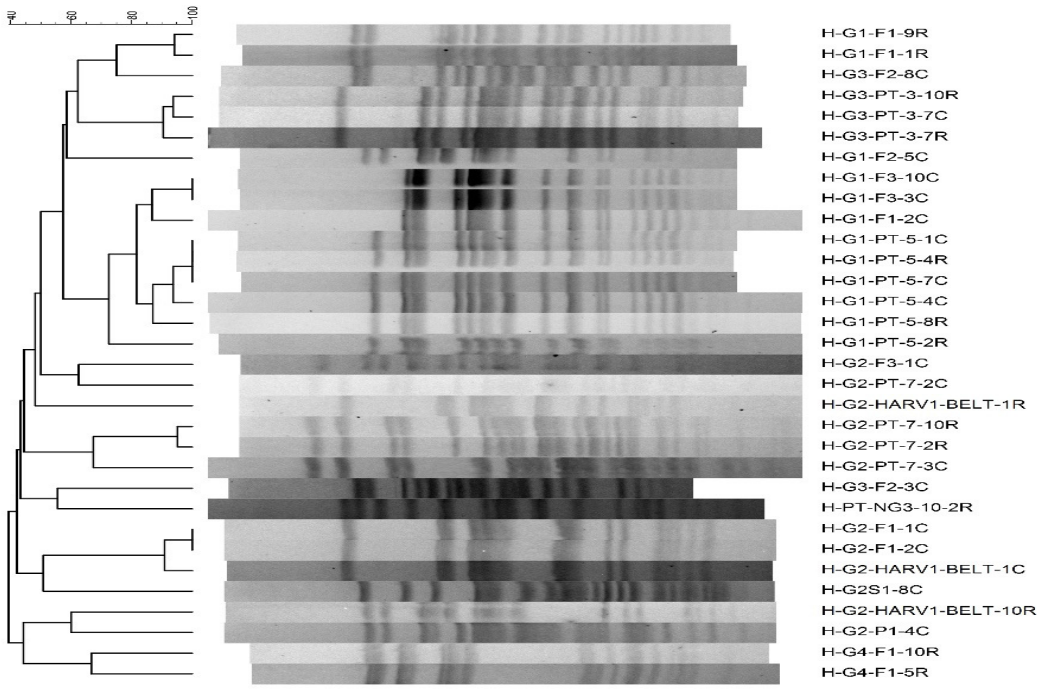

Figure 1. Dendrogram of pulsed-field gel electrophoresis patterns showing the relatedness of shiga toxin-producing *E. coli* isolates recovered from a portion of the native pecan orchards. The cluster cutoff was set at 85% similarity.

Beneficiaries:

We worked primarily with Pecan Growers in Oklahoma. The results from this project had been shared through presentations at Oklahoma Pecan Growers Association meetings, International association for Food Protection annual meetings, and seminars at other academic institutions.

Lessons Learned:

The work could not have been achieved without the support of native pecan growers in Oklahoma. Sharing information in lay terms with growers involved is critical for building a trust relationship.

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Additional Information:

Dobhal, S., G. Zhang, C. Rohla, M. W. Smith, and L. Ma. 2014. A simple, rapid, cost-effective, and sensitive PCR method for detection of *Salmonella* in environmental and pecan samples. J Microbiol. Methods. DOI: 10.1002/jsfa.6640.

USE OF NONDESTRUCTIVE HANDHELD SENSOR TECHNOLOGIES TO ASSESS NITROGEN USE EFFICIENCY AND PLANT QUALITY IN OKLAHOMA FLORICULTURE SPECIALTY CROPS

Project Summary:

Hand-held, nondestructive, optical sensors (GreenSeeker™, SPAD, and atLEAF) were evaluated as tools to quickly predict plant nitrogen status. These sensors can be used to increase Oklahoma horticulture industries profitability over the long-term by providing a means to quantitatively assess crop growth and nutrient needs. Replicated greenhouse experiments were conducted at the Oklahoma State University Horticultural Research Greenhouses over two growing seasons. This research provided growers with quantitative sensor values associated with crop production for several important greenhouse crops to maximum production efficiency and consistency as related to nitrogen fertilization and monitoring plant nutrient status. Economic margins are tight for greenhouse growers, so they are constantly looking for efficient ways or new technology to improve productivity, enhance competitiveness, and increase sustainability.

Project Approach:

Spring Experiment (2013)

Early in February, the following plugs were received:
- Begonia 'Fibrous Bronze Leaf Eureka White' and 'Fibrous Green Leaf Eureka White' cultivars
- Marigold 'American Inca II Orange' and 'American Inca II Yellow' cultivars
- Zinnia 'Interspecific Profusion Yellow' and 'Interspecific Profusion White' cultivars
- Geranium 'Diploid Maverick Light Salmon' and 'Diploid Maverick Red' cultivars

Plugs were transplanted into standard 6" pots filled with media. Cultivars were distributed throughout the greenhouse in a completely randomized design (CRD).

Species	Received	Transplanted	Fertilized	1st Sensed	Recovered	Ended
Begonia	02/05/2013	02/20/2013	03/21/2013	03/27/2013	04/03/2013	04/24/2013
Marigold	02/05/2013	02/08/2013	02/11/2013	03/04/2013	03/15/2013	04/05/2013
Zinnia	02/05/2013	02/08/2013	02/11/2013	03/06/2013	03/15/2013	04/08/2013
Geranium	02/05/2013	02/11/2013	02/27/2013	03/15/2013	03/21/2013	04/26/2013

Five different rates of slow release fertilizer were added to the surface of the pots. Treatments were 0, 5, 10, 15 and 20 g of 15-9-12 N-P-K. The experiment, consisting of five treatments replicated 32 times with single pot replications, had a total of 160 pots per cultivar.

After three to four weeks of establishment, plants filled the pots and sensing was initiated using a GreenSeeker™ handheld NDVI sensor, and a Soil-Plant Analysis Development (SPAD) chlorophyll meter. To assure that sensor readings and the foliar nitrogen content represent the same individual plant, eight pots were randomly assigned and numbered per each treatment. Those pots were sensed weekly in the same order with leaves from two plants being sent to the lab for leaf nitrogen content analysis.

After one week of taking readings, fertilizer supplementation was applied to half of the remaining pots and the other half was kept as a recover control. For the 0 g treatment, 12 pots were supplemented with 10 g of 15-9-12 N-P-K, and the rest were left for recovery control, and for the 5 g treatment, 12 pots were supplemented with 5 g of 15-9-12 N-P-K and the rest was left as recovery control, thereby giving a total of 84 pots.

Fall experiments (2013)
In mid-August 2013, the following rooted cuttings and plugs were received:
- Poinsettia; 'Prestige Red' and 'Freedom Red' cultivars
- Dianthus 'Telstar White' and 'Ideal Select' cultivars
- Chrysanthemum 'Amico Bronze' and 'Jacqueline Yellow' cultivars

The same "modified-protocol" used for the spring experiments was used for fall 2013 experiments except a new atLEAF chlorophyll meter was added. The atLEAF meter is similar to the SPAD meter, however, it costs about a tenth of what the SPAD meter costs thus we want to also see if it produced similar or better results as the atLEAF sensor would be accessible to both small and larger growers because of the lower price. For chrysanthemum fertilizer supplementation, half of the 0 g treatment was supplemented with 15 g, half of the 5 g treatment was supplemented with 10 g, and the 10 g treatment was supplemented with 5 g of 15-9-12 N-P-K.

Species	Received	Transplanted	Fertilized	1st Sensed	Recovered	Ended
Dianthus	08/07/2013	08/12/2013	09/05/2013	09/12/2013	09/30/2013	10/25/2013
Poinsettia	08/15/2013	08/21/2013	09/05/2013	09/24/2013	09/30/2013	11/19/2013
Mums	07/11/2013	07/15/2013	07/19/2013	07/29/2013	08/16/2013	11/04/13

Ten random pots per treatment were assigned for the recovery treatments and were sensed for NDVI, SPAD and atLEAF for two weeks for dianthus and four weeks for poinsettias and chrysanthemums.

The experiments were carried out by Rania Basyouni and Amir Khoddamzadeh.

<u>Goals & Outcomes Achieved:</u>

Our established goal was to generate quantifiable data to help growers benefit from the use of optical sensor technology to monitor nutrient needs and plant quality and in their greenhouse crops by expanding the technology to additional horticultural crops and to disseminate the information. The use of these sensors will help growers determine how much fertilizer is needed

by their plants and reduce pollution of nutrient run-off, save on fertilizer costs, and produce better quality plants that will increase profits.

Activities completed: In spring, data was collected using GreenSeeker™ handheld NDVI sensor and a SPAD meter for zinnia, begonia, marigolds and geranium. In the fall, data was collected using NDVI, atLEAF, and SPAD meter for poinsettias, dianthus, and chrysanthemums.

Plant	Fertilizer rate (g)[z]	Optical sensor[y]	Sensor Range[x]	Leaf N Correlation %[w]
Poinsettia 'Freedom Red'	15	NDVI	0.53-0.69	100%
		SPAD	41-53	100%
		atLEAF	46-55	100%
Poinsettia 'Prestige Red'	15	NDVI	0.52-0.75	50%
		SPAD	38-53	75%
		atLEAF	45-55	75%
Chrysanthemum 'Jacqueline Yellow'	15	NDVI	0.82-0.91	17%
		SPAD	36-49	33%
		atLEAF	48-55	0
Chrysanthemum 'Amico Bronze'	20	NDVI	0.82-0.91	83%
		SPAD	35-37	17%
		atLEAF	40-50	0
Geranium 'Diploid Maverick Light Salmon'	15	NDVI	0.44-0.59	50%
		SPAD	48-52	100%
Geranium 'Diploid Maverick Red'	15	NDVI	0.43-0.59	100%
		SPAD	48-53	100%
Begonia 'Fibrous Bronze Leaf Eureka White'	5	NDVI	0.33-0.53	25%
		SPAD	25-40	50%
Begonia 'Fibrous Bronze Leaf Eureka White'	5	NDVI	0.35-0.51	50%
		SPAD	27-44	75%
Marigold 'American Inca II Orange'	10	NDVI	0.43-0.48	75%
		SPAD	57-66	100%
Marigold 'American Inca II Yellow'	10	NDVI	0.40-0.49	100%
		SPAD	59-73	100%
Zinnia 'Interspecific Profusion White'	10	NDVI	0.36-0.45	100%
		SPAD	36-42	100%

Zinnia 'Interspecific Profusion Yellow'	10	NDVI	0.36-0.49	100%
		SPAD	38-44	100%
Dianthus 'Ideal Select Red'	10	NDVI	0.39-0.59	0%
		SPAD	60-67	0%
Dianthus 'Telstar White'	10	NDVI	0.45-0.76	0%
		SPAD	60-65	0%

[z]Based on Osmocote 16-9-12 slow release fertilizer giving optimum flower number or salability percent.
[y]NDVI (Normalized Difference Vegatative Index) using GreenSeeker™ hand held placed 61 cm above the plant canopy and SPAD (Soil Plant Analysis Development) using a Minolta SPAD-502 meter.
[x]Optimum sensor reading starting two weeks after transplanting up to flowering.
[w]Leaf nitrogen concentration correlated with each sensor across three to five weeks.

The goal of communicating this research to greenhouse growers has been achieved with the development of an Oklahoma State University Cooperative Extension fact sheet, which can be viewed at http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-9045/HLA-6719web.pdf. This publication has been viewed and downloaded over 1,700 times since 2014. This research project was reported to five growers at the Oklahoma Nursery and Landscape Associate fall update workshop as part of a tour of the departmental research greenhouses and to Oklahoma growers and landscape professionals at the 68th annual Oklahoma Turfgrass and Landscape Conference & Trade Show in December 2013. Therefore, the target of getting the information out to Oklahoma specialty crop growers has occurred and will continue. We are in the process of publishing full results from this research to reach as many growers as possible too. Results were also presented at ASHS in July 2014 to other scientists and growers to increase results dissemination and to form collaborations to go after federal funding to further this research area.

Beneficiaries:

Greenhouse growers and nursery operations benefit from this research. Oklahoma alone has approximately 150 greenhouse growers both big and small that can adopt the GreenSeeker™, SPAD, and atLEAF sensor technology. It will be exciting to see the technology adoption by the industry and how they incorporate it into their business to assess nutrient needs, quality standards, and consistency because of the ability to quickly monitor plant nutrient status using a nondestructive method. Using optical sensors to monitor plant nutrient needs will prevent product shrinkage in commercial production with timely supplemental nutrient applications, reduce over application of fertilizers, reduce unneeded leaching, reduce time and money associated with collecting leaf samples to be sent to labs for analysis, increase turnover of production space, and increase plant quality. Cutting the fertilizer application rates by 20% in Oklahoma alone would save $100,000 per year in fertilizer costs alone. Reduced leaching can

also help growers meet environmental regulations. Thus, the benefits of this research and technology go beyond individual growers and society as a whole benefits as well.

Lessons Learned:

Sensors data showed a correlation with leaf nitrogen except for dianthus. The slender leaves of dianthus may have affected sampling procedure, thus plants with larger leaves should be targeted.

Both chlorophyll meters, SPAD and atLEAF, were highly correlated with each other except for chrysanthemums where only SPAD showed correlations.

The atLEAF sensor showed similar correlations with leaf nitrogen for poinsettia but not chrysanthemum. So depending on the plant, atLEAF could be a cheaper alternative to SPAD.

When comparing the strength of the correlations, in general SPAD correlated greater than the GreenSeeker™ NDVI sensor for leaf nitrogen concentration. The GreenSeeker™ NDVI showed a weak correlation with leaf nitrogen in the early stages of establishment due to plant small size, thus larger background noise areas interfered with the readings. Also, in later stages of establishment, flower anthesis interfered with the GreenSeeker™ sensor values, making it reliable during mid vegetative stage only.

Results varied between species and cultivars when additional fertilizer was added to plants deficient in nutrients at the time of sensor analysis. Better responses were seen in poinsettia, chrysanthemum, dianthus, and geranium. In zinnia, begonia, and marigold only marginal improvement in plant quality and salability at marketing time was noticed. Additional fertilizer may need to be applied earlier than six weeks into production or at a higher rate than a total fertilizer amount of 15 g controlled release fertilizer per pot if supplemental fertilizer is added late in crop production.

Sampling location and number of samples per leaf, number of leaf samples submitted for leaf nitrogen analysis, effect of plant water status, and plant nutrient status other than nitrogen may explain some of the variability among cultivars, sensors, and correlations thus should be evaluated in future research.

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Additional Information:

Reference to extension or journal publications are listed below.
Basyouni, R., and Dunn B. Oklahoma State University, Division of Agricultural Sciences and Natural Resources. (2013). Use of reflectance sensors to monitor plant nitrogen status in

horticultural plants (HLA-6719-4). Stillwater. Oklahoma: Oklahoma Cooperative Extension Service.

Basyouni, R., and B.L. Dunn. 2014. Oral: The use of nondestructive sensors to assess nitrogen needs of greenhouse plants. HortScience 49:S165. (Abstr.)

Basyouni*, R., B.L. Dunn, and C. Goad. 2015. Use of nondestructive sensors to assess nitrogen status in potted poinsettia *(Euphorbia pulcherrima* L. *(Willd. ex Klotzsch))* production. Sci. Hort. 192:47-53.

Khoddamzadeh, A.A., and B.L. Dunn. 2015. Application of optical sensors for nitrogen management in chrysanthemum. HortScience (submitted)

Khoddamzadeh, A.A., and B.L. Dunn. 2014. Poster: Application of precision agriculture technology to determine N level in chrysanthemum. HortScience 49:S357. (Abstr.)

OKLAHOMA PROVEN PLANT SELECTION PROGRAM

Project Summary:

Oklahoma Proven (*OKP*) is a promotional and plant evaluation program designed to help consumers choose plants appropriate for Oklahoma gardens. Consumers are sometimes frustrated with choices of plant material found in some garden centers and often lack the knowledge to select appropriate plants. In general, there is a significant demand for low input plant materials that are relatively pest free. There are also many plants common to the trade used with great success in Oklahoma, yet remain unknown to the gardening public. The hope is that aiding consumers with plant selection will lead to greater gardening success, enthusiasm, and increased sales for Oklahoma green industries. The program started in 1999 and has been very successful to date. Each year a tree, shrub, perennial, and annual is chosen and promoted. Promotion of *OKP* occurs throughout the year, but a concentrated media push in early February/March is the marketing goal. Posters and brochures are distributed to local nurseries and county extension offices promoting *OKP* plants making it easy for consumers to identify plants that will do well in their gardens. Photographs of *OKP* Plant Selections and the *OKP* logo are available online for use by the media or industry professionals.

Project Approach:

This is an ongoing program, so activities for the promotional year begin the prior year with taking and selecting pictures for promotional material. In the fall the promotional material is created. This material includes updating the web site, developing a poster and brochure, creating flyers, creating a Power Point presentation, and writing articles for news releases. In 2013 we promoted Specialty Fruit for Small Spaces (Collector's Choice), Winterberry Euonymus cultivars (Tree), Chaste tree improved varieties (Shrub), Walker's Low Catmint (Perennial), and Dakota Gold Sneezeweed (Annual); in 2014 we promoted Seven-son flower (Collector's

Choice), Desert-willow (Tree), Blue Muffin Viburnum (Shrub), Switchgrass varieties (Perennial), and Big Twister Corkscrew Rush (Annual).

Brochures and posters are printed at the end of the previous year for mailing early the year of the publication. We printed 10,000 brochures each year (2013/2014), which provide names and pictures of the current year's selections as well as each plant chosen since the beginning of the OKP program in 1999. We mailed two copies to retailers, educators, and others on our OKP mailing list and invited people to request more copies if they so desired. In the early part of each year we distributed approximately 550 posters to retailers, growers, and county extension offices. By the end of each year we distributed nearly all 10,000 copies of the brochures published for that year.

Promotion of Oklahoma Proven occurs throughout the year, but a concentrated media push in February/March is the marketing goal. Local nurseries receive the posters and brochures and a majority of the brochures are distributed to county extension offices and through various workshops and events held throughout the year. The photographs on the OKP Plant Selections webpage and the Oklahoma Proven logo are available for use by the media or industry professionals.

In September of each year, Mike Schnelle and I attended the ONLA Trade Show and distribute fliers of the OKP list and seek feedback and comments from ONLA members. Mike Schnelle also serves on the ONLA Board.

Oklahoma Proven Project partners include an advisory committee made up of university (educators), industry (growers – retail and commercial, landscape, and other horticulturists), and staff in the Agricultural Communications Services Unit. The Advisory Committee acts as a resource for the marketing and plant evaluation coordinators and meets at least once a year. Agricultural Communications staff assists in the layout, design and printing of the poster and brochure.

Goals & Outcomes Achieved:

The *Oklahoma Proven* Selection Program will help consumers choose plants appropriate for Oklahoma by marketing "Proven" plants selected from the evaluation program and from surveys targeted at identifying under-utilized plants. The marketing effort will be statewide and will include television promotion, point-of-purchase materials, and other marketing efforts. Examples include:

- Approximately 200,000 weekly viewers through the *Oklahoma Gardening* television program were exposed to OKP plants through several episodes, which aired each year highlighting the years' selections. Also many OKP plants were planted and labeled in the studio garden which is visited by hundreds of visitors each year.

- Exposure to OKP plant material through workshops, training, and presentations (7 workshops and over 35 presentations through our department alone) were given to the general public, Master Gardener (MG) volunteer program, extension personnel, and

industry. OKP plants were introduced to 322 (2013) and 256 (2014) new Master Gardener volunteers in 28 counties through training.

- A survey was conducted the spring of 2014 through SurveyMonkey. The survey consisted of ten questions and was sent to 300 Master Gardener Volunteers; the results of 100 respondents is as follows.

Q1. Have you heard of the Oklahoma Proven Plant Selection?

Yes – 99 **No** – 1

Q2. If yes to question one, how did you first learn about it?

County Extension Program – 9
Master Gardener Program – 78
Retail Garden Center/Nursery – 5
Other Program (i.e., plant workshops, conference, etc.) – 8

Q3. Several media sources promote Oklahoma Proven Plant Selections, which have you seen or used?

Brochure – 85
Poster – 45
Website – 49
Magazine article – 25
Power Point presentation – 33

Q4. Have you ever purchased plants from the Oklahoma Proven list after learning of the program?

Yes – 92 **No** - 8

Q5. When you shop for landscape plants, do you consciously seek out plants on the Oklahoma Proven list?

Yes – 87 **No** - 13

Q6. Approximately how much do you spend each year on Oklahoma Proven plants?

$0.00 - $49.99 – 33
$50.00 - $149.99 – 45
$**150.00 - $299.99** – 16
$300.00 - $499.99 – 3
More than $500.00 – 3

Q7. Did you buy any of the 2013 plants?

Yes – 45 **No** – 55

Q8. If so, which ones?

Fruits for small spaces – 9
Dakota Gold Sneezeweed – 6
Walker's Low Catmint – 24
Chaste Tree – 26
Winterberry Euonymus – 8

Q9. As a Master Gardener, about how many times or at what frequency per year have you recommended Oklahoma Proven plants to the public?

0 – 4
1-5 – 38
6-10 – 25
11-15 – 9
> 15 – 24

Q10. As a Master Gardener, about how many times have you given presentations about the Oklahoma Proven program to the public?

0 – 73
1-5 – 23
6-10 – 1
11-15 – 1
> 15 – 2

- Media coverage included press releases and articles; articles are initially released in the early issues of Horticulture Tips (http://www.hortla.okstate.edu/research-and-outreach/resources/hort-tips). The county educators use Horticulture Tips for articles in their local newspapers and newsletters.
- Plantings of the OKP plants are found at many of the display gardens managed by Master Gardeners. Garfield County has established an arboretum next to their office highlighting woody plants and has planted many of the herbaceous plants around the building. Kingfisher County Extension has established demonstration plantings with Oklahoma Proven plants at their office. Several other county extension offices have display gardens with Oklahoma Proven plants distributed throughout.
- The Oklahoma Proven website, http://oklahomaproven.okstate.edu/, provides easy access to information as well as high resolution images free for use.

Beneficiaries:

County Extension offices benefit by the materials provided by using them for programming to their clients (residents). The Master Gardener Volunteers work through the county offices and often conduct the educational programming for the county. The brochure is used extensively by extension educators and Master Gardener Volunteers for workshops and lectures. In addition, others groups such as civic and municipal agencies use the program material.

Lessons Learned:

Occasional delays to the early release of materials sometime occur. These delays are sometimes attributed to the time of year, i.e. university schedules, pressures of end of semester and graduation, the holiday break, and priority deadlines of other projects for Ag Communications. The time needed for attaining all the images needed for the publications and the publishing and editing of the material can result in some short delays as well.

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EXPANDING TOMATO AVAILABILITY FOR MARKETS DURING OKLAHOMA'S HOT SUMMERS

Project Summary:

Tomato is a must have crop for farmers that sell fresh market crops particularly at local direct markets. Because of this tomato is always included in the crop mix of small fresh market producers. During Oklahoma's hot summers (particularly during 2011 and 2012) farmers had an extremely difficult time producing tomatoes due to poor fruit set and the resulting lack of product that was available for sale. This project investigated new tomato cultivars for potential to set fruit at the higher temperatures during our hot summers. Over the course of three years 16 different trials were completed and several cultivars of tomatoes were identified that produced at a higher level than cultivars used in the past. This information was shared directly with local growers through presentations at conferences, popular press articles, field events, and through publication of trial results each year both as printed and electronic documents.

Project Approach:

Multiple tomato field trials were completed using grower fields and growers to collect the data and care for trial plots. Project partners included individual farmers, county extension educators, and state research and extension specialists. Farmers were responsible for care of their trials and data collection. County extension educators were involved in outreach events and were also included in planning and identifying potential farms for collaboration. State research and extension specialists were involved in growing and delivering tomato transplants each year, writing reports, and presenting results. Presentation of trial results were done at two-state

horticulture meetings (Oklahoma and Arkansas), national professional meetings, and to specific groups of growers at field day and tomato tasting events.

Goals & Outcomes Achieved:

Goal: Complete grower trials at several locations (up to four locations) within the state during a two year period resulting in trial data of up to eight separate trials (4 locations x 2 years).

- Result: 16 trials with results published in 2012-2015 MP-164

Goal: Sharing of information discovered through outreach events with farmers.

- Results: Stillwater trial site hosted a field day in July, 2014.
- Results: Tomato trial results shared with growers and general public at tomato tasting in Jenks site in July, 2014.
- Results: Tomato trial results shared at HIS with growers in 2013, 2014 and 2015
- Results: Tomato trial results and process shared with university and USDA professionals at national conference for the American Society of Horticultural Science in 2014.

Goal: Determine tomato varieties/plasticulture with highest potential for fruit set during hot weather.

- Results: Performance of varieties varied from site to site. Solar Fire was in the top three performers in 2012 and 2013, top five in 2014; Bella Rosa and Tribeca were in the top five in one location in 2012 and three locations in 2013, in addition Tribeca was in the top five at 5 out of 8 locations in 2014; Tribute was in the top five at two locations in both 2012 and 2013; Valley Girl was in the top five at 6 out of 8 locations in 2014; Red Morning was in the top five at 4 out of 8 locations in 2014.
- Results for 2015: Valley Girl was the highest producing variety followed by BHN 964 and Volante in the 2015 trial.

Goal: Determine variety performance in several locations and unique environments

- Trial locations ranged from western, central, and eastern areas of the state. A total of seven trial sites were able to complete trials although there were nine different sites that attempted trials.

Goal: Determine the effects of plasticulture on tomato yield and quality.

- Two sites did not use plasticulture due to the system that the grower is using (permaculture). These sites had lower yields than other trials in the project.

Clearly convey the progress towards achieving the outcomes by illustrating baseline data that has been gathered to date and show the progress toward achieving set targets.

- Progress: Two grower trials in 2012, five grower trials in 2013, Eight grower trials were completed in 2014 and one grower trial in 2015.

- Baseline data gathered: The 16 grower trials gathered harvest data that included weight and count of marketable fruit, weight of cull fruit, and average fruit weight for the 12

varieties in the trial. Data is available for public through Vegetable Trial Reports MP-164 as given below.

Beneficiaries:

Best estimate would be that 200 to 250 growers of fresh market tomatoes in the state will benefit directly from these trials and consumers which will have a steadier supply of fresh tomatoes.

Lessons Learned:

It was beneficial to have several sites so all risk were spread over a number of locations. During the 2014 growing season a frost killed some of the trials while others in different parts of the state were spared. Some of these trials were replanted and some were abandoned. Having the number of trials across the state also help mitigate losses from both biologic and non-biologic issues.

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Tomato trial reports for 2012-2015 can be viewed at: http://www.hortla.okstate.edu/research-and-outreach/research/vegetable-trial-reports

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THE OKLAHOMA FRUIT AND VEGETABLE ASSOCIATION GROWTH PROJECT

Project Summary:

The OFVA has been helping to promote the specialty crop industry in Oklahoma for the past 30 years by encouraging research addressing the production and marketing needs of Oklahoma fruit and vegetable growers, sponsoring educational events and representing grower interests at the state and national level. Over that time, the specialty crop industry in Oklahoma has seen drastic changes in the size of producer's operations, from mostly larger monocultures to now smaller diversified operations. Many of these small orchard and market garden operations are managed by growers new to farming.

The goal of this project was two fold:

(1) Enhance grower competence and success by providing a convenient avenue for growers to access industry related information, news and events.

(2) Enhance grower competence and success by sponsoring educational activities targeting small growers, both new and established.

The demand for local grown foods is at an all-time high in Oklahoma as witnessed by a proliferation in the number and size of farmers markets and other direct marketing venues. Many of the growers supplying product to these markets are new to the business and are hungry for any information that will improve their management ability and ultimately their profitability. Consequently the timeliness of this project couldn't be better.

Project Approach:

The plan of work to achieve the stated goal included three primary activities:

1. Develop an OFVA Facebook page.
2. Sponsor educational field days/tours.
3. Develop an OFVA membership recruiting brochure.

During 2013, the first year of the grant, one educational activity was conducted. A Hoop House Symposium/field day was conducted on October 23 and 24 in Ardmore, OK. The event was cosponsored by the Noble Foundation and the OFVA and consisted of a formal educational program on day one and a tour of three Oklahoma hoop house operations on day two. Attendees received instruction on the latest developments in hoop house specialty crop production from research and industry leaders on day one and were able to compare and contrast the different types of hoop house structures and production practices used by area growers on day two. The target number of participants for the symposium/field tour was 100. The actual number of attendees was 68. The majority of those surveyed said they were satisfied or very satisfied with the event.

OFVA cosponsored a Plasticulture Field Day at the 2014 Horticulture Industries Show during January in Tulsa, OK. Dr. Bill Lamont, PSU Extension Vegetable Crop Specialist served as the guest speaker for the event. Dr. Lamont is recognized nationally as an expert in plasticulture production systems for vegetable crops. Approximately 70 people attended this educational event. A second field day sponsored by OFVA was held on July 19 in Tulsa at South Wood Landscape and Garden Center. Approximately 100 attendees participated in a tomato variety taste test to determine which of the varieties represented in an OSU variety trial had the best eating quality.

OFVA sponsored one educational event during 2015. A tour of two fruit farms, Thunderbird Berry Farm located in Broken Arrow, OK and Livesay Peach Farm located in Porter, OK was conducted on June 30. Six growers attended the tour. Also, a trifold membership brochure was developed and is available for distribution.

Goals & Outcomes Achieved:

Through the various educational activities sponsored by OFVA, approximately 250 new or small scale fruit and vegetable growers increased their knowledge level in the area of season extension (hoop house) production, vegetable, plasticulture and small tree fruit production.

The OFVA Facebook page in conjunction with the website make it possible to disseminate information in a more efficient and timely manner.

The promotional brochure provides a quick overview of the mission and member benefits of OFVA and contact information. The trifold format enables it to be included as an insert in folders and inserted easily in a pocket.

As a result of the various activities conducted as part of this growth project, the OFVA has realized an increase in membership. Paid membership at the end of 2013 totaled 24. Paid membership at the end of 2014 totaled 58. Paid membership as of November 20, 2015 is 38.

Beneficiaries:

The educational activities sponsored by OFVA not only provided growers with information to enhance their effectiveness as managers, they provided opportunities for growers to network with one another and share successes and failures.

Before the Facebook pager and website were developed, information was disseminated primarily via email messaging. Now OFVA meeting notices, calendar of events and the OFVA newsletter are accessible at both locations.

Lessons Learned

When developing a budget for the 2013 field day activity, no money was allocated for a tour bus because the event was originally planned to take place at a single location (or several locations in close proximity) during the summer. Summer came and went without a field day. Knowing we needed to conduct a field day, the OFVA Board voted to cosponsor an educational event in collaboration with the Noble Foundation which contained a multiple location field day component. Approval was obtained from the USDA to reallocate money to cover the cost of bus rental. Money initially designated for field day advertising was used to cover the cost of a bus to transport attendees to Leon's Greenhouses (Kingston, OK), Peach Crest Farms (Stratford, OK) and Phocas Farms (Edmond, OK).

With the exception of the 2015 event, attendance at field day/educational events was exceptional. The poor showing at the 2015 fruit tour was most likely due to being scheduled on June 30, too close to the Fourth of July holiday.

Despite a few setbacks that occurred throughout the span of this project, the goals of the Oklahoma Fruit and Vegetable Association Growth Project have been achieved. Membership in OFVA now exceeds what it was prior to the implementation of the project. Approximately 250 new or small scale fruit and vegetable growers increased their knowledge level through participation in OFVA sponsored educational events. Access to the OFVA website and Facebook

provides a convenient avenue for growers to access industry related information, news and events. The OFVA promotional brochure provides a convenient and efficient method for recruiting new members

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PRODUCTION OF CLEAN CANNA LILY RHIZOMES AND CONTAINER PLANTS

Project Summary:

The goal of this proposal was to provide guaranteed virus-free cannas to producers and consumers either in the form of rhizomes to producers that grow cannas in the field, or to Oklahoma nurseries. We chose to focus on producing plants of six canna varieties using apical meristems production and tissue culture. Horn Canna Farms grows over 150 acres and more than 30 varieties of canna and agreed to provide the rhizomes needed for this project at no cost. Our goal was to return clean material of 6 varieties for field production. The goal of this proposal is to provide guaranteed virus-free cannas to the producers and consumers. This will be achieved by screening fields of canna to diagnose for viruses, and by micropropagation of canna stocks using shoot apical meristems to produce virus-free material. Virus-free cannas can be produced through micropropagation. Apical buds can be excised from growing plantlets and placed in culture for production of multiple shoots. The apical buds are typically virus free and explants grown from excised buds are reported to be virus free. Multiple shoots generated in culture can be divided to produce multiple plants. These stocks can be grown for seed and greenhouse production.

The advantage would be healthier product to all markets. The greatest advantage would be to the commercial greenhouse growers, such as Horn Canna Farms Inc, because they have the largest opportunity for profits and also the largest opportunity for loss. Clean cannas are sold at a premium as potted plants. The goal of this project is to have a minimum profit margin in excess of 25%. For example, if the production cost for Horn is an average of $0.24 per bulb to grow, harvest, process and place in final shipment. We hope to achieve an average price in excess of $0.30 and could achieve $0.50 or even $1.00 per bulb.

As far as we know, all other cannas come from out of the country. Brazil and Israel market their cannas as "virus-free". However, our experiences with Israeli bulbs indicate that they are highly infected with virus. Horn Farms purchased 180,000 rhizomes from Brazil and we tested a

fraction of these cannas and also found them to be virus infected. Horn Farms Inc received some Israeli bulbs from a customer to custom grow 4-5 years ago and they were absolutely infested.

There are cannas being marketed as "virus-free". Importantly, producing virus-free cannas here (in the USA), will create a competitive advantage. In addition, we keep US dollars here instead of supporting "sweat shop" operations out of the US. Horn Farms recently paid after freight and customs, $ .50 per bulb for the Brazilian cannas. That tells me that if other people are willing to pay that much for the Brazilian cannas (which their bulbs are much smaller than ours) we should be able to increase our pricing to similar pricing. It is likely that the $.50 Brazil cannas are being purchased by re-wholesalers and marketed to bulb distributors, greenhouses, and retailers at a minimum. Also production costs will be kept low by working with OSU.

There is no private sector tissue culture facility for production of ornamental plants in Oklahoma, although ornamentals are the fourth largest agricultural industry in Oklahoma. For the private sector to develop such a production method, it would cost $200,000-$300,000 to build such a facility. The Verchot laboratory at OSU has tissue culture facilities that can be employed for production of cannas via micropropagation. These facilities include media preparation areas, autoclaves, transfer hood, growth room, and cold storage facilities. Production of cannas, or other ornamentals, at OSU means that large quantities of plants can be produced at a reasonable price. This will lower the unit price per cultivar. Using OSU production laboratories to work with canna growers will serve to keep costs low and enable production that would otherwise contribute to market stagnation.

Project Approach:

We developed a multiplex PCR diagnostic detection system and visual disease indexing system to monitor virus disease in a large production system. There are five viruses infecting cannas: Canna yellow streak virus (CaYSV), Canna yellow mottle virus (CaYMV), Cucumber mosaic virus (CMV), Bean yellow mosaic virus (BYMV), and Tomato aspermy virus (TAV). We developed PCR primers that can detect each virus and developed a mutliplex PCR system using three primer sets that can detect as little as 1 picogram of virus in 10 ug of total plant nucleic acids. We created several assays for routine multiplex detection of 3 to 5 viruses. Potyvirus primers detect both CaYSV and BYMV. Cucumovirus primers detect both CMV and TAV. Multiplex carried out using Potyvirus, Cucumovirus and CaYMV primers can detect all viruses that infect cannas. Another multiplex assay detects three viruses simultaneously, CaYSV plus CaYMV plus BYMV, and allow for monitoring these species in a large population.

Visual disease assessment was made routine and could be carried out by undergraduate assistants in the laboratory. We had a field day of undergraduates working with workers at Horn Canna Farms to teach them disease assessment for the field.

We launched a greenhouse production and germplasm screening program to identify and segregate clean planting stocks for production. In 2013 diagnostic evaluations of 3000 plants were performed. In 2014, 2000 plants were evaluated. Visual assessment of disease is carried by scoring plants on a scale of 1-4, where 1=healthy, 2=mild symptoms (these plants are monitored further because they could also need fertilizer or show other non-virus infections

which are treatable), 3=mosaic disease, 4=necrosis/brown/dying. We developed alternative characteristics to include in the scale to accommodate red leaf and variegated varieties of canna. We conducted statistical comparisons of visual scores and diagnostic outcomes to determine the accuracy of visual assessments. This enables undergraduate and graduate students doing the assessments to evaluate their success in disease identification, and the value of the visual scoring system. We have noted that for certain varieties, visual scoring is not as effective as for other varieties and this might be due to host tolerance to disease, where the host has the genetic program that tolerates infection and does not produce disease.

Beneficiaries:

We worked primarily with Horn Canna farms. We also created public information through social media to service the home grower and greenhouse producer. We have a following of 400 on twitter where we provide information about growing cannas.

Goals & Outcomes Achieved:

In 2013 we generated 100 plants through tissue culture and verified 80 to be clean of viruses after they were transferred to the greenhouse and allowed to produce flowers. In 2014 we expanded this production and changed the process to increase production and shorten the time plants were maintained in culture. We identified useful antiviral chemicals for treating explants and useful disinfectants that significantly improved greenhouse production by reducing disease. In 2012 and 2013, we established a relationship with a company in Korea named BIG LTD. to test their anti-viral compounds on our tissue culture system and have broadened these interactions. By the end of 2013 BIG had failed to secure the licenses needed for US import of their antiviral chemicals causing this work to stop. However, we continued independent test and identified Virkon as a useful greenhouse disinfectant and quercetin as a valuable compound in tissue culture for controlling potyvirus infection. Most recently, a new virus problem emerged in red leaf canna and we identified it as a strain of bean yellow mosaic virus. We have produced 3 peer reviewed publication, three extension articles. All these articles document disease in canna and were written to alert the scientific community and inform growers of best practices.

Propagation of virus-free hybrid canna in tissue culture.

We tested several growth conditions and explants starting first with apical and axillary meristems tips which were excised from plants. The shoot lips are trimmed to 1 cm3 cubes, cleaned with sterile water, and soaked in a solution of sodium hypochlorite (0.6%) for 10 min then washed twice in sterile water. Kromer and Kukulczanka (1985) employed a medium enriched with ascorbic acid, malt and yeast extracts. Buds develop from isolated meristems can be passaged to nutrient solution to develop shoots and roots. Cultures will be placed under 16 hr illumination with 52 mol•s•'•m•' if cool-while fluorescent light at 28°C (Hosoki and Sasaki 1991). Plants will be transferred at -25 d from nutrient solution to sterile container growth medium in a growth chamber. Plants are transferred at -25 d from sterile growth medium in a growth chamber to greenhouse. Growing plants are repotted to soil. Nutrients are provided in three components: Osmocote (19-5-9 or 19-6-12 6 @ 15 lbs per cubic yard), Micromax (1.51bs/cubic yard) and dolomite (6 lbs per cubic yard when water contains less than 30 ppm calcium). We observed the

number of shoots, shoot height, number of leaves, and fresh weight. Plants look normal and so now abnormalities following tissue culture.

As research progressed, we eliminated shooting medium and move buds directly into growth medium for simultaneous root and shoot regeneration. We tested sanitization treatments including heat treatment, treating buds with non-fat dry milk, and antiviral compounds. In 2013, we produced virus free flowering plants and we have 100 plants in the greenhouse. Currently we have produced through tissue culture plants of the following varieties: Burning Ember, Tropical Sunshine, City of Portland, Crimson Beauty, Tropical Role, Corsica. These flowering plants were propagated in the greenhouse and our total population is about 100 plants. Flowering time is about 3 months after planting, as expected.

Greenhouse production system to augment tissue culture

In total we have produced 3000 plants through greenhouse production, tissue culture, and germplasm screening. We found that the CaYMV is a DNA virus and virus sequences are likely to be, integrated into the host genome. CaYMV causes a mild or no disease symptoms most of the time, unless there is potyvirus infection. The combination of viruses is problematic. Horn has reported that production seems to be quite improved in 2014 and that the crop looks healthier.

In the greenhouse we tested four different fertilizers, treating plants weekly. We wanted to see which fertilizers improved the number of shoots produced. We tested Fertilome, Scotts 10:10;20 fertilizer, Dynamix granule fertilizer. We found the greater success in causing more shoots to emerge using Dynamix. This means that these rhizomes are expanding and producing more buds with this fertilizer treatment. We compared Promix and LC1 soil mixes. We found that LC1 performs best. Of 110 rhizomes grown in LC1 and fertilized with Dynamix 50% produced multiple shoots, whereas 30% of plants grown in Promix and fertilized with Dynamix produced multiple shoots. If we used Fertilizome or Scotts liquid fertilizer with LC1 soil, 15-25% of plants produced multiple shoots.

We also identified Dupont Virkon as a valuable sanitization treatment for greenhouse floors, walls and tools. This reduced disease in the greenhouse by 50%. In fact we treated soils with Virkon, but we are looking for compounds through Bayer Crop Science which may be better used for soil treatment and that we can recommend to growers for field or greenhouse care.

Diagnostic testing

With regard to laboratory testing and micropropagation, we developed reliable PCR technology for screening samples. There are five viruses that infect Canna: Canna yellow mottle virus (CaYMV, Badnavirus), Bean yellow mosaic virus (BYMV, Potyvirus), Tomato aspermy virus (TAV, Cucumovirus), Cucumber mosaic virus (CMV, Cucumovirus) and Canna yellow streak virus (CaYSV, Potyvirus) (Fisher eta/. 1997, Hayward 2008, Lockhart 1988, Monger eta/. 2010, Monger et a/. 2007, Pappu and Druffel 2008). We've completed a 4 year study of plant virus disease and now we provide information to growers about the diseases that are likely to encounter. We have prepared three extension reports and two peer reviewed scientific papers

providing disease characteristics, virus identification, and characterizing the problem in the industry. We propose solutions for disease management. We presented at the Botanical Gardens Spring Event, and one presentation on Oklahoma Gardening TV show.

Diagnostic testing determined that CMV and TAV are rarely a problem in cannas. We detected these viruses in less than 1% of plants tested. CaYSV and BYMV are two potyviruses that are causing the most damage to cannas. We find them in 80% of plants tested, and we also find aphids mixed into the rhizomes. Aphids are known vectors for potyviruses such as CaYSV and BYMV, so this is likely to be the problem. It is likely that rhizomes need to be washed with insecticide before storage or before planting to eliminate disease.

The workflow for greenhouse production and screening was provided in the report last year and is provided in Figure 2. We are following the same workflow and with the improved mutliplex PCR testing methods, we can screen more accurately and at a higher rate than when this project began in 2012. The multiplex testing reduces costs and enables us to completely analyze 500 samples per week by PCR. Infected material and healthy material are quickly segregated and the healthy material is propagated for production at Horn Canna Farms. We established a production database that is shared among all workers in our greenhouse. The database includes summary tables which we provide to Horn, along with the rhizomes, so they are aware of our analysis and results. We have also met with one of Horn's customers (Longfield Gardens) at the farm to explain our workflow and "certification" process and this enabled Horn to obtain an expanded contract for 2014.

Lessons Learned:

The database and workflow for turnover and production were critical to success. Germplasm screening costs less than tissue culture production and these two need to be run in parallel

Not all varieties of cannas are amenable to tissue culture, so we need to have a the two pronged approach to really impact the industry

The work could not have been achieved without the Maxwell Robot from Promega. This robot provides a method of nucleic acid isolation that enabled multiplex diagnostic detection of RNA and DNA viruses. We tested a range of protocols and procedures and had we not procured this robot through a private source, this program would not have succeeded so well

Using the robot, we could train undergraduates to do much of the work. This project proved to be a terrific opportunity for undergraduate training

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Publications resulting from ODAFF funding

Rajakaruna, P., Shafiekhani, M., Kim, T., Payton, M., Chauhan, R. & Verchot, J. (2013). *Production of discernable disease phenotypes in canna by five plant viruses belonging to the genera Potyvirus, Cucumovirus, and Badnavirus. Plant Pathology J* ***1-8****.*

Chauhan, RP, Hamon, HF, Rajakaruna, P., Webb, MA, Payton, ME and Verchot J. (2014). Reliable detection for Bean yellow mosaic virus, Canna Yellow Streak Virus and Canna yellow mottle virus in Canna Varieties with red foliage. Plant Disease Accepted for publication. Posted online on 3 Sep 2014, First Look.

Chauhan, RP, Rajakaruna P, and Verchot J (2014) *Complete genome sequence of nine isolates of Canna yellow streak virus reveals its relationship to the Sugarcane mosaic virus subgroup of potyviruses, intraspecies genetic diversity. Arch of Virology, accepted.*

EPP-7327 Plant Viruses Infecting Cannas; Extension Fact sheet
EPP-7673 Integrated Pest Management of Cannas for Production in Controlled Environments; Extension Fact sheet

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PLASTICULTURE GARDEN GRANTS PROGRAM

Project Summary:

With the need for more locally available fresh fruits and vegetables and promoting a healthier Oklahoma, the Oklahoma Department of Agriculture utilizes the plasticulture grant program to encourage limited resource farmers a way to start growing specialty crops on a commercial scale. Participants are chosen from applications reviewed by specialty crop industry leaders and allowed on the program for three consecutive years. The grant covers the cost of installing the plastic, drip irrigation and supplies for a maximum of one acre. As participants roll off the program, this allows for new participants to be added with an average of 20 new participants a year.

Project Approach:

Plasticulture grants are awarded by a competitive process. Press releases are sent statewide to promote the grant and solicit applicants to apply. Individuals must qualify based on Langston University's definition of a limited resource farmer being defined as a person with a direct or indirect gross farm income of no more than $100,000 in each of the two previous years and has received little or no assistance from the government. Participants must also own forty acres or less. The applications are judged by a panel of three to five industry leaders including cooperative extension agents, past plasticulture participants and university leaders. Once applications are scored and ranked, the Oklahoma Department of Agriculture notifies the applicant to let them know if they were approved or denied.

Once selected based on their marketing skills and experience, participants must have their water and soil tested to ensure that adequate supply and quality are available for the production of specialty crops. Also, the plasticulture coordinator makes site visits to the garden to ensure that tractors and proper equipment would be able to access the garden area. After all these steps have been met and the contracts and purchase order has been issued, ODAFF is notified by the participant that the garden site has been tilled and ready for installation the program coordinator will contact the appropriate contractor to install the garden.

Sixty gardens were installed across the state in the spring of 2013 with the assistance of five contractors and ODAFF staff that ranged in size from ¼ acre to 1 acre. During the garden installation process, the contractors install the plastic mulch, drip irrigation and set up the irrigation equipment. ODAFF utilizes SCBG funding to pay the contractors and purchase the plastic mulch and irrigation supplies.

By requiring participants to sell a minimum of 50% of the specialty crops they grow, the plasticulture program is helping generate revenue for the farmers along with providing access to healthy fruits and vegetables to both their families and people in the community. Participants are required to submit annual production reports documenting the weight of produce sold and the sale of the specialty crops. Failure to comply and turn in production reports results in termination from the program. Nine Plasticulture participants were affected by the two tornadoes, hail and storms that came through Oklahoma that spring.

Goals & Outcomes Achieved:

ODAFF's initiative to assist limited resource farmers grow or increase their production of specialty crops has been met through the Plasticulture program. We have seen that the majority of farmers who stay in the program for three years gain confidence in their ability to grow and market specialty crops while increasing their business skills to grow their business. For many growers this is not the only job they have. Due to the advantage of weed suppression, better water retention in the soil and increased utilization of water through drip irrigation, plasticulture makes it possible to be successful growing specialty crops even for those who are doing it as a side job.

Beneficiaries:

The 60 individuals who were selected to participate in the program directly benefited by increased revenue from the production of specialty crops. Each recipient is required to keep production records throughout the year. This year participants showed sales of over $91,140.00 worth of specialty crops. To promote and encourage healthier eating habits among the underserved community, participants and their families were able to consume $13,055.00 worth of fruits and vegetables that they would have otherwise had to purchase or would have went without.

Lessons Learned:

Participants learned they have to be diligent in checking to make sure water is reaching the end of the rows every day. Gophers or other animals can cause damage to the drip irrigation system resulting in loss of production to the section of the row where the water was unable to reach.

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OKLAHOMA GROWN FARMERS MARKET PROMOTION

Project Summary:

Oklahoma growers are limited on available markets for specialty crops as we do not have any major wholesale markets within our state. The typical specialty crop operation would be classified as small to medium size and lends itself to marketing through a Farmers Market. With markets having anywhere from 6 to 35 vendors on a daily basis, ODAFF felt they could have a greater impact on sales therefore increasing production by providing promotional grants to markets. Advertising grants were awarded to markets who met the requirements established by ODAFF as a 100% Oklahoma Grown Farmers Market. In 2013 ODAFF recognized 63 markets as 100% Oklahoma Grown Farmers Market and awarded 30 of those markets with promotional grants up to $2,000.

Project Approach:

ODAFF's Farmers Market coordinator mailed and emailed the grant application to market managers of the 63 100% Oklahoma Grown Farmers Market on file along with posting a link to the application on the OK Grown website (www.okgrown.com). After the submission deadline an external committee was gathered to review the applications and select which proposals would receive funding. Applications from markets were evaluated, ranked, and selected by the committee based upon the following criteria:

A. Are all the projects allowed under the terms of the grant?
B. Is the grant application complete?
C. Will the project raise awareness of specialty crops grown in Oklahoma?
D. Are the projects credible and have a high likelihood of success?
E. Are the projects worth the total investment?
F. Will the projects help to increase vendor and consumer participation at the market?

Markets were able to receive up to $2,000 for projects to increase advertising solely featuring specialty crops, displays, and promotions of markets. Grant funds were distributed in two allocations per contractual agreements with the markets. Each market received ½ of their approved funding up front and after expending it must submit receipts, progress reports and photos or examples of what the money was used to purchase. ODAFF staff reviews each receipt to make sure they fall within the allowable timeframe and are for projects that solely benefit specialty crops. Upon approval from ODAFF staff, the second allocation is made and those receipts must be submitted at the time of the final report. ODAFF staff made two sight visits to all 30 famers markets that received grants to insure that the grant funds were being used appropriately. Markets are required to submit an annual report within 60 days of the end of their market season.

Goals and Outcomes Achieved:

Although the goal of increasing the number of 100% Oklahoma Grown Farmers Market was not met, the number of markets was equal to the previous year at 63. We do feel the grant was successful in growing the customer base for the 30 markets by educating the public about the markets with the promotional campaigns. Reports from markets receiving grants have shown a significance increase in vendor and customer attendance in addition to sales revenues increasing to over $2,800,000 for those markets. This is an increase of 86% from 2012, which is not a true representation of growth/new customers as our state experienced a crippling drought in 2012 and markets had very little produce to sell.

Beneficiaries:

The funds utilized for this project not only benefited the 30 100% Oklahoma Grown Farmers Markets that were approved for the grant; but also impacted the specialty crop growers that were selling at the markets and the increased awareness of where to purchase locally grown fruits & vegetables from consumers. As stated earlier, those markets who received funding showed sales in excess of $2,800,000.

Lessons Learned:

When it comes to advertising there is not a "perfect fit" to encompass the diverse markets that we have within our state. ODAFF felt by allowing each market to utilize the funds differently to conduct promotions or purchase advertising that promotes the specialty crops would be the most effective in allowing the markets to reach their goal of increasing consumers and sales of specialty crops.

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AG IN THE CLASSROOM SCHOOL GARDENS

Project Summary:

The initial purpose of the Ag in the Classroom School Garden grant was to provide funding of $500 to ten schools to develop school gardens. School gardens provide hands-on learning for students and the opportunity to make connections to important science, math, language arts, and art standards, as well as nutritional information. Working in a garden would give students the opportunity to make real-life connections between the standards they are taught and the food that they eat. Students would also have the opportunity to participate in cooperative learning and problem solving as they worked together to design, build, plant, grow, and harvest a garden. AITC staff wanted to give ten schools the opportunity to create traditional gardens, container gardens, or other creative garden plans. Students would participate in the preparation, planting, harvesting, and consumption of the garden produce. Through their experience, students would also learn about the health benefits of eating fresh fruits and vegetables. School cafeterias are working to provide healthier foods for students to consume and if the students are growing these foods in their own gardens, then the AITC staff believed they would be more likely to try them.

Project Approach:

The Ag in the Classroom State Coordinators promoted the school garden grant during conferences, professional development workshops, and at other venues. The application was posted on the Ag in the Classroom website. The criteria were simple and basic. When the applications came in, 16 schools applied for grants. One school was a Christian school and the Oklahoma Department of Agriculture, Food and Forestry could not enter into a contract with the school. This left 15 qualifying schools. The Ag in the Classroom coordinators decided to change the amount of the grants to $375 and award grants to the remaining 15 schools that had applied.

After the schools signed the contract and received the money for the grant, the participating teachers were given pre-tests to determine their student's prior knowledge of Oklahoma specialty crops and the foods nutritional value. Ag in the Classroom staff also encouraged the teachers to give the pre-test to students at their school whose classes were not participating in the grant so that growth of knowledge could be determined.

The AITC State Coordinators emailed the teachers at various points during the life of the grant to provide lesson ideas and to offer resources to the schools. The participating teachers purchased a variety of materials including lumber, garden tools, garden hoses, compost, seeds, and different fruit and vegetable plants to get the garden projects off the ground at each of the participating sites.

The school's plans for this project were to increase the knowledge and understanding of the students in where their food comes from due to the fact that the majority of students do not have the opportunity to garden at home. Most students have no understanding of the planting or cultivating process of getting plants to plates. Individual classrooms or groups of students were responsible for their own little piece of the gardens or section of garden.

AITC Staff asked the teachers to document the student's participation in the garden. The teachers submitted pictures and final reports stating what Ag in the Classroom lessons were used, how the garden was connected to state standards being taught, and the student's increase of knowledge about fruits and vegetables. The teachers were asked to have students complete a post-test at the end of their garden experience, in order to show an increase in students knowledge, visual recognition and consumption of Oklahoma specialty crops.

Beneficiaries:

Over 300 students were directly involved in the school gardens, with even more benefitting from the produce served in the cafeterias. The students learned about planting, harvesting, collaboration with teachers and other classmates, garden design, and of course healthy food choices, which will help the students as they continue to get older. The community involvement with the contributors, parents, and other teachers created a collaborative climate at each of the school sites. Each school stated that the gardens were very impacting on the students, teachers and parents involved.

The excitement and interest in gardening will most definitely carry on even past this project. One school created an area that families can enjoy by hiking, picnicking, and sharing in the harvesting of the garden. They stated that, "parents and grandparents who were involved were so enthralled to see the opportunities that await their families." Ag in the Classroom State Coordinators have listened as students who have participated in school gardens explained what they learned about germination, growth, garden pests (insects, rabbits and deer) and excitedly shared about the gardens they now have at their houses.

Goals & Outcomes Achieved:

Through the process of creating the gardens, students at each site learned the importance of planning the layout of a garden, the planting process and the time that it takes for produce to grow and be harvested. The schools final reports and pictures showed students participating in the cultivating of the soil, the construction of square foot garden beds, and the planting of the fruits and vegetables. Many of the schools started the plants indoors and transplanted them outside when the temperatures were conducive to growth. One school developed a 10' x 20' garden in the shape of Oklahoma.

Teachers at the schools used AITC Harvest of the Month poster sets to educate students about the plants they were growing and the nutritional benefits of eating the produce. Some of the vegetables that were planted, which are featured in the poster sets, include: sweet potatoes, lettuce, cauliflower, carrots, spinach, pumpkins, watermelons, radishes, and squash. Students learned how to examine the seeds before planting them. They cared for these plants as they grew

by determining how much water they needed and how often to water the plants. Students measured the growth of the plants and monitored their progress. They learned to identify the plants as they grew and how to determine the difference between plants and weeds growing in the garden. Additionally, students learned the importance of soil, worms, and bees as they relate to the garden. The students enjoyed the harvesting of produce during their project. One school decided to keep seeds from their produce to plant in their gardens next year, reinforcing students understanding of the plant life cycle.

At a few of the schools, the students and teachers planted fruits and vegetables that would be harvested and used in the school cafeteria. One of the participating schools stated, "Students take pride in knowing that the items they have grown are being used to prepare meals which will be served to all students in the school lunch program." Students at another site learned about recipes and used the radishes they harvested to make the radish dip recipe on the AITC Website. The students were able to make real-life connections during this project. The garden project fostered a sense of community for the students. This project gave students a new perspective and appreciation for farmers and ranchers. Another school reported, "Students must use their problem solving skills and work as a team for a common goal. We were able to show them real-life connections to what they are taught in science, language arts, math and art. These real-life connections get them excited about learning."

The post-test that were collected showed that the students who participated learned the difference between a vegetable and a fruit, how often and when to water the garden, were able to name Oklahoma specialty crops at a higher percentage, and also many students reported that their consumption of the fruits and vegetables did increase.

Schools reported several AITC lessons were used in conjunction with the garden project. Some of the lessons that were used are: Melon Madness, Pumpkin, Squash and Other Cucurbits, Case of the Missing Pumpkin, Agriculture is a Cycle, Garden Grid, and Plant Parts We Eat. Additionally, schools used the Harvest of the Month poster sets and the recipes and activities found in the AITC resource "Oklahoma's Bountiful Harvest."

Lessons Learned:

The School Garden Grant has been a challenging grant for various reasons. While the AITC staff is excited to report the positives of the garden experience throughout this report, unfortunately obstacles also arose. When the grant was developed, the AITC staff thought the administering of a simple pre and post-test would be the best way to determine student's increase of knowledge. However, during the life of the grant, educators were required to administer more and more test to their students. This increase in testing prompted teachers to shy away from non-state mandated test, therefore many of the participating schools did not actually administer the garden surveys they received. Instead they reported growth in their final reports, but because the test were not administered, the AITC staff cannot determine if the increase in vegetable recognition and consumption was indeed 15% as was originally planned.

Weather also played a factor in the implementation of the gardens. For one of the teachers selected to receive this grant, her project was delayed due to weather. This teacher is a Moore

teacher and the Moore tornado hindered this project a little bit because the school area chosen for the garden had to be repaired and worked over. The teacher finally was able to relocate to a different spot.

Other challenges faced include changes of school personnel. Some schools received their monies but for reasons such as leaving the district, new principals and other similar issues the gardens did not happen. One school went through three teachers and two superintendents during the life of this grant. Other schools did not read the fine print of the contracts and purchased items not funded by the grant, or waited to purchase the items until after the contract had expired. The Oklahoma Department of Agriculture, Food, and Forestry is now in the process of invoicing these schools and requesting the repayment of the grant money. This money will be refunded to USDA or reallocated to another approved Specialty Crop Block Grant project.

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OKLAHOMA WINE TRAILS

Project Summary:

The Oklahoma Agritourism Program created a project plan to increase visits to Oklahoma Wineries for the purpose of increasing Oklahoma wine sales, thus increasing demand for Oklahoma grapes. This assisted in creating awareness of the industry and enticing visitors to participate in visiting and purchasing Oklahoma wine. The main goal of the wine trail is to take the planning work out of the visits and encourage Oklahomans and neighboring states to add the experience of the over 60 wineries in Oklahoma to their "must do" list.

With the industry growing quickly as it is in Oklahoma and the trend to buy local and purchasing products with locally grown specialty crops this was the ideal time to roll out such a project.

Project Approach:

Create an easy to access and easy to understand set of wine trails, the project ended up with 31 wineries on 10 trails

The project consisted of:

- **Wine trail map**- designed and printed to be distributed through the Agritourism channels for travel brochures. These can be ordered online and distributed through Oklahoma tourism/visitor centers, local tourism/Visitor centers, local hotels, tradeshows attended by the Oklahoma Agritourism Program and Oklahoma wineries -Printed 50,000 pieces
- **Passports**- A small booklet designed to be a guide to the 31 wineries and also a travel journal with the incentive to collect stickers at each winery for each trail the traveler completes. There are wine tips, facts and room to take notes on all of your favorite Oklahoma wines.-Printed 2000 booklets, Oklahoma Grape Industry Council printing an additional 3000 booklets at the time of printing. We also printed stickers that were provided to the wineries to use in the passport books.
- **Wine Charms-** To launch the program we have a collection of wine glass charms. Each charm is designed for each wine trail. At each winery, a visitor will receive a code and after completing the trail they will submit these codes online to receive their free wine charm for that trail completed.
- **Website-** To support the printed pieces we have built a microsite with the url www.OklahomaWineTrails.com which houses a printable map, passport and information on how to receive the wine charms and submission details. We have utilized the site to drive consumers to an added portion of the existing Agritourism website. The consumer could browse, print, and create canned or custom trails from the site.
- **PR campaign-** We launched a press release in the major metropolitan areas of Oklahoma. This garnered coverage on Oklahoma Horizon, Discover Oklahoma, Tulsa World, The Journal Record and others.

The Oklahoma Grape Industry Council served as an advisory committee on the project guiding some of the creative elements and bringing ideas of what to highlight and what their customers say they are looking for when setting out on a wine tasting and wine tour.

Goals & Outcomes Achieved:

This project is aimed at increasing Agritourism visits at Oklahoma Vineyards and Wineries resulting in increasing tasting room sales as well as the demand for Oklahoma wines at restaurants and liquor stores.

This project was launched at the Wines of the West Festival in July of 2014. We do not yet have the data to measure the expected outcome of % of market share as to date. The expectation is to increase the sale of local wine from 2% to 5% in two years based on Oklahoma excise tax reports.

Results as of Oct 2014:

- We do know we have sent out well over 10,000 wine trail maps, completely out of printed passports and sent over 50 wine charm requests at the beginning of October 2014.
- This map has been extremely popular request at our Agritourism staffed travel shows and the customer reaction has been tremendous
- We have reached out to the wineries on the trails and each one has said they have seen an impact and are continuing to see customers coming in with the map and the passport book
- The OGIC is currently applying for grant funds to further promote the wine trails
- The Agritourism Program will continue to fund the wine trail map when we need to print additional quantities
- We have also printed 8-1/2 X 11signs and 1'x3' posters for the wineries to display in store and a pop up banner that some individual wineries have displayed for the program as various events
- Website Analytics from June-mid Oct 2014
    - There is a total average of about 16.8 visits per day.
    - The big spike happened on July 17th and there were 335 sessions on that day. (That's skewing the average site visits a bit.)
    - It's interesting that almost 29% of visitors are returning to the site.

Beneficiaries:

- The Oklahoma Grape Industry Council and all Oklahoma Wineries have benefited from this program
- There were 31 wineries on the trails as well as 9 additional wineries that were listed but not on the trails (they were omitted either for hours or geography) that all were promoted and benefited from this project
- ODAFF, OGIC and the ABLE commission have started work on a possible Memorandums of Understanding regarding a "Proudly made from Oklahoma Grapes" sticker for the wines that would meet qualify. This sticker would use the creative done on this map and would keep consistent with the wine trail campaign in the future

Lessons Learned:

- This project proved to be much more time-consuming at the beginning of the project than anticipated. The work that it took to get the data collected on the wineries, coordinate hours and proximity to get a solid plan together took much more work up front than anticipated, however now that the ground work has been completed this should be something we can update on an ongoing basis
- The wine community has really accepted this concept and some have even started working together within the trails. This is exciting to see and we hope to continue to foster these partnerships and possibly assist with future promotions using the trail concept

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Additional Information:

Attached in Appendix A is a copy of the wine trail map that has been distributed and the passport can be viewed at the following link:
http://oklahomawinetrails.com/assets/files/wine_trails_passport.pdf

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OKLAHOMA FARM TO SCHOOL COOKBOOK

Project Summary:

The purpose for the Oklahoma Farm to School Cookbook grant was to print 500 copies of a cookbook which focused 100% on Oklahoma grown specialty crops and contained resources about Farm to School, school gardens, and food safety. The cookbook was created through a grant funded by the Oklahoma State Department of Health for school child nutrition professionals. The recipes emphasized locally grown produce, were kid friendly, and were scaled up to quantities of 50 and 100 servings. Each recipe provided nutritional information: calories, fats, and sodium per serving size, along with other useful information. The cookbooks were originally distributed to school nutrition directors who were participating in the Farm to School program. However, the school nutrition directors many times have several schools they administer within their districts and the Oklahoma Farm to School staff noticed the cookbooks were not getting to the school cafeterias where they would be used more effectively.

In addition to printing 500 copies of the cookbooks, the Farm to School staff wanted to conduct a minimum of ten trainings for food service providers at schools, senior nutrition centers, military bases, and tribal governments to train them in the proper handling of fresh fruits and vegetables. These trainings would feature recipes from the cookbook.

The cookbook and the trainings were important to the health of Oklahomans. Approximately 80% of Oklahoma's older adults and 84% of Oklahoma's adolescents eat fruits and vegetables fewer than five times each day. The low sodium, low sugar, and low fat recipes in the cookbook emphasize simple-to-prepare methods to prepare most of the fresh grown Oklahoma produce including greens, melons, tomatoes, peppers, cucumbers, squash, broccoli, root vegetables, and many other vegetables. School food service experts who work in Oklahoma's school kitchens provided most of the recipes. The recipes provided inspiration to prepare cost-efficient recipes, which meet the new school lunch guidelines and offer healthy, great tasting recipes that students and adults would be eager to try.

Project Approach:

After bidding out the cookbooks and selecting the bid to print, the cookbooks were proofed and 500 copies were printed. Oklahoma Farm to School staff prepared a cover letter to include with the cookbook. Additionally a survey was created for use before and after the trainings.

The Farm to School trainings were developed and school foodservice personnel were invited. These trainings were held from April-September. Due to the focus on face-to-face trainings, cookbooks were not mailed and the mailing boxes were not ordered.

Beneficiaries:

The benefits of printing 500 cookbooks and hosting the eleven trainings have allowed more school cafeteria's to serve fresh, nutritional, and delicious recipes to students. Over 60 school districts in Oklahoma participated in the trainings, resulting in 367 child nutrition directors and food service personnel receiving cookbooks. According to the US Department of Education, the average school size for the state of Oklahoma is 1,809 students. You can see that through the trainings that over 100,000 students in Oklahoma have potentially eaten these delicious and healthy recipes, therefore increasing their consumption of Oklahoma specialty crops.

Goals & Outcomes Achieved:

Eleven Farm to School trainings were implemented. These trainings included over 60 school districts and 367 child nutrition directors and food service personnel. Attendees learned how they could develop a Farm to School program in their district if they did not already have one. They also learned simple knife skills to increase proficiencies when preparing local foods from scratch and participated in hands-on training in preparing multiple recipes from the Oklahoma Farm to School cookbook.

In addition to school food service personnel, multiple partners attended the trainings that ranged from USDA FNS SW region staff, local farmers, tribal groups, State Department of Education and Health staff, and OK Food & Farm Alliance members. Trainings were credited by the Oklahoma School Nutrition Association and provided participants with 4 hours of training credits. Media included two major articles in the Tulsa World newspaper; one recipe and information printed in the National School Nutrition Association magazine; and online mention in SNA News Briefs.

Prior to each training, surveys were completed by attendees with various questions about Farm to School participation which included 1) was the training helpful, 2) was the Farm to School cookbook useful, and 3) what recipes did food service personnel think would work best on their menu. Immediately following the trainings, the participants were asked the same questions. After the trainings, 99% of the participants thought the cookbook would be useful in their menu planning. 100% of the participants increased their knowledge of proper food and knife handling, preparation, and cooking techniques for fresh fruits and vegetables. Favorite recipes to be used in the cafeteria varied amongst the participants.

Lessons Learned:

The Oklahoma Farm to School director accepted a new position with another agency before being able to follow up with participants after the trainings to determine how many recipes had been added to school menus. When the Oklahoma Department of Agriculture, Food and Forestry hired a new director, it made it difficult to follow up with the schools during the transition. However, according to the National Farm to School website, of the schools who participated in the trainings: at least three districts have increased their food budget spent locally and at least five districts have maintained the same amount of money spent locally. This means that the Oklahoma Farm to School program is having a positive impact in the schools and staff is hopeful that the new recipes are a contributing factor.

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