FINAL PERFORMANCE REPORT

GRANT INFORMATION

AGREEMENT

AMS Agreement Number:	2016-SCBGP-OK-0055			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Award Amount:	$468,536.69			

RECIPIENT

Recipient Organization Name:	Oklahoma Department of Agriculture, Food & Forestry
Recipient's Point of Contact	
Name:	Jason Harvey
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REPORT

Report Type:	Final Report
Date Report is Submitted:	12/20/2019

GRANT ADMINISTRATION

Amount Requested	Direct and/or Indirect Expended to Date
$37,453.76	$34,845.84 has been spent as direct cost

Project Title	Investigation of Cumin (Cuminum cyminum L.) as a New Oklahoma Specialty Spice Crop			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Niels Maness			
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PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Scientists at Oklahoma State University assessed the potential for production of cumin (*Cuminum cyminum* L.) as a new spice crop in Oklahoma. Various aspects of production and handling included germplasm performance, crop establishment, season of production, integrated pest management strategies, and harvesting and handling strategies. Crop yield, plant performance, seed quality and spice potency were documented to objectively measure quality and estimate yield potential for this potential new Oklahoma crop. Results were extended to stakeholders on-farm and at grower conferences. Cooperation with Kalustyan, a US spice crop importer, established a vital marketing link for assessing cumin value to establish potential profitability for this crop.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Obtain and evaluate performance of cumin varieties/accessions under controlled environments and field conditions	XX	
2	Evaluate various production and handling practices for increasing yield and quality of cumin	XX	
3	Demonstrate cumin production and handling on-farm and through presentations at grower conferences		XX

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Established the production season for cumin in Oklahoma	Objectives 1, 2 and 3 – Our discovery of freeze tolerance for cumin in year 2 was tested in year 3 to firmly establish a planting date for cumin. Plantings occurring too early (October and November) resulted in excessive winter-kill; plantings in December and February exhibited higher seed yields than plantings in March which were limited in growing season for seed production prior to onset of summer heat in June. Although the December/February plantings were sufficient to mature limited seed for many of the 21 cumin genotypes we tested, spring rains in April and May proved devastating for plant survival due to onset of cumin blight. Because rains in April and May prevail across Oklahoma, no tolerance to cumin blight was observed in the genotypes studied (or in studies conducted elsewhere, to our knowledge) and chemical control of cumin blight was unsuccessful, our final recommendation is that cumin is not suited for production in Oklahoma as a new spice crop. Outcome 4, indicator 1 – we tested 21 cumin genotypes (one from Turkey, one from a US seed supplier, 16 from USDA plant accessions and 3 from India) instead of the 18 originally proposed. Outcome 4, indicator 2 – we conducted on-farm trials in south-western Oklahoma (Roosevelt) and north-central Oklahoma (Perkins-Coyle, Oklahoma; freeze tolerance of cumin was discovered at this location) and at the Cimarron Valley Research Station near Perkins, Oklahoma to evaluate cumin production practices and genotype performance.
2	Confirmed cumin blight as the cause of early plant death for plants; chemical control of disease was unsuccessful	Objective 2 - Plants were cultured for disease by the OSU Plant Disease Diagnostic Lab, which proved that cumin blight was the most likely cause for plant death. In accordance with recommendations, azoxystrobin was

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
		applied as a seed treatment and as a foliar spray at flowering and beyond. Unfortunately control measures could not overcome disease progression – brought on by persistent spring rains in Oklahoma's climate.
3	Transplanting is not an option for cumin establishment	Objectives 1 and 2 – since we had a limited seed supply of cumin accessions from the USDA we originally attempted field establishment as transplants. Although we could grow transplants in the greenhouse to a sufficient size for transfer to the field, none of the plants survived more than 2 weeks. Cumin has a tap root system with few branching roots and appears not compatible for field establishment via transplanting.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Although the Oklahoma environment offers a production window suitable for cumin production (winter planting with spring harvest), statewide prevalence of spring rain and subsequent susceptibility of the crop to cumin blight make production of cumin in Oklahoma impractical.	Our outcome 5, indicator 7 outcome (adoption of a minimum of 3 viable production and handling technologies) was only partially realized in this project – a) planter modification for high density cumin planting was achieved, using a 6 inch row spacing and 30 lb seed per acre planting rate; b) combine harvester modification and c) seed cleaner modification were not achieved since we were unable to produce a seed crop yield greater than 300 lbs per acre. Our outcome 8, indicator 5 outcome for yield was mostly under 100 lbs/acre but was as high as 300 lbs/acre. Even taking the highest yield of 300 lbs/acre, returns at $0.8 per lb would be $240/acre – considering production costs of irrigated peanuts ($772/acre) it appears that cumin is not a viable crop for the state. Even though we used regular azoxystrobin fungicide application as a preventative measure for cumin blight, this disease was too prevalent

#	Challenge or Development	Corrective Action or Project Change
		to allow seed maturation due to persistent spring rains in Oklahoma.
2	While cumin production in Oklahoma may not be feasible, domestic US production may be feasible in climatic zones exhibiting low rainfall during anticipated flowering and seed set.	An overarching goal for this project from our marketing cooperator's perspective (Kalustyan) was to establish a domestic US source of cumin to overcome contamination issues which had plagued this crop via a peanut allergen recall of cumin, as well as to distribute world-wide production of cumin more broadly to protect against crop failures. Although we have concluded that our project's intent to investigate feasibility of cumin as a new spice crop for Oklahoma is not viable (which led to our inability to complete objective3 3 and outcome 8, indicator 5), we have learned a lot about this crop and it's response to climate and cultural techniques. A more detailed discussion of year tree findings and areas of the US most suited climatically for cumin production is located in the "Lessons Learned" section – we believe the desert south-west portion of the US, with moderate temperatures, higher pH soils, low rainfall in April, May and June and more rainfall in winter months to germinate and establish a cumin crop, may be the most suited for cumin production.

LESSONS LEARNED

Our major finding in 2018 (year two of this study) that fall/winter seeding of cumin was optimum to allow cumin seed set prior to onset of hot summer temperatures in Oklahoma proved out in our 2019 studies – cumin seed yields (Table 1) and plant height (Table 2) were generally greatest for planting dates in December, 2018 and February, 2019 for our replicated variety evaluations and for the December, 2018 planting for the USDA accessions (Table 3). It should be noted that while October plantings were established for the cumin varieties, none of the plants survived the winter and the extremely low yields for the November planting were due to poor winter survival at this date also. Unfortunately, seed yields for plantings after November were severely reduced due to onset of cumin blight (even though seed fungicide treatments were applied and plant fungicide sprays were applied at weekly intervals throughout the flowering and seed set stages of development) with no varieties averaging more than 75 pounds per acre in seed production. Many of the USDA accessions out-yielded the varieties but none yielded more than 300 pounds per acre, leaving yields even for top

performers more than 5 times less than the yield target of at least 1,500 pounds per acre for profitable production in our state.

Table 1. Cumin variety seed yield (pounds per acre) in 2019 at Perkins, OK.

	Old Indian	Indian #1	Indian #2	Indian #3	Johnny's	Turkish
Planting Date						
11/20/2018	1.6	0	0	0	0	8.6
12/20/2018	37.3	47.1	47.4	0	53.1	36.5
2/5/2019	11.6	16.3	17.4	16.1	43.8	44.5
3/7/2019	0	30.5	24.4	0	14.4	8.4

Table 2. Cumin variety maximum plant height (inches from ground level) in 2019 at Perkins, OK.

	Old Indian	Indian #1	Indian #2	Indian #3	Johnny's	Turkish
Planting Date						
11/20/2018	5.5	0	4	0	0	5.6
12/20/2018	4.7	4.6	5.2	0	3.9	4.7
2/5/2019	4.3	5.3	4.1	5.3	4.7	5.1
3/7/2019	3.0	4.7	3.0	0	3.9	4.9

Table 3. USDA Cumin Accession seed yield (pounds per acre) and maximum plant height (inches from ground level) in 2019 at Perkins, OK.

planted					planted			
12/11/2018					2/5/2019			
	Plant	Plant	Seed			Plant	Plant	Seed
Origin	Name	height, in	lbs/acre		Origin	Name	height, in	lbs/acre
Morocco	M89-9	4.5	90.6		Morocco	M89-9	3.3	3.
Libya	CUMI 6/83	5.8	24.6		Libya	CUMI 6/83	4.5	5.
Colombia	CUMI 8/92X	6.8	272.1		Colombia	CUMI 8/92X	5.0	0.
Jordan	W6 17070	5.5	102.5		Jordan	W6 17070	4.7	16.
Uzbekistan	Z078	4.8	108.8		Uzbekistan	Z078	3.8	0.
Palestinian Territory	CU CY 2-01	5.8	161.6		Palestinian Territory	CU CY 2-01	4.5	0.
Palestinian Territory	CU CY 2-02	5.8	238.4		Palestinian Territory	CU CY 2-02	6.5	80.
Palestinian Territory	CU CY 2-03	5.6	120.6		Palestinian Territory	CU CY 2-03	5.0	0.
Palestinian Territory	CU CY 2-04	6.3	130.5		Palestinian Territory	CU CY 2-04	5.0	175.
Palestinian Territory	CU CY 2-05	8.0	285.2		Palestinian Territory	CU CY 2-05		
Palestinian Territory	CU CY 2-06	5.3	115.4		Palestinian Territory	CU CY 2-06	5.5	19.
Palestinian Territory	CU CY 2-07	5.3	50.4		Palestinian Territory	CU CY 2-07		
Tajekistan	TJK 2006:076				Tajekistan	TJK 2006:076	7.0	36.
Tunisia, Medenine	Tun 213	3.0	3.0		Tunisia, Medenine	Tun 213	5.0	37.
Tunisia, Sfax	Tun 262				Tunisia, Sfax	Tun 262		
Ethiopia, Shewa	Kemune				Ethiopia, Shewa	Kemune		

The combined results from year 2 (2018) and year 3 (2019) of this study leads us to not recommend cumin for further study as a new spice crop for Oklahoma, due to its severe susceptibility to cumin blight.

Why is cumin blight (causal agent Alternaria burnsii) a limiting factor for cumin production in Oklahoma?

Cumin blight is caused by infection of flowering and fruiting cumin plants by the fungus *Alternaria* – while *Alternaria burnsii* is most recognized as the causal agent of cumin blight, most sources indicate that a variety of species of the *Alternaria* fungus can cause disease. Regardless of the specific species causing infection and disease expression, susceptibility to *Alternaria* notably increases in cumin under rainy conditions. Unfortunately, rain is most prevalent in Oklahoma during the months of May and June (Figure 1), coinciding with our flowering and seed set window for cumin. In 2018 we became aware of severe susceptibility to cumin blight and in 2019 we applied the maximum rate of Azoxystrobin (a fungicide labeled for cumin with specific activity against cumin blight) throughout flowering and seed set in hopes of preventing or at least delaying disease progression. While fungicide application may have delayed disease progression in 2019, cumin blight brought on by May/June rains was still rampant and an apparent yield limiting factor in our cumin trials.

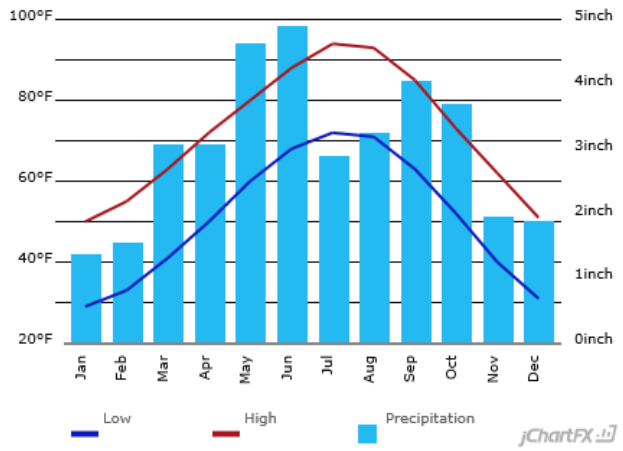

Figure 1. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Oklahoma City, OK. Although absolute values change for rainfall amounts and temperatures, all areas of Oklahoma suitable for cumin production display the same tendency for highest rainfall in May and June.

If not Oklahoma, where should cumin grow best in the US?

Although not an objective of our work, we feel compelled to suggest alternative locations for cumin production outside of Oklahoma since the overarching reason for our research was to develop a domestic US source for cumin. Based on our findings we know cumin can survive freezes typical of Oklahoma, but continued exposure to winter temperatures (if planted prior to December) seems to result in excessive winter kill of the crop. We will thus assume that our latitude is likely the farthest north in the US that is suitable for cumin production. Our rainfall pattern, with most rain occurring in May and June, appears to stay consistent in US states east of Oklahoma, which likely rules out production there. Of the states west or south of Oklahoma, climatological data indicates:

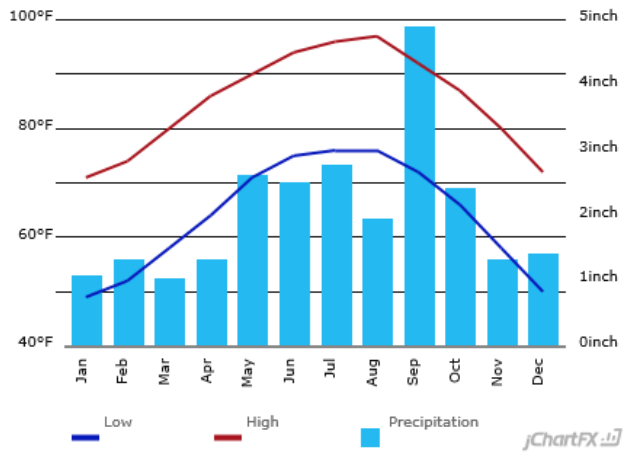

Figure 2. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Weslaco, TX. Temperatures in mid-October may be low enough for cumin germination – this is important to target seed maturity by the end of April prior to the normally wet month of May. We would place Weslaco (and most of south Texas) as marginally favorable for cumin production.

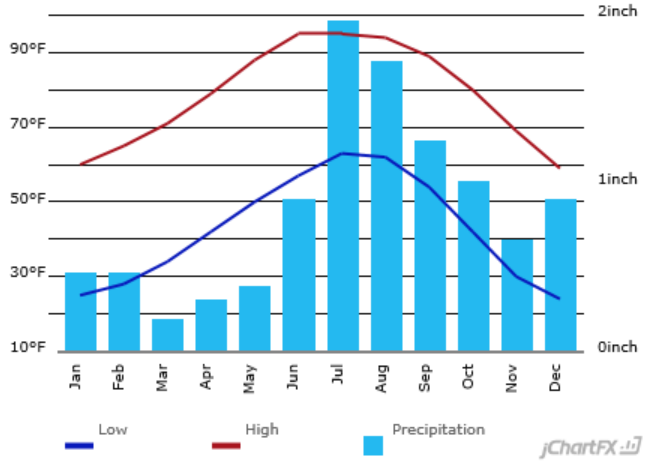

Figure 3. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Hatch, NM. On average Hatch appears slightly more favorable than Weslaco due to low average rainfall throughout May. Temperatures and rainfall appear favorable for planting in October or November to achieve the May harvest. Because of the prevalence of rainfall in June, an early planting in October or November may be necessary to complete seed set in May (perhaps early May) at this location.

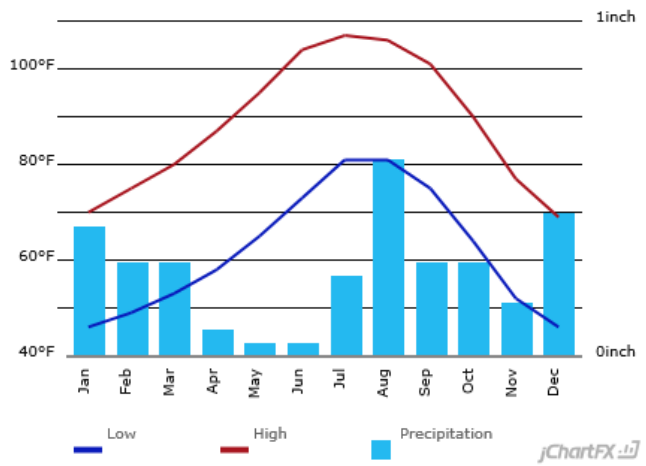

Figure 4. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Yuma, AZ. The southern Arizona climate fits cumin better than climates in south Texas and New Mexico in terms of rainfall, although some irrigation may be necessary. High temperature may limit the production window. A planting in November would need to be harvested in early May to avoid high temperature injury to the plants.

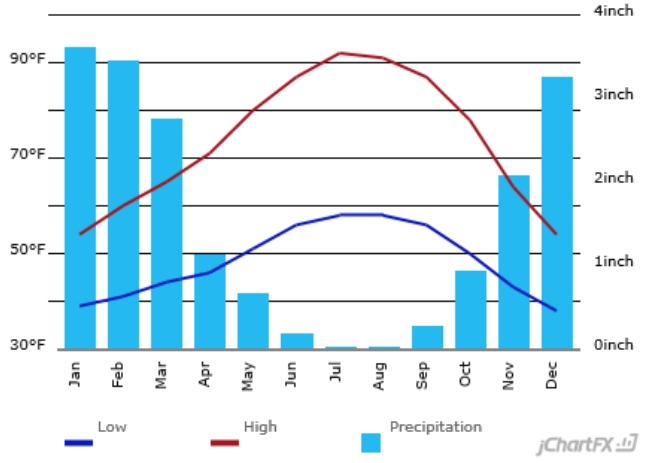

Figure 5. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Sacramento, CA. Temperature and rainfall in Sacramento, CA are very favorable for a January/February planting and May/June harvest period.

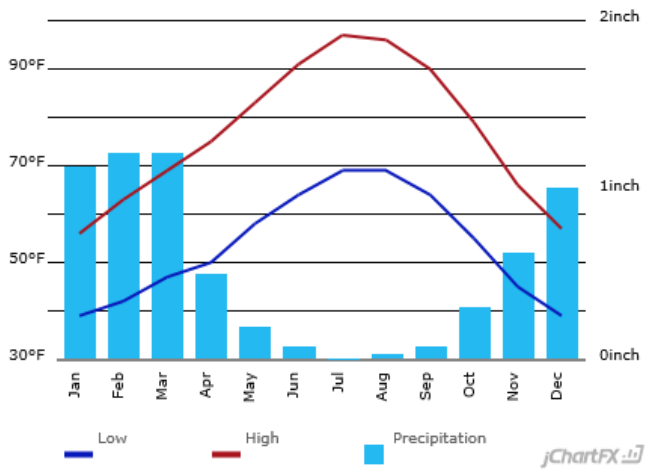

Figure 6. Average climatological data (rainfall and temperature averages from 1981 to 2010) for Bakersfield, CA. Although high temperatures may move the planting window slightly later, the production window for cumin based on climate appears to be similar to Sacramento - January/February planting and May/June harvest period.

Summary of conditions promoting cumin production:

In earlier studies we found that cumin germination and plant survival was favored by moderate and reducing soil temperatures – leading to a recommendation that cumin be sown and allowed to establish during the winter. We tried fall planting (October and November) in Oklahoma and found that plants did germinate but survived poorly over the winter. Plantings in December and February did best – even though multiple freezing events occurred in 2019, good winter survival was documented which confirmed the freeze tolerance observation in 2018. Soil pH also impacted cumin plant germination and survival, with very low viability in soils with pH values below 5 and better emergence and survival of plants established in soils at pH 6 or above.

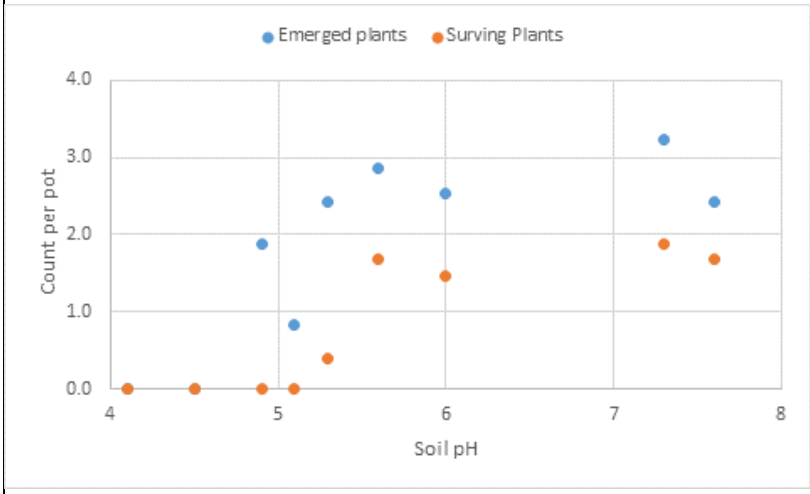

Figure 7. Effect of soil pH on cumin plant emergence and subsequent plant survival. Soils at various pH levels were obtained from various locations in Oklahoma and utilized in a greenhouse to evaluate pH ranges most suited for cumin production. Of 5 seeds planted into each pot, plant emergence was extremely limited in soils below pH 5; plant survival after emergence was mostly favored in soils of pH above 5.5 or 6.0.

Close planting at a shallow planting depth (approximately ¼ inch) should favor upright growth and deter lodging of cumin – using our 6 inch row spacing we found that cumin plants had room with canopies barely touching. Planting rates of greater than 30 lb live seed per acre did not appear to impact yield (although our yields were greatly depressed by onset of cumin blight). Low rainfall during the bloom and seed set stage of development is essential to prevent early plant death brought about by cumin's severe sensitivity to cumin blight – our observation of this disease, in a geographical location where cumin has not been grown, suggests that the disease causal agent was ubiquitous here and may be presumed to be ubiquitous in other potential growing areas as well. Since rainfall triggers disease onset, production of cumin should occur in climates where rainfall is least likely to occur during the sensitive stages for the disease (flowering and seed set) during April, May and June. Cumin does not tolerate high temperatures – while our work does not offer a maximum temperature, we did observe plant decline for late plantings which had not yet reached flowering stage (and thus did not likely decline because of cumin blight) when temperatures climbed above 90 °F.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Although we have no plans to promote cumin production in Oklahoma, we will recommend that cumin production be investigated in the desert southwest (Arizona and California). This should assist Kalustyan and others interested in development of a domestic US source of cumin for the spice trade.

BENEFICIARIES

Number of project beneficiaries: 20

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☑ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 4, Indicator 1	21 cumin genotypes (16 USDA cumin accessions, one Turkish genotype, one genotype from a US seed supplier and 3 genotypes from India) were evaluated.
2	Outcome 4, indicator 2	Plantings were established at 2 grower locations and at the Cimarron Valley Research Station. We indicate 20 project beneficiaries above -, even though our final recommendation was not to grow cumin in Oklahoma, because this project can eliminate cumin as a cropping choice for them, saving time and money trialing a crop which is not suited for Oklahoma's climate.
3	Outcome 5, indicator 7	We only partially achieved this – while we did identify a likely planting density and seeding rate for cumin, we were not able to achieve a yield which could justify combine harvest or seed cleaning testing.
4	Outcome 8, indicator 5	Since the prevalence of cumin blight (even with chemical fungicide measures applied) caused catastrophic plant death and failure to obtain viable seed yields, we were unable to achieve this outcome.

DATA COLLECTION

See the "lessons Learned" section for a summary of our results.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$56,203.00	$51,379.72
Fringe Benefits	$18,610.00	$16,003.98
Travel	$10,220.00	$1,366.63
Equipment	$0.00	$0.00
Supplies	$7,750.00	$4,818.28
Contractual	$0.00	$0.00

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Other	$4,400.00	$2,991.00
Direct Costs Sub-Total	$97,183.00	$76,559.61
Indirect Costs	$0.00	$0.0
Total Federal Costs	$97,183.00	$76,559.61

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Evaluation of Ground Covers upon Soil Health and Young Pecan Tree Performance			
Recipient Organization Name:	Choctaw Nation			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Jack Hicks			
Phone:	580-326-3201 Ext. 6016			
Email:	jackhicks@choctawnation.com			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The Choctaw Nation of Oklahoma's Department of Agriculture conducted cover crop research to evaluate its impact upon soil health and tree performance in a non-producing pecan orchard located in Garvin, Oklahoma and a young, producing pecan orchard located at the Noble Foundation in Ardmore, Oklahoma. Five cover crop treatments were established and replicated three times for a total of 15 sample blocks at each site. Initial recordings of tree trunk diameter and soil samples were collected at the center of each block to establish a baseline for research. Cover crops were planted between November and December of 2016. Soil and leaf samples were collected each July, and tree shoot and trunk growth were assessed

during dormancy. Additionally, soil moisture was measured through ground sensors to determine which cover crops provided the least amount of orchard floor water competition. The results will be disseminated to socially disadvantaged and beginning farmers through print media and field days to ensure they are utilizing best cover crop practices for their pecan orchards. In addition, results will be published and shared at the annual Oklahoma Pecan Growers' Association meeting, and the Samuel Roberts Noble Foundation will share the project outcomes in a peer reviewed journal and through the Noble Foundation monthly publication, *AG News and Views.*

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Determine which cover crop improves the overall soil health of the pecan orchards, thus lowering the need for water and synthetic inputs.		XX
2	Compare soil moisture measurements to determine which cover crop offers the least amount of competition for orchard floor water.		XX
3	Ascertain which cover crop provides the greatest overall tree growth and pecan production (Ardmore orchard) through nutrient uptake.		XX
4	Provide educational opportunities concerning cover crop practices to pecan farmers through print media and field days.	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	PFLA and Haney Soil Test were collected and analyzed.	Objective 1: To create a baseline of phospholipid fatty acids and nutrient availability of the orchard floor surrounding each sample tree.
2	Trunk diameter collected	Objective 3: To determine which cover crop provides the best overall pecan tree performance.
3	Installed thirty AgriSource soil moisture sensors.	Objective 2: Measure water content and soil temperature at multiple depths in order to determine which cover crop offers the least amount of water competition among young trees.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
4	Three workshops were held throughout reporting period with an approximate total of 175 attendees.	Objective 4: Provide educational opportunities concerning cover crop practices to pecan farmers through print media and field days

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Extreme weather conditions	N/A
2	Sensor malfunctions	N/A

LESSONS LEARNED

For this type of study, it will require additional years of research to achieve adequate information on the soil metrics to determine which cover crops have an impact on tree performance.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Noble Research Institute will continue researching this subject. Continuous of this research is part of Noble's pecan initiative over the next 5 years. Due to leadership changes and departmental reorganization, Choctaw Nation will not further research.

BENEFICIARIES

Number of project beneficiaries: 175

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 4, Indicator 2a.	Three workshops were held discussed the grant and the use of cover crops in pecan plantings (Pecan 101 workshop 9/25/18 Ardmore, OK, Pecan Harvest and Orchard Management 10/25/18, Perkins OK and Pecan Harvest and Orchard Floor Management 10/30/18, Burneyville, OK). Of approximate 175 people in attendance 25% verbally indicated ground cover practices for their pecan operation.
2	Outcome 5, Indicator 8	Working with the NRCS, Noble Research Institute and other, the Choctaw Nation has hosted 16 different Soil Health Workshop/meetings to discuss the importance of ground covers and principles behind soil health and benefits growers can achieve. There have been approximately 140 have gained knowledge to the importance of ground cover in these meetings.

DATA COLLECTION

PFLA and Haney Soil Test were collected in each treatment block at the beginning of the project and each year after that. Soil sample results were analyzed with LSMeans and there were no differences in the results. We expect these results would be significantly different after a couple more years. With the extreme weather conditions during the study period a number of newly planted trees were lost in the Garvin orchard, therefore a good sample of trees to collect tree performance measurements from were not available. Tree performance measurement were collected on the older trees at the Noble orchard and the results will be analyzed along with the soil samples after the fifth year. Along with tree performance, nut characteristics and total tree production has been collected and will continue to be collected on these trees.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$0.00	$0.00
Fringe Benefits	$0.00	$0.00
Travel	$3,532.00	$2,281.00
Equipment	$0.00	$0.00
Supplies	$9,848.00	$9,644.63
Contractual	$36,330.00	$30,893.75
Other	$0.00	$0.00
Direct Costs Sub-Total	$49,710.00	$42,819.42
Indirect Costs	$0.00	$0.00
Total Federal Costs	$49,710.00	$42,819.42

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Food Safety Modernization Act Training and Technical Support for Oklahoma Agricultural Producers			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Ravi Jadeja			
Phone:	405-744-3922			
Email:	Ravi.jadeja@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Each year, foodborne diseases cause approximately 48 million illnesses, 128,000 hospitalization and 3,000 deaths in the United States. In order to manage this public health burden, the Food Safety Modernization Act (FSMA) was enacted in 2011. Education and technical assistance, especially for small and medium-sized produce growers, are essential elements in the successful implementation of FSMA.

With the finalization of the Produce Safety Rule the subsequent practices that must be implemented to comply with these new regulations, Oklahoma farmers face a significant challenge. According to an internal survey, approximately 60 farms in Oklahoma required to comply with produce safety rule requirements. Even though many small farms are exempt from the produce safety rule, customers are increasingly requesting compliance with FSMA and third-party audits. Project stakeholders, including owners and operators of small and medium-sized farms, beginning farmers and socially disadvantaged farmers must be trained on the new practices as well as understand the new regulatory paradigm in order to remain operationally viable.

The overall goal of this proposal was to build an infrastructure in Oklahoma to support FSMA-compliant food safety training and technical assistance as it relates to the produce industry

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Develop a team of PSA trainers in Oklahoma	XX	
2	Develop and deliver Oklahoma produce industry specific training and technical assistant programs along with PSA trainings	XX	
3	Evaluate the impact of project's training and technical assistance program	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	7 team members attended the PSA Lead Instructor training. 2 Instructors achieved the lead instructor certificate 5 team members received FSMA readiness review training	Objective 1: Develop a team of PSA trainers in Oklahoma

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
2	21 Produce safety rule workshops were organized and a total of 302 participants trained in FSMA rule 4 FSMA readiness reviews conducted Assisted 7 farms to develop food safety plans and programs to meet produce safety rule, GAP, Harmonized GAP+ and Primus	Objective 2 &3: Develop and deliver Oklahoma produce industry-specific training and technical assistance programs along with PSA training Evaluate the impact of project's training and technical assistance program.
3	Web page was updated with the updated water testing calculators. In addition to easy to use water quality calculators, approved sanitizer list, food safety plan templets, records templets to meet GAP requirements were developed.	Objective 2 Develop and deliver Oklahoma produce industry-specific training and technical assistance programs along with PSA training

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	During the fall participant numbers were low in some workshops due to harvest and farmers market days	Worked with farmers' markets to organize training on days convenient to growers Organize training around Horticulture Industry Show, Farmers market conference helped with participation
2	We were not able to use out of state travel money because most of our trainers were trained right before the grant funds were allocated (due to limited availability of Produce Safety Alliance Training). For most training trips, OSU was able to provide vehicle at no cost.	We utilized a portion of funds to support FSMA readiness review training of instructors. Budget was slightly modified to reduce the travel amount
3	A large number of farms in Oklahoma are exempt from the produce safety rule requirements	We were able to work with local retailers and distributors who encouraged local growers to receive produce safety training

LESSONS LEARNED

1) It is essential to work with farmers markets so that they can encourage participants to attend trainings

2) Try to offer as many training as possible during winter (due to availability of growers)

3) One-on-one assistance is the key to improve stakeholder involvements

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

1) We are planning to offer the produce safety rule training at cost to participants. We have a total of 12 trainings scheduled for years 2020 and 2021.

2) Due to numerous requests received from aquaponics and hydroponics growing operation, we prepared a comprehensive produce safety rule and Harmonized GAP guidance documents suitable for small produce growing operations. The document was distributed during workshops conducted. We are also planning to prepare a series of fact-sheets on the same topic. The fact-sheets will be made available at no cost through OSU extension and the project website.

3) Produce safety alliance required surveys were collected after each workshop. Findings were utilized to improve training and also shared with Produce Safety Alliance.

4) Most workshops included pre and post-tests to measure participants' knowledge gain (due to time limitations/request form participants, tests were not included in workshops conducted at El Reno Federal Detention Facility and several custom training organized for farmers' markets and tribes).

5) Training materials and participant surveys results were also shared with the Southern Center (https://sc.ifas.ufl.edu/) for broader distribution

BENEFICIARIES

Number of project beneficiaries: 302

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☑ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☑ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 6, Indicator3	302 participants learned about Good Agricultural Practices, safe handling of soil amendments from biological origins, post-harvest produce handling, and factors that influence the safety of produce crop. During the workshops/training antimicrobial wash treatment methods were demonstrated. A list of approved antimicrobials suitable for produce wash was distributed among participants. One-on-one assistance provided in setting up/review post-harvest wash treatments.
2	Outcome 7, Indicator 5	302 participants attended the produce safety training compliant to the produce safety rule. Food safety programs for 7 growing operations were developed. These programs helped growers improve their reach to market (compliance with PSR and/or third party audits were required by the organization).

DATA COLLECTION

The following information was collected:
1) Participant satisfaction surveys: These surveys are required by the produce safety alliance to determine the participant satisfaction with the overall workshops. This multi-page survey includes information about the participants satisfaction regarding workshop location, organization and training quality for each module. Surveys results were used to improve workshops provided and training materials.

2) Pre and post-tests results
Pre and post tests were utilized to understand participants knowledge gain. Findings of the tests were used to incorporate additional materials related to the topics participants struggle to fully comprehend.

3) Follow-up surveys (verbal/telephonic)
Follow up surveys were utilized to understands a mid-term impact of the training provided. The information collected was also utilized to understand the grower/commodity specific needs.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$6,470.00	$10.819.50
Fringe Benefits	$1,540.00	$1,772.16
Travel	12,800.00	$8,312.21
Equipment	$0.00	$0.00
Supplies	$0.00	$0.00
Contractual	$0.00	$0.00
Other	29,500.00	$19,386.57
Direct Costs Sub-Total	$50,310.00	$40,290.44
Indirect Costs	$0.00	$0.00
Total Federal Costs	$50,310.00	$40,290.44

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Whole-chain traceability to improve food safety: melons			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Brian D. Adam			

Phone:	405-744-6854
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PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The project will improve food safety in melon supply chains by making whole-chain traceability accessible for small- and mid-size producers, combined with intensive food safety training programs for food handlers. Whole-chain traceability systems provide a vital key for timely withdrawal of product from the market after a problem is discovered. Recently developed traceability technology that overcomes obstacles to adoption and also provides value-added opportunities will be adapted for melons, and a pilot system will be deployed in Oklahoma melon supply chains. Because most foodborne illness outbreaks involve mistakes by people, combining rapid recall traceability with intensive food safety and traceability training can greatly enhance food safety as well as value-added opportunities for producers.

Consumers are increasingly concerned about the safety and wholesomeness of the food they eat. Recent well-publicized Salmonella, Listeria, and E. coli outbreaks have heightened that concern. Meanwhile, public health officials and advocates concerned about American dietary habits are emphasizing the need for plentiful supplies of fresh fruits and vegetables available to and affordable for all consumers. The combined objectives of food safety training for produce handlers and implementation of innovative traceability technology can help resolve these apparently conflicting goals.

To minimize costs of providing fresh foods to consumers by optimizing their supply chain management, as well as to increase safety of the product, a growing number of retail chains requires that their suppliers employ sophisticated traceability technology. An affordable whole-chain traceability system accessible to even small producers could greatly improve food safety for specialty crops such as melons, reducing risks to both consumers and producers. Moreover, traceability can enable producers to earn price premiums for sustainable, certifiable, or identifiable specialty food products. These value-added opportunities provide additional motivation for farmers to adopt traceability.

Whole-chain traceability systems provide a vital key for timely withdrawal of product from the market after a problem is discovered, or recall of a product after a food-borne illness outbreak. Conversely, failure to identify the source of a contamination can cause significant economic losses to multiple industries resulting from public uncertainty on the potential for human hazard, affecting industries ultimately found to not be related to outbreaks.

However, a traceability system accomplishes little if few firms participate. Although some vertically-integrated supply chains have successfully implemented systems to trace and track products within the supply chain, technological and institutional constraints make tracing and tracking products exceedingly more difficult when transactions occur across several companies in a fragmented supply chain.

Obstacles to implementing whole-chain traceability systems in fragmented supply chains include deep-seated concern by firms of disclosing their proprietary information, costs of implementation and operation relative to perceived value, lack of standards for sharing information, and potential for increased liability. These obstacles severely limit potential participation by firms in whole-chain traceability systems, thus greatly limiting value of traceability for improving food safety and improving value to consumers. Moreover, small firms are at a disadvantage in implementing effective traceability systems because of the high investment and implementation costs, as well as the high transaction costs of implementing agreements and technological interfaces with distributors.

OSU has developed technology for a whole-chain traceability system that can quickly pass information up and down the supply chain that allows firms to selectively share only that information that they choose, with only firms that they choose. This overcomes the privacy barriers to implementation, but research is needed to find ways to overcome remaining barriers, especially reducing costs and increasing value to participating firms.

The purpose of this project is to improve food safety in the supply chain for melons by making whole-chain traceability technologically easier to implement and by using it to facilitate value-added activities. By encouraging participation, it will greatly increase both the scope and speed of traceback capabilities for food safety events in the supply chain. The focus of this project is on melons, but lessons learned from this pilot should readily lead to the long-term goal of whole-chain traceability for other specialty crops. To ensure the system can be effectively used by industry personnel, the project will solicit their input as part of food safety certification training sessions that will train industry personnel to effectively use traceability for food safety and value added

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Develop an effective interface between OSU's whole-chain traceability system (PCD-WCTS) and melon producers	XX	
2	Deploy pilot traceability systems for melons		XX
3	Train personnel in the melon supply chain in Food Safety and Traceability	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Conducted and analyzed surveys (10) to understand melon growers' needs	Objective 1 and Objective 3
2	Developed detailed melon supply chain models	Objective 1
3	Constructed an interface between OSU's NWCTI Traceability System and a stylized software system representative of what a watermelon producer might use in actual implementation of whole-chain traceability	Objective 1
4	Used detailed melon supply chain models to measure changes in recall time for a food safety event with and without a traceability system.	Objective 1
5	Constructed an economic model to estimate cost-reduction advantages of using whole-chain traceability to optimize supply chain management for melons	Objective 1
6	Conducted grounded theory research to determine the potential benefits of blockchain technology in whole-chain traceability in segmented supply chains	Objective 1
7	Conducted 7 comprehensive food safety onsite audits for melon growers (including on-farm readiness review to test FSMA compliance)	Objective 3:
8	Developed and provided the following programs: 1 Food defense plan, 3 food defense plans reviewed, 1 traceability program developed, 2 HACCP plans, 2 food fraud plans, 3 HACCP plans reviewed	Objective 3
9	Assisted with Primus, FSMA and Harmonized GAP+ audits preparation and mock audits	Objective 3:
10	Conducted and analyzed surveys (10) to understand melon growers' needs	Objective 1 and Objective 3

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Software company whose melon management software is used by large cooperating melon producer was not willing to cooperate with OSU computer scientists	This impeded our progress in completing Objective 2. Since we were unable to obtain cooperation, we proceeded with developing an interface between OSU's traceability

#	Challenge or Development	Corrective Action or Project Change
	in developing traceability software interfaces to the NWCTI system.	system and a stylized system that includes key data fields identified by research in melon production and distribution nationally as well as by conversations with Oklahoma growers.
2	The large melon producer who initially offered and provided some support on the project was unwilling or unable to provide additional information on data needs and supply chain configuration to help deploy even a stylized version of the traceability system.	Together with the Challenge in #1 above, this prevented our completion of Objective 2. As a substitute, we constructed a stylized interface between OSU's traceability system and a hypothetical melon producer. We modeled the hypothetical melon producer using information from published data on melon production, and from information provided in initial stages of the project by the large melon producer, so we believe the stylized software system and the hypothetical producer are representative of actual melon firms and software.

LESSONS LEARNED

1. Each food product's supply chain is sufficiently different that traceability systems must be adapted to meet the individual needs of the supply chain and of the individual firms

2. Although the traceability system developed by OSU (and used in this project) provides a way to overcome confidentiality concerns about information sharing, simply setting up such a traceability system may be difficult because the firm is concerned about revealing information to the traceability provider.

3. Although traceability technology such as that used in this project overcomes some barriers to adopting traceability technology, significant barriers remain, at least for some supply chains.

4. This project demonstrates that traceability systems, using technology that is currently available, can meet many needs of food production companies if the remaining barriers are resolved and the companies choose to adopt the technology.

5. A significant barrier to fully meeting all the objectives of the project was a lack of cooperation by key industry players, even though an initial agreement of cooperation was received. Those doing similar work in the future should have robust contingency plans for cases where cooperation is not received.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

1. We are continuing to refine and improve the economic and supply chain models to estimate the impact of cost reduction and value-added benefits of implementing whole-chain traceability systems in melon supply chains

2. We will extend those efforts to other food products, especially fresh fruits and vegetables

3. We will publish the results of these efforts in applied journals and trade journals, and also disseminate them through

BENEFICIARIES

Number of project beneficiaries: 64

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☑ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 6, Indicator 3: Number of individuals who learn about prevention, detection, control, and intervention food safety practices and number of those individuals who increase their food safety skills and knowledge (not including Produce Safety Rule training participants)	-More than 45 workers were certified by PSA - More than 45 workers learned about traceability - HACCP plans were developed for 2 firms - 7 Food Safety Plans were reviewed - 1 Traceability Plan was developed - 3 Traceability plans were reviewed

		- 2 food fraud plans were developed - 1 was developed - 3 food defense plans were reviewed
2	Outcome 6, Indicator 4: Number of improved prevention, detection, control, and intervention technologies	1 traceability system interface with a model melon management software was developed

DATA COLLECTION

Number of participants in training seminars was counted, and learning was measured through evaluations. Those who showed competence were counted

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$69,902.00	$69,277.81
Fringe Benefits	$5,375.00	$7,978.09
Travel	$4,500.00	$3,146.27
Equipment	$0.00	$0.00
Supplies	$3,000.00	$2,199.91
Contractual	$0.00	$0.00
Other	$0.00	$0.00
Direct Costs Sub-Total	$82,777.00	$82,602.08
Indirect Costs	$0.00	$0.00
Total Federal Costs	$82,777.00	$82,602.08

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Zoysiagrass Sod Promotes Sustainability of Shaded Landscapes and Creates Novel Markets for Producers

Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Charles Fontanier, PhD			
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PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Potable water used for landscape irrigation can represent over 40% of outdoor domestic water use during the summer months. Promotion of drought tolerant plant materials is critical to decreasing water use while maintaining aesthetic and functional landscapes. In Oklahoma, bermudagrasses represent the majority of turfgrass species used for residential lawns. However, bermudagrasses possess very poor shade tolerance, thus being limited to full sun locations. As a consequence, tall fescue has often replaced bermudagrass in shaded Oklahoman landscapes. Although tall fescue has superior shade tolerance, it also has a higher water requirement than most warm-season turfgrasses. Further, tall fescue swards are susceptible to devastating summer diseases that can result in annual replanting. Zoysiagrasses are a group of warm-season turfgrasses that have good drought resistance and excellent shade tolerance. Zoysiagrasses are capable of producing an attractive, dense turf using fewer pesticides and fertilizer than bermudagrasses, but widespread adoption of Zoysia spp. has not occurred in Oklahoma. The underlying goal for this project is to encourage replacement of tall fescue with zoysiagrasses towards promoting sustainability and water conservation.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Identify key hurdles to zoysiagrass adoption by consumers, landscape contractors, and sod producers.	XX	
2	Evaluate planting methods, cultivar selection, and fertility requirements for establishing and growing zoysiagrass sod for production.	XX	
3	Quantify water use requirements of zoysiagrass, bermudagrass, and tall fescue in shade.	XX	
4	Develop recommendations for municipalities and sod producers that will promote zoysiagrasses in urban markets.	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	We planted 15 zoysiagrass cultivars from a broad range of origins, appearances, and availability at the Bixby research station. These cultivars include several off-patent or soon-to-be off-patent cultivars that have strong performance records in neighboring states.	Plots contributed towards completion of Obj 2, evaluate planting methods, cultivar selection, and fertility requirements for establishing and growing zoysiagrass sod for production. The broad range of zoysiagrass genotypes is important for achieving Outcome 5, Indicator 1: selection of two elite performing cultivars for the Oklahoma region.
2	Establishment rate data were collected on newly planted grasses at the Bixby station. These data were collected monthly until the growing season ended.	Plots contributed to completion of Obj 2, evaluate planting methods, cultivar selection, and fertility requirements for establishing and growing zoysiagrass sod for production. The broad range of zoysiagrass genotypes is important for achieving Outcome 5, Indicator 1: selection of two elite performing cultivars for the Oklahoma region.
3	We collected water use data from twelve genotypes (11 zoysia and 1 bermuda) under shaded and non-shaded conditions at the Stillwater research station.	Obj 3, to quantify water use requirements of zoysiagrass, bermudagrass, and tall fescue in shade. Results will be used to guide selection of elite performing cultivars as suggested by Outcome Indicator 1 and Obj 4.
4	Sod tensile strength data were collected 13 months after planting for 15 zoysiagrass cultivars.	Data contribute towards completion of Obj 2, evaluate planting methods, cultivar selection, and fertility requirements for establishing and growing zoysiagrass sod for production. The broad range of zoysiagrass genotypes is important for achieving Outcome 5, Indicator 1: selection of two elite performing cultivars for the Oklahoma region.
5	Shared research outcomes and held stakeholder discussion sessions with state sod producers.	Activity contributes to Obj 1 to identify hurdles to adoption among producers and directly achieves Outcome 5, Indicator 8.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Irrigation availability at the Bixby station was delayed in Year 1 of the grant.	Plots were established in Year 2 and harvest data collected in Year 3 (1-year delay).

LESSONS LEARNED

The major lesson learned in regards to research methodology was that quantifying water use rates can be challenging if rainfall is abundant during the growing season. Future projects investigating similar topics should prioritize the use of rainout shelters or similar methods to prevent interference of rainfall on measurements.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

The project results will continue to be disseminated through peer-review journals and at state-wide industry conferences.

BENEFICIARIES

Number of project beneficiaries: 52

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 5, Indicator 1	Zeon and Zorro were the 2 best performing cultivars and may have potential for use in Oklahoma where medium-fine textured grasses are needed. Innovation and Palisades were 2 good performers for medium to coarse-textured grasses.
2	Outcome 5, Indicator 8	At least 13 sod producers gained knowledge of the relative performance of zoysiagrass cultivars through outreach education at the state Turf conference. At least 2 sod producers and approximately 30 green industry stakeholders gained new knowledge of zoysiagrass performance under moderate shade in Oklahoma.

DATA COLLECTION

Nov – May (2017-18): Trips to the Bixby research station were made periodically by the PI and Co-PI to monitor plot construction and transport equipment for maintaining plots and harvesting sod. Plot irrigation installation was completed near the end of May.

Zoysiagrass cultivars were maintained under greenhouse conditions in preparation for field planting in summer. Over 15 zoysiagrasses were propagated under greenhouse conditions in anticipation of planting sod production studies at the Bixby research station. This entailed weekly clipping and regular fertilizer and pesticide applications to ensure plant health.

Due to the delay in the field studies, a greenhouse experiment was conducted to determine the relative water use rates and drought resistance of bermudagrass, tall fescue, and zoysiagrass under shaded conditions. The turf visual performance under a controlled drying cycle was compared to a well-watered control. The rate of water loss and onset of drought stress were recorded for each turfgrass to determine how each species differed in their response to shaded and non-shaded conditions.

Jun – Sept (2018): The Bixby project was planted in early June 2018. In total, 17 turfgrass cultivars were planted from sprigs and another two plots were planted as plugs to test the relative establishment rates of each planting method. The cultivars were selected to represent a variety of new and old cultivars having differences in leaf texture and source of origin. Two fertilizer rates were used to test the effect of N rate on production rate. Data related to green coverage (visual ratings and image analysis) were collected monthly. Treatments and plot maintenance was performed periodically as needed to ensure integrity of the plots.

Data were collected from the Stillwater location beginning in June 2018. Soil moisture content was measured 2 to 3 times per week at 5 depths on each plots. Differences in soil

moisture content were used to estimate ET rates under sun and shade. Visual ratings and measurement of canopy greenness (NDVI) were used to characterize cultivar response under shade.

Oct-Nov (2018): Analysis of data from the Bixby field study indicated cultivars varied in their establishment rate with coarse-textured plants having a faster growth habit than finer textured plants. As was expected, Meyer zoysiagrass was one of the slower cultivars tested – in particular when established from plugs as opposed to sprigs. In general, all cultivars responded well to the sprigging planting method.

Data from the Stillwater location were analyzed and contributed to a MS student thesis. In general, all zoysiagrasses performed better than bermudagrass under shaded conditions but turf quality declined throughout the season suggesting none were able to tolerate the severity of the shaded conditions. Water use rates among zoysiagrass cultivars did not vary in the sun but minor differences were detected in the shade.

Two presentations were given at the 2018 Oklahoma Turf Research Foundation conference in Owasso, OK. Updates on the Bixby project were provided in the sod producer session, while updates from the Stillwater site were provided to landscape professionals in the general session.

Dec-Jul (2018-19): Data from both the Stillwater and the Bixby study were collected in a similar manner as the previous year. Sod tensile strength was collected 17 August 2019 (~13 months after planting) using a custom-made testing device fitted with a load cell and capable of logging the peak force needed to tear a 12-inch wide sod pad. At the time of this measurement, most treatments and cultivars had reached full coverage although some were visually not as mature as others. Sod tensile strength ranged from a low of 24 N for Meyer planted from plugs to 73 N for Zeon planted as sprigs and fertilized at the low N rate. In general, no difference was seen between high and low N rates although there was some evidence this response was cultivar-specific. Plugged grasses were typically worse than sprigged grasses. Most cultivars developed since 1990 outperformed the current standards Meyer and El Toro in regards to sod tensile strength, although sod handling quality was typically acceptable for all zoysiagrass entries.

Data collected from the Stillwater site were somewhat different in 2019 than in 2018. First, 2019 represented the second year of shade stress and potentially is of more value when selecting cultivars for use in these environments. Secondly, the unusually wet spring likely contributed to delays in green-up witness for shaded plots. Top performing cultivars in the Stillwater study included Zorro and Zeon, as well as Innovation and Palisades. The very fine textured cultivar Diamond performed well in 2018 but demonstrated substantial loss of density in 2019.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$34,600.00	$36,205.27
Fringe Benefits	$1,634.00	$2,482.80
Travel	$6,000.00	$1,569.17
Equipment	$0.00	$0.00
Supplies	$14,632.00	$19,008.74
Contractual	$0.00	$0.00
Other	$2,400.00	$0.00
Direct Costs Sub-Total	$59,267.00	$59,266.00
Indirect Costs	$0.00	$0.00
Total Federal Costs	$59,267.00	$59,266.00

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

N/A

Project Title	Identifying Risk of Damage and Depredation of Pecans by Feral Swine			
Recipient Organization Name:	Oklahoma State University			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	W. Sue Fairbanks			
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Email:	Sue.fairbanks@okstate.edu			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Oklahoma is one of the top-producing states for pecans, generating about $28 million dollars in revenue, annually (USDA 2012a). Native pecan groves and planted pecan orchards also attract feral swine, which may use the trees as habitat and the nuts as a food resource. In addition to direct consumption, foraging behaviors such as rooting, digging, and trampling by feral swine also result in damage (Seward et al. 2004), and may reduce harvest efficiency by producers. Numerous zoonotic diseases carried by feral swine (USDA APHIS 2015, Seward et al. 2004) also raise concerns about contamination in pecan groves and food safety for human consumption (USDA APHIS 2015).

Oklahoma State University and the Noble Research Institute partnered to identify areas and timing of use of pecan groves and orchards by feral swine, and to quantify the effects of rooting damage on the efficiency of pecan harvest with a common harvest method. We used global positioning technology (GPS) and geographic information systems (GIS) to assess where (spatial) and when (temporal) feral swine used pecan orchards and groves. Based on these results we developed risk maps that can be used to prioritize management intervention to reduce depredation or damage, and to assess potential for contamination by zoonotic diseases carried by feral swine (USDA APHIS 2015, Seward et al. 2004). We used a before-after-control-impact (BACI) study design to quantify the efficiency of the commonly-used shake and harvest method in areas with and without substrate damage by feral swine. We produced an online calculator, based on these results, that producers can use to evaluate harvest loss due to feral swine substrate damage compared to inherent efficiency of the harvest method. This information can help determine cost effectiveness of feral swine control.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Identify and prioritize use of pecan groves and orchards by feral pigs (*Sus scrofa*)	XX	
2	Quantify loss of pecans resulting from feral pig rooting behavior	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Developed a resource selection model describing spatial and temporal use of pecan orchards and groves by feral swine before, during, and after pecan harvest.	Identifies areas and times to prioritize feral swine control with respect to pecan operations.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
2	Developed GIS layers (maps) indicating probabilities of use of different areas within pecan orchards and groves by feral swine during pre-harvest, harvest, and post-harvest of pecans.	Visually depicts areas of high probability of use by feral swine in and around pecan orchards and groves.
3	Developed a quantitative model of the factors affecting pecan harvest efficiency in areas damaged by feral swine vs control	Quantifies the loss of pecans due to reduced efficiency of harvest in areas with rooting damage by feral swine compared to undamaged areas, while controlling for confounding factors.
4	Developed a Pecan Loss Calculator that pecan producers can use to quantify monetary loss due to inefficiency of the harvest method and monetary loss based on area of damage by feral swine given acreage, production rate, and market prices. https://nobleapps.noble.org/agcalculators/calculators/pecanloss	Publicly available calculator for use by pecan producers to assess feral swine control efforts and methods based on cost effectiveness.
5	Published article "Surficial soil damage by wild pigs (*Sus scrofa*) decreases pecan harvest efficiency" in the journal Crop Protection.	Increases awareness of feral swine on pecan production and the existence of the Pecan Loss Calculator on the Noble Research Institute's website.
6	Numerous presentations and workshops presented at international, national, regional, and state meetings for pecan producers, natural resource managers, and wild pig conference attendees.	Provided information and, in workshops, hands on training in identification of feral swine damage and capture techniques used in this study.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Challenge: At the end of the tracking period, several collared pigs swam the Red River into Texas. Special permission had to be obtained from landowners to hunt down the pigs and retrieve the collars.	We maintained communication with neighboring landowners in Texas and Oklahoma to facilitate retrieval of collars and removal of feral swine at the end of each year of data collection.

#	Challenge or Development	Corrective Action or Project Change
	These issues increased the amount of time required to obtain the GPS collars.	
2	Development: The Pecan Loss Calculator has received much use (Noble tracks the number of visits), and the work in general, is receiving much media coverage, including several publications in popular journals.	None

LESSONS LEARNED

The BoarBusterTM trap was highly effective at capturing large numbers of feral swine (all or a large proportion of a sounder) in one event, which was our goal at the end of the data collection period to retrieve GPS collars and remove as many feral swine as possible. However, it was also effective in selectively capturing the specific age and sex of individuals that we wanted to deploy the radio collars on, without capturing and disrupting the majority of the sounder at the beginning of the data collection periods. Only minor maintenance of the traps was required despite our heavy use of them during the study.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

The Pecan Loss Calculator will continue to be available on the Noble Research Institute webpage to assist pecan producers with decision-making regarding control of feral swine. We have a second manuscript in preparation for publication.

BENEFICIARIES

Number of project beneficiaries: 500

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 5, Indicator 1.	A biological model that predicts use of pecan orchards and groves, both spatially and temporally based on resource selection by wild pigs during pre-harvest, harvest, and post-harvest of pecans.
2	Outcome 5, Indicator 1.	Three maps (GIS layer) showing probability of use of pecan orchards and groves by feral swine during pre-harvest, harvest, and post-harvest of pecans
3	Outcome 5, Indicator 1.	A model to quantify proportion of harvestable pecans lost to inefficiency of the harvest method and to inefficiency of harvest specifically related to substrate damage by feral swine, while controlling for confounding factors affecting harvest efficiency. In areas without surficial soil damage by wild pigs, inefficiency of the harvester was 10%, while in wild pig-damaged areas, there was an additional 34% loss of pecans.
4	Outcome 5, Indicator 1.	Construction of a Pecan Loss Calculator to allow producers to calculate monetary loss due to inefficiency of the harvest method and monetary loss based on area of damage by feral swine given acreage, production rate, and market prices. https://nobleapps.noble.org/agcalculators/calculators/pecanloss
5	Outcome 5, Indicator 1.	1 publication: Boyer, K.S., W.S. Fairbanks, C. Rohla, and S.L. Webb. 2020. Surficial soil damage by wild pigs (*Sus scrofa*) decreases pecan harvest efficiency. Crop Protection 128:104992. 1 ms for publication in preparation: Boyer, K.S., W.S. Fairbanks, C. Rohla, and S.L. Webb. (In Prep) Resource selection by wild pigs (*Sus scrofa*) in response to pecan (*Carya illinoinensis*) availability and harvest.
6	Outcome 5, Indicator 6.	Personnel trained as first responders to recognize wild pig sign and damage and to lead control efforts: Stephen Webb, Kelly Boyer, Josh Gaskamp, Kye Hennington, Derick Warren, Mike Proctor, Russell Stevens, Mike Porter, Will Moseley, Steven Smith.
7	Outcome 5, Indicator 8.	Workshops: Wild Pig Management Workshop, Noble Research Institute, Ardmore, Oklahoma. 4 October 2018. 35 attendees.

		Wild Pig Management Technical Training Workshop, Wichita Mountains Wildlife Refuge, Lawton, OK as part of International Wild Pig Conference, Oklahoma City, Oklahoma. 16 April 2018. 110 Attendees (to workshop). Wild Pig Research, Management and Control Workshop. Texas A&M AgriLife Extension, Dallas, Texas. Date. 60 attendees.

DATA COLLECTION

Objective 1.
BoarBusterTM traps (www.boarbuster.com) developed by the Noble Foundation were used to capture feral swine in pecan groves and orchards on the Noble Research Institute's Red River Farm in southcentral Oklahoma. Upon capture, 1-2 adult female pigs (per sounder) were sedated using a mixture of Xylazine and Telazol in order to affix a Vectronic Vertex Lite GPS collar with Iridium communication. When all procedures were completed, we injected tolazoline as a reversal to the xylazine for a faster recovery. All other pigs in the trap were euthanized. Collars were programmed to take 1 GPS location every 30 min September-December 2016 and 2017. GPS locations were downloaded from satellites on a daily basis, reducing the need to track the pigs manually with VHF telemetry. At the end of the study period, we used the GPS locations and VHF telemetry to assist with locating and deploying traps for recapture to recover the collars. All pigs captured after data collection were destroyed. Collared pigs that could not be recaptured in the trap were tracked down and removed by shooting.

Vegetation classes in the study area were will delineated based on the functional relationship that the vegetation provides for wild pigs on the Red River Farm using high-resolution (30-m) National Agriculture Imagery Program data (U.S. Department of Agriculture, Farm Service Agency, Salt Lake City, Utah). Roads, buildings, anthropogenic, and topographic (elevation, slope, roughness, etc.)features, and water sources were also digitized. We used generalized linear mixed models to assess resource selection by wild pigs based on vegetation class (including pecan orchards and groves), distance to water, terrain roughness, and distance to anthropogenic features (roads, oil pads, buildings) for pre-harvest, harvest, and post-harvest periods. The resulting resource selection functions were used to build a map of relative probability of use for the study area for each of the periods of study (pre-harvest, harvest, and post-harvest). These maps show the shift in probability of resource selection by wild pigs in relation to pecan availability and harvest. The resultingrisk map can be used to focus efforts to control feral pigs and suggest new control methods.

Objective 2.
We used a before-after control-impact (BACI) experimental design, where the control was non-damaged areas, impacted areas were damaged by actions of wild pigs, before was before harvest and after was post-harvest. Damage due to rooting, wallowing, and trampling activity by wild pigs was quantified by visual inspection in pecan groves and orchards on Red River

Farm. Five 0.33m2 frames were randomly thrown within each damage plot and each matched non-damaged plot. Depth of damage at the deepest point (in damage plots) was measured and number of pecans within the frame was counted. Sampling was conducted after tree shaking, immediately before and after the harvester collected pecans to minimize any loss of pecans between sampling due to depredation. During pre- and post-harvest sampling, at least 5 nuts were collected outside sampling frames and sized and weighed to determine whether size or weight was related to efficiency of collection by the harvester.

Pecan size and weight were highly correlated, so we used pecan size in our analyses because size is easier to estimate in the field. Pecans in planted orchards were significantly larger than those in native pecan groves, so we used source (orchard or grove) as a factor in our analyses as a surrogate to size. We used generalized linear mixed model to evaluate the influence of factors (orchard or grove; treatment [damaged or control plot]; depth of damage; and year) on percentage of pecans not successfully collected by harvesters (i.e. pecan loss). Using the results, we developed an online calculator to estimate the monetary loss of harvestable yields due to wild pig damage and due to inefficiency in harvest machinery, given production rate, area of wild pig damage, acreage of pecan orchard/grove, and market prices.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$30,450.00	$33,098.83
Fringe Benefits	$1,638.00	$3,203.88
Travel	$7,128.00	$6,638.82
Equipment	$0.00	$0.00
Supplies	$5,784.00	$2,057.47
Contractual	$0.00	$0.00
Other	$0.00	$0.00
Direct Costs Sub-Total	$45,000.00	$44,999.00
Indirect Costs	$0.00	$0.00
Total Federal Costs	$45,000.00	$44,999.00

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

Non-technical Publications

Webb, S.L., K. Boyer, and C. Rohla. 2018. Wild pigs: another problem for pecan producers. Pecan South 51(10):6–13.

Webb, S.L. 2018. Calculate your pecan losses with new online tool. Noble Research Institute News and Views 36(11):5.

Webb, S.L. and K. Boyer. 2018. Wild pigs put pecans at risk, research learns more. Noble Research Institute News and Views 36(11):1–3.

Webb, S.L. 2017. Wild pigs and pecans. Noble Research Institute News and Views 35(10):8.

Pecan Loss Calculator

Pecan Loss Calculator. Noble Research Institute, Ardmore, OK. https://nobleapps.noble.org/agcalculators/calculators/pecanloss

Presentations

Moseley, W., and S.L. Webb. 2018. Someone, or something, is taking a piece of your pecan pie: wild pigs and their influence on the pecan industry. Texas Pecan Growers' Association, San Marcos, Texas.

Gaskamp, J.A., and S.L. Webb. 2018. Someone, or something, is taking a piece of your pecan pie: wild pigs and their influence on the pecan industry. Oklahoma Pecan Growers' Association, Quapaw, Oklahoma.

Boyer, K.S., S.L. Webb, W.S. Fairbanks, J.A. Gaskamp, and C. Rohla. 2018. Damage and resource selection by wild pigs (Sus scrofa) in a pecan-producing agricultural landscape. Central Plains Society of Mammalogists Annual Meeting, October 2018, Stillwater, OK.

Boyer, K., and W.S. Fairbanks. Poster: Wild pig impacts in pecan operations. International Wild Pig Conference. 2018. Oklahoma City, Oklahoma.

Boyer, K, W.S. Fairbanks, S. Webb, J.A. Gaskamp and C. Rohla. 2017. Poster: Wild pig (Sus scrofa) impacts in pecan operations. Central Plains Society of Mammalogists Annual Meeting, October 2017, Dubuque, IA.

Boyer, K, W.S. Fairbanks, S. Webb, J. Gaskamp and C. Rohla. 2017. Poster: Preliminary data on feral hog impacts in pecan operations. Oklahoma Natural Resources Conference, February 2017, Tulsa, OK.

Media Coverage

Sunup TV – Oklahoma State University on OETA: https://youtu.be/mpbpXFtII8A

https://www.noble.org/news/publications/ag-news-and-views/2018/november/wild-pigs-put-pecans-at-risk-research-learns-more/

https://www.paulsvalleydailydemocrat.com/community/wild-pigs-sure-like-those-pecans/article_794695bf-c809-549e-99ef-0e4ce726db26.html

http://oklahomafarmreport.com/wire/news/2018/11/00617_NobleBoarBusterWildHogsandPecans11302018_114443.php#.Xe50OmxYaAj

http://journalrecord.com/2018/12/03/researchers-target-swine-to-protect-states-24m-pecan-industry/

https://www.pecansouthmagazine.com/magazine/article/wild-pigs-another-problem-for-pecan-producers/

http://www.swineweb.com/wild-pigs-put-pecan-production-at-risk-shows-joint-noble-oklahoma-state-study/

https://www.growingproduce.com/nuts/scientists-go-hog-wild-to-control-pecan-pest/

https://www.farmprogress.com/farm-life/wild-pigs-put-pecan-production-risk

https://www.agrimarketing.com/s/120842

https://iapps2010.me/2018/12/04/wild-pigs-relish-pecans/

Project Title	Evaluation of Strawberry Production in Oklahoma Utilizing Plasticulture			
Recipient Organization Name:	Oklahoma Department of Agriculture Food & Forestry			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/28/2018
Recipient's Project Contact				
Name:	Jason Harvey			
Phone:	405-606-1477			
Email:	Jason.harvey@ag.ok.gov			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

For many years strawberries where grown in Oklahoma without plastic. Some of the issues with that is fruit is not as clean because fruit is laying on the ground or in grass or weeds. Fruit was also harder to pick. Plasticulture strawberries increased production, because of drip irrigation and black plastic. The drip irrigation helps control the amount of inputs, such as fertilizer and water. It also reduces the amount of water and fertilizer used because it is all going into the root of the plant and not to areas of the field were water and fertilizer is not needed. Black plastic also aids in earlier production along with weed control.

With food safety being a big concern as we move forward in growing fruits and vegetables, it is important to show farmers how they can grow a cleaner produce on top of the plastic rather than on soil, grass or weeds. All strawberry varieties do not perform the same on black plastic mulch, therefore it is important to find the varieties best suited to Oklahoma varying growing conditions.

This grant was to build off the success of the 2015 Evaluation of Strawberry Production in Oklahoma Utilizing Plasticulture project that was funded through a Specialty Crop Block Grant. Six growers that had participated in the original project agreed to take part in the 2nd trial. Soil test were conducted at each location and the appropriate amendments were added to adjust soil ph to around 6.5 and Red Ripper cow peas were planted for a cover crop May 2017.

Seed beds were worked and prepped starting the middle of August by making 8 to 10 inch high beds that were overlaid with a 1.25 mil black plastic mulch with drip tape. Rye grass was broadcast between rows once the beds were completed to serve as weed control and barrier against mud during harvest time.

Five varieties of strawberry plugs were planted the first of September. The varieties were:
Camino Real
Festival
Ruby June
Sweet Charlie
Chandler

ODAFF staff responsible for the program left for another job. Without a staff member to oversee the project coupled with a late freeze that devastated the strawberry crop in Oklahoma; the project was terminated.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*

1	To identify strawberry varieties best suited for Oklahoma growing conditions utilizing the Plasticulture growing method		X

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Cover crop planted, grown and tilled into soil.	The objective of this project is to **identify** strawberry varieties best suited for Oklahoma growing conditions utilizing the Plasticulture. The utilization of cover crops is a sustainable way of providing nutrients and building soil health in a sustainable manner that will in turn lead to healthier plants accomplishing Outcome 4
2	Strawberry plugs ordered/delivered and planted on time.	Having all of the participants receive and plant their plugs at the same time will allow for better statistical analysis when comparing the different varieties allowing for the accomplishment of Outcome 4, Indicator 1: Of the 5 cultivars being tested ODAFF is hopeful to recommend 2 of the cultivars as being best suited for Plasticulture production in Oklahoma

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Loss of staff member	In December 2017 the ODAFF staff person responsible for the project resigned. During this timeframe the state of Oklahoma was in the midst of budget shortfalls and a hiring freeze was placed on all state agencies and ODAFF was not able to fill the vacancy. At the time of this report ODAFF is still without a staff person in the position.
2	Late freeze that damaged crop	In agriculture you are always dealing with weather conditions unless growing inside a controlled environment. Best you can do is have a plan in place to help mitigate any losses.

LESSONS LEARNED

Due to the unforgiving impact of Mother Nature on this project we were not able to learn much from this project as the late freeze damaged the crop so that harvest was unattainable. What we did learn from this and the previously funded project is that if you are going to do a research project, multiple years of data are necessary to get the best understanding of which varieties work best in Oklahoma. We seem to never have the same growing conditions year in and year out with varying freeze dates, temperatures and rain fall and its necessary to not go off of one year's data. Also relying on farmers to conduct research trials can also be difficult as they are not trained researchers and each plot can be treated differently.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

N/A

BENEFICIARIES

Number of project beneficiaries: 6

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

Select the Outcome Measure(s) that were approved for your project.

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results

1	Outcome 4, Indicator 1:	N/A; project was not able to be completed due to loss of staff member.

DATA COLLECTION

Participants were given a grid to follow when planting the different varieties. The beds were prepared with plastic and irrigation during September and the plugs were put in the ground during the first part of October. The participants were asked to log the dates of harvest and weigh the berries as they were picked. The six people that directly benefited from this project were the six selected to participate. Although no harvest data was collected due to the freeze damage, each of the participants have been imparted with knowledge of how to conduct a research trial if they wanted to test other varieties in the future.

Data was not able to be collected for this project although cover crops were planted and strawberry plugs were planted. When the staff member responsible for this project left for another job, ODAFF was unable to fill the position coupled with a late freeze that severely damaged strawberry production across the state left many producers with little to no production

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$0.00	$0.00
Fringe Benefits	$0.00	$0.00
Travel	$0.00	$0.00
Equipment	$0.00	$0.00
Supplies	$9,680.21	$8,874.73
Contractual	$1,050.00	$0.00
Other	$0.00	$0.00
Direct Costs Sub-Total	$10,730.20	$8,874.73
Indirect Costs	$0.00	$0.00
Total Federal Costs	$10,730.20	$8,874.73

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

The $8,874.73 in funding utilized for this project went towards the purchase of irrigation supplies (T-tape, connections, flow regulators), plastic mulch, strawberry plugs (Camino Real Festival, Ruby June, Sweet Charlie & Chandler), cover crop seeds and seeds for row covers. All items purchased were utilized towards this project.

Project Title	U-Pick Education Booklet			
Recipient Organization Name:	Oklahoma Department of Agriculture, Food & Forestry			
Period of Performance:	**Start Date:**	9/30/2016	**End Date:**	9/29/2019
Recipient's Project Contact				
Name:	Micaela Danker			
Phone:	405-740-0794			
Email:	Micaela.danker@ag.ok.gov			

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

The Oklahoma Agritourism program conducted a project to help producers educate consumers about proper u-pick practices, food safety and handling, nutrition value and value-added possibilities of specialty crops. These goals were accomplished by creating and distributing an interactive booklet targeting consumers and creating the awareness of these educational opportunities. The booklet encouraged adult and child interaction by educating on access of the crops, production, preparation of value added products and perseveration of the specialty crops for future use.

There is an increasing demand by consumers for fresh, local produce. These consumers are also interested in connecting with the farmers, seeing the land that produces the produce and learning about the growing practices. In addition, families and schools are looking for educational opportunities in relation to farming as to ensure the next generation knows where their food comes from and how it is made. The Agritourism Program has made great headway in increasing awareness of the opportunities to visit local farms and the u-pick possibilities. The producers do a good job of educating the visitors when they can. However, there is a need for continuing the experience beyond the farm, e.g. how to wash the produce before eating, what nutritional value the produce has, how to make jelly, pie, etc.

Collaboration was initiated with the Oklahoma Cooperative Extension Service to ascertain consumer demand for making jelly and the best way to package information for our target audience. Discussions included food safety, recipe legitimacy, quick non-jelly items to

include, and potential tours based on the material and led by OCES. Research was compiled and framework for educational booklet was finished.

The producer list was updated to 53 individual locations from the previous project's 47. This included removing some defunct producers and adding new producers identified during the previous year. The bid process was completed, identifying the company that would execute the creative component of the educational booklet and social media content. Booklet production began and social content was set to include strawberries, blackberries, blueberries and peaches in individual spotlight videos.

In April 2017, the production of the education booklet was finalized. Print bids were acquired and material was printed. The strawberry carousel ad was launched and booklets were distributed to all strawberry growers in April, followed by the blackberry video and blueberry carousel ad and grower distribution in June, then the peach carousel ad and distribution in July.

In the second year, the producer list was modified in order to accommodate an increase in fruits and herb producers and eliminating the vegetable category which had failed to resonate with consumers. A new category was added to the map entitled "Classes." This allowed the designation of farms that were teaching classes about preparation, handling, storage and adding value to the specialty crops they sold. Modifications were made to the print and online versions of the booklet. The new version was printed and distributed to producers.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Educate consumers about proper u-pick practices and food safety of specialty crops.	XX	
2	Educate consumers about the nutrition value and value-added possibilities of specialty crops.	XX	
3	Educate the consumers about specialty crops by increasing the knowledge of these crops and the possibilities for consumption, preparation and preservation for later use.	XX	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	10,000 copies of the 12,000 printed educational booklets were distributed through the individual u-pick farms and through tours initiated by the Oklahoma Cooperative Extension Service in several Oklahoma counties in addition to one technology center and several agricultural conferences in the state. Feedback upon receiving the booklet was universally positive. The booklet contained information geared toward adults and older children as well as an activity sheet for young children, therefore making it useful to the entire family.	Objective 1, 2, 3
2	8,000 copies of the 10,000 printed maps, taken from the back page of the booklet, were distributed through the free brochure program targeting tourists across the U.S. and internationally located on the state tourism website www.travelOK.com. The remaining 2,000 maps were distributed at Farmers Markets and from u-pick farm locations listed on the map.	Objective 3
3	The carousel ad featuring strawberries ran for 30 days on Facebook and Instagram. Reach: 28,522 Impressions: 49,722 Button and Link Clicks: 1165 Reactions, shares and comments: 368	Objective 2, 3 Outcome 2 Indicator 1
4	The video ad featuring blackberries ran for 30 days on Facebook and Instagram. Reach: 76,860 Impressions: 158,638 Video Views: 40,130 Link clicks: 244 Reactions, shares and comments: 946	Objective 2, 3 Outcome 2 Indicator 1
5	The carousel ad featuring blueberries ran for 30 days on Facebook and Instagram. Reach: 31, 603 Impressions: 64,849 Button and Link clicks: 1,119 Reactions, shares and comments: 385	Objective 2, 3 Outcome 2 Indicator 1
6	The video ad featuring peaches ran for 37 days on Facebook and Instagram.	Objective 2, 3 Outcome 2

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	Reach: 66,741 Impressions: 161,700 Video Views: 47,763 Link clicks: 125 Reactions, shares and comments: 407	Indicator 1

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	Several new growers were identified because of the popularity of the campaign. Additional growers are considering diversifying into berries because of the popularity of the campaign. In addition, more booklets will be used for the jelly-making tours organized by the county extension offices and tech centers.	A portion of the remaining funds were used to update the educational booklet and the map on the back cover to incorporate the new growers and to print the new version.

LESSONS LEARNED

- That there are more farms offering u-pick opportunities in Oklahoma than previous thought.
- That many consumers are unaware of u-pick opportunities.
- Consumers are seeking opportunities to experience the farm.
- That consumers desire to know more about the produce – how to prepare, what products can be made, nutritional value, etc.
- By learning what the consumer desires, we can target material more effectively.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Our plans are to continue updating and printing the map of locations of specialty crops every year as well as continue distributing it to producers and consumers.

BENEFICIARIES

Number of project beneficiaries: 53

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales

☑ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption

☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access

☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

☐ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 2, Indicator 1	During the u-pick season, social media ads informing people about the farms located on the Jelly-Making trails had a reach of 203,726 with 2,116 unique reactions (likes, comments, shares.). The social media ads encouraged buying specialty crops from local producers while also learning different ways to store/prep/preserve them. The social media ads also linked back to the website which educated the consumers on all the different access points in our state.
2	Outcome 2, Indicator 1	10,000 booklets and 8,000 maps were distributed from farms, the state tourism website and special events.

DATA COLLECTION

Data was collected by contracted marketing firm through social media analytics. Once each advertisement ran, we received a social report detailing impressions and website clicks.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$0	$0
Fringe Benefits	$0	$0
Travel	$0	$0
Equipment	$0	$0
Supplies	$0	$0
Contractual	$11,000.00	$12,000
Other	$24,743.00	$17,999.20
Direct Costs Sub-Total	$35,743.00	$29,999.20
Indirect Costs	$0.00	$0.00
Total Federal Costs	$35,743.00	$29,999.20

PROGRAM INCOME (IF APPLICABLE)

N/A

ADDITIONAL INFORMATION

www.Okjellymaking.com