RECIPIENT INFORMATION

State Department of Agriculture: Oklahoma Department of Agriculture, Food & Forestry

STATE PLAN COORDINATOR

Coordinator Name: Jason Harvey
Title: Agriculture Marketing Coordinator
Phone Number: 405-606-1477
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OUTREACH

OUTREACH TO SPECIALTY CROP STAKEHOLDERS TO IDENTIFY FUNDING PRIORITIES

OUTREACH TO IDENTIFY FUNDING PRIORITIES

Whenever at workshops, field days or meetings with producers who grow specialty crops the Secretary of Agriculture, Director of Marketing and other staff members within the Market Development division spoke about the SCBG and welcomed input on funding priorities for projects.

IDENTIFIED FUNDING PRIORITIES

Funding Priority 1: Specialty Crop research, pest and disease control

Funding Priority 2: Developing or improving marketing channels for specialty crops

Funding Priority 3: Good Agricultural Practices

OUTREACH NOT CONDUCTED (IF APPLICABLE)

N/A

OUTREACH TO SOCIALLY DISADVANTAGED AND BEGINNING FARMERS

IDENTIFYING SOCIALLY DISADVANTAGED AND BEGINNING FARMERS

ODAFF worked with extension agents from the 2 land grant institutions in Oklahoma and establishing working relationships within the various Native American tribes located within our state.

ENGAGING SOCIALLY DISADVANTAGED AND BEGINNING FARMERS

ODAFF continues its working relationship with Langston University and their staff members whose responsibilities are to grow the universities involvement in specialty crop research and extension outreach focusing on socially disadvantaged and beginning farmers. Work has continued with our tribal organizations within the state, specifically those who are emphasizing and growing their involvement in the agriculture sector with programs for their members.

OUTREACH NOT CONDUCTED (IF APPLICABLE)

N/A

COMPETITIVE REVIEW PROCESS

PROPOSAL SOLICITATION

A press release announcing the request for proposals (RFP) for the 2022 Specialty Crop Block Grant was created by ODAFF's public information officer and disseminated to over 440 statewide media outlets on January 31, 2022. The grant application and manual were posted to ODAFF's website https://ag.ok.gov .The application was available to any interested party. Information pertaining to the grant was publicized on an electronic daily agriculture newsletter that is mailed to over 6,000 agriculturalists along with being promoted on the agency Facebook page. The application manual and application was emailed to those individuals or organizations who had submitted a proposal in the past three years in addition to the department heads at our two land grant universities and individuals that had contacted the grants personnel inquiring about the program.

ODAFF also conducted a webinar for the first time on February 4th. ODAFF's grant coordinator went over the application and highlighted changes made for 2022. Time was made at the end of the webinar to address any questions that potential applicants may have. A local television station recorded a portion of the webinar and used to promote the grant on afternoon and evening news.

GRANT PROPOSALS RECEIVED

Number of Grant Proposals Received: 11

APPLICATION REVIEW PANEL

REVIEWER SELECTION

ODAFF's grant coordinator and director of marketing made a list of potential reviewers comprised of individuals who had experience with SCBG or other grants, were specialty crop producers, involved within the specialty crop industry, leaders in other ag organizations or commodity groups or had scientific background. After the submission deadline of February 28th, the grant coordinator reviewed the submitted applications to determine what entities had submitted proposals and who else was serving as collaborators on the projects. From there individuals were selected who did not have a clear connection to any of the proposals. The individuals were then contacted by phone to explain the process and time allotment needed and if they agreed a formal invitation to serve on ODAFF's selection committee for the Specialty Crop Block Grant was emailed.

REPRESENTED FIELDS OF EXPERTISE

The selection committee was comprised of 3 individuals with various knowledge/involvement within the specialty crop industry or grant administration. One committee member serves as the executive director of the Oklahoma Nursery and Landscape Association which has a membership of over 100 wholesale and retail nurseries and greenhouses. Another committee member serves as the director of field services

for the Oklahoma Farm Bureau which is our states largest agricultural organization. In addition to his role at Farm Bureau he and his family are involved in a highly diversified specialty crop operation and participates in 3 Farmers Markets around the state. The final member of our committee is a specialty crop producer who specializes in cut flower and vegetable production. This individual has also been successful in writing and receiving ODAFF grants.

PREVENTING REAL OR PERCEIVED CONFLICT OF INTEREST

The committee members were asked about conflicts of interests with submitted applications and were selected on the basis that they did not have any direct working relationships with any of the submitted applicants. The reviewers signed a conflict of interest form; which is held on file at ODAFF.

SHARING THE RESULTS OF COMPETITIVE PROCESS WITH APPLICANTS

The ODAFF grant administrator reviewed each application that was submitted to ensure that all proposals met the guidelines established by USDA. Eleven (11) proposals were deemed to be eligible for consideration and were emailed to the members of the selection committee along with a copy of the application manual and a score sheet with a rubric in which to evaluate each proposal. The committee scored each application using the provided materials and included comments about the proposals. The score sheets were emailed to the ODAFF grant coordinator and combined with the results from other reviewers to determine an initial ranking. It was determined that nine (9) applications would be asked to participate in the 2nd phase of the selection process and were invited to come before the committee and give an oral presentation about the proposal. These nine (9) applicants were notified via an emailed letter their proposal would be moving on and were given the date, location and time for their presentation. Those proposals not selected for the 2nd phase received an emailed letter thanking them for the submission and letting them know that their proposal did not score high enough with the selection committee to be considered for funding. The letter provided the applicants with comments from the committee members on why their project received low scores.

The committee met in person April 5th at the Oklahoma Department of Agriculture in Oklahoma City. Applicants were scheduled for 30-minute presentations in which they were given 15 minutes to talk about their proposal and how it will benefit the specialty crop industry and Oklahoma producers. The committee then had 10 minutes they could ask questions and the final 5 minutes was for the committee to make any notes. After the presentations were completed the committee ranked the applications from top to bottom and the scores were combined to establish a final ranking of proposals. The committee then started with the highest-ranking project and determined if they wanted to fund the project and if there were any modifications to the budget needed. This process was repeated until all available funds had been allocated to projects. The applicants were notified by the ODAFF grant administrator that their projects had been selected to be included in Oklahoma's State Plan and any modifications needed to the application and/or budget via phone call and letter. The projects that did not rank high enough to be included in the State Plan were notified by letter thanking them for their time and were given comments from the committee on why the project did not rank higher.

COMPETITIVE PROCESS NOT CONDUCTED (IF APPLICABLE)

N/A

OVERALL STATE PLAN BUDGET SUMMARY

#	Project Title	Direct	Indirect	Total
1	Understanding tomato virome in Oklahoma	$86,924.00	$0.00	$86,924.00
2	Insect Response To Regenerative Agriculture Practices In Pecan Orchards Under Cattle Grazing	$63,931.00	$0.00	$63,931.00
3	Improving Nitrogen and Nutrient Uptake Efficiency of Pecans Using Mycorrhizal Fungi	$84,705.00	$0.00	$84,705.00
4	Fertility management in soilless growth media for vegetable and ornamental crop production	$82,570.00	$0.00	$82,570.00
5	Oklahoma Gardening QR Code Signage	$23,012.00	$0.00	$23,012.00
6	Investigating Novelty Trees for Their Edible and/or Ornamental Potential for the Oklahoma Green Industry	$55,150.00	$0.00	$55,150.00
7	Development of a Turf Management Curriculum for Secondary Education in Oklahoma	$69,737.00	$0.00	$69,737.00
8	Woody and Luminescent Cut Flowers as a Value-Added Product	$62,864.73	$0.00	$62,864.73
Grant Administration		$0.00	$45,990.00	$45,990.00
Total		**$528,893.73**	**$45,990.00**	**$574,883.73**

STATE DEPARTMENT OF AGRICULTURE OVERSIGHT

Start Date: 9/30/2022 **End Date**: 9/29/2025

GRANT ADMINISTRATION BUDGET NARRATIVE

Budget Summary	
Expense Category	**Funds Requested**
Personnel	$0.00
Fringe Benefits	$0.00
Travel	$0.00
Equipment	$0.00
Supplies	$0.00
Contractual	$0.00
Other	$0.00
Direct Costs Subtotal	$0.00
Indirect Costs	$45,990.00

Total Budget	$45,990.00

Budget Breakdown by Year			
Year 1	**Year 2**	**Year 3**	**Total**
$15,330.00	$15,330.00	$15,330.00	$45,990.00

PERSONNEL

N/A

FRINGE BENEFITS

N/A

TRAVEL

N/A

EQUIPMENT

N/A

SUPPLIES

N/A

CONTRACTUAL/CONSULTANT

N/A

OTHER

N/A

INDIRECT COSTS

Indirect Cost Rate	Funds Requested
8%	$45,990.00

Indirect Subtotal	$45,990.00

PROJECT TITLE

Project 1: Understanding Tomato Virome In Oklahoma

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

In this project, Dr. Ali (Plant virologist), at The University of Tulsa will focus on viruses of tomatoes to determine what type of viruses are infecting tomatoes and their significant impacts on tomato yields and possible management. In Oklahoma, tomatoes are one of the most popular vegetable and also home garden crop. Tomatoes are grown both in the field as well as in the greenhouse and provide cash income to growers in local markets. Tomato is infected by a large number of viruses worldwide. In order to encourage growers in Oklahoma to increase tomato acreage in the coming future, we need to first identify the problem and determine what sort of viruses pose a significant threats to tomato production and their possible solution. During our previous surveys for viruses in Oklahoma over the last several years, we noticed several virus-like symptoms in tomatoes in various counties of the state. County extension educators and local tomato growers have limited knowledge on the type of viruses that infect their crops in order to minimize losses. Therefore, we proposed to survey and identify viruses infecting tomatoes, their transmission vectors and determine possible sources of resistance in tomato varieties. This information will be useful in future integrated pest management strategies adopted by tomato growers. This could also help to minimize the annual losses caused by viruses in their tomato crops and encourage growers to increase acreage in order to obtain maximum yield for local markets and to export out of state.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Importance of the Project: Tomato (*Solanum lycopersicum)* belongs to the family *Solanaceae.* It is one of the most economically important vegetable crops worldwide which is cultivated as a vegetable for its edible fruit. It is mainly used for nutritional purposes because it contains vitamin C and photochemical lycopene. It is consumed either raw, or cooked**.** Global cultivation of tomatoes exceeded 5.0 million hectares, which produced 186.0 million tons in 2020 with a value of approximately 86.0 billion dollars (FAOSTAT, 2020).

In the United States of America (USA), tomatoes are grown on 2,72,900 acres with a production value of nearly 1.6 billion dollars in 2020. In Oklahoma, although there are 240 documented farms (range from 1 acre to 2,000 acres) as of 2017 (NASS, 2021) which decreased from 306 farms listed in 2012 (NASS, 2021). Nevertheless, tomatoes are grown almost everywhere in the home garden of so many undocumented farms due to their small acreage. Approximately 40 documented farms are listed in the greenhouses under a 170,185 sq feet area. Most of the tomato production contribute annually to local markets and generate cash income to the growers. There is a great potential to increase tomato production in Oklahoma, if we could minimize the impact of plant diseases particularly viruses.

Plant viruses causes approximately US$ 30-50 billion yield losses annually and infect many major agricultural crops. Virus diseases are also one of the limiting factors to tomato production worldwide because they are responsible for significant yield and fruit quality losses, causing important economic damage. At least 312 virus species have been documented to infect tomato worldwide which is the largest number of viruses known for any cultivated plant. Forty-five of these viruses, have been identified in the last 10 years. Majority of these viruses have significant impact on tomato plant and cause economic losses in tomato production worldwide.

Two of the tomato infecting viruses: Tomato spotted wilt virus (TSWV), and Tomato yellow leaf curl virus (TYLCV) are number 2nd and 3rd respectively in the 'Top 10" plant viruses. Yield losses in tomato vary and depend on the type of virus infection and environmental conditions. However, TSWV (negative ssRNA-Tospovirus genus) and TYLCV (ssDNA-Begomvirus genus) are the front runners in terms of producing economic losses in tomato worldwide. TYLCV is the most destructive disease of tomato and an infection at an early stage can result 100% yield loss.

A recent emerging virus infecting tomato is Tomato brown rugose fruit virus (ToBRFV) which is recently described member of the Tobamovirus genus. It was first reported in 2014 in tomatoes in Israel but later in more than a dozen of countries. It was first detected and eradicated in the United States in 2018. and its spread is currently being closely monitored by the USDA. Tomatoes and other solanaceous hosts such as peppers, eggplants, tomatoes, and cut-leaf ground cherry are all hosts of the virus. It is transmitted by seed and spreads easily via mechanical contact. ToBRFV can reduce fruit quality and yield and restrict global trade. No information exists in tomato crops of Oklahoma on this virus as no study has been done so far.

Our long-term goals are to protect tomato crops from these notorious and emerging virus diseases of tomato in Oklahoma by minimizing the effects of these viruses, encourage growers to increase tomato cultivation, and as a result, sustain the productivity and profitability among tomato growers.

Justification of the project and preliminary work: Plant viruses just like human viruses pose a significant threat to agricultural crops and are responsible for billions of dollars of economic losses by reducing both yield and quality of produce worldwide. Yield losses in tomato crops by plant viruses could be minimized, reduced or even eliminated by effective management strategies. However, it is important to know the etiology and epidemiology of viruses for a particular crop in a locality before designing specific and long-lasting control measures to effectively manage virus diseases. Among the control methods, screening for genetic sources is one of the most economical control methods which could limit the virus infection as well further spread to other crops and could provide a good resource for breeding programs.

Therefore, it is very important to know about these viruses in Oklahoma and determine which type of viruses are out there that need more focus to develop effective management strategies. In Oklahoma, tomatoes are grown for a long time (both small and large scale) on a number of farms all over the state for fresh produce to be consumed locally or exported to other states. However, no studies have been done on virus diseases of tomatoes which are one of the most detrimental impediments to the successful production of tomatoes.

During the 2019-2021 growing seasons, the Principal Investigator (PI) conducted a number of surveys for viruses infecting cucurbits, cotton and other crops located in eight out of nine agricultural districts of Oklahoma. During surveys, the PI always saw some tomato plants showing typical virus-like symptoms. For example, during 2021 growing seasons, tomato plants in several fields showed a variety of symptoms caused by virus infection as shown in Fig. 1.

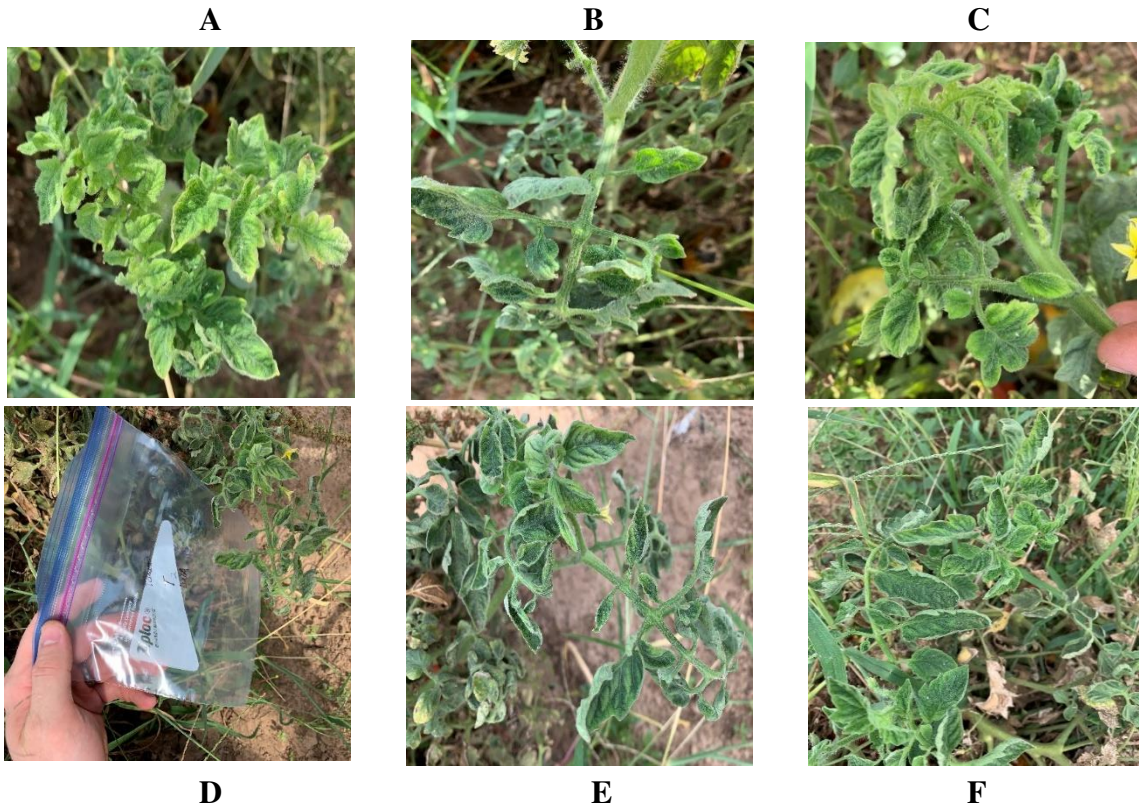


Fig. 1 Tomato plants showing typical virus-like symptoms in grower's fields located in Bixby, Tulsa County during 2021 growing seasons. These symptoms includes (A) yellowing and chlorosis, (B-C) leaf rolling, cupping, with whiteflies visible on the leaves (D) stunting, and interveinal chlorosis, (E) mottling and leaf rolling and (F) mild mosaic with leaf rolling.

Due to limited budget, a few samples including shown in Fig.1 D that were also infested for whiteflies were collected and tested in the lab. The results showed that tomato plant was infected with TYLCV which is the first report of this virus infecting tomato and the presence of its vector noticed in Oklahoma. TYLCV is one of the most notorious and well-known tomato–infecting-begomovirus and is transmitted by whitefly (*Bemisia tabaci*). This virus could threaten tomato production state-wise. Therefore, it is an urgent need to manage and determine the epidemiology of these viruses including TYLCV in tomato fields and educate both growers and County Extensions agents about the impact of these viruses.

So far no information exist (other than the research in the PI's lab) on tomato viruses. In this project we emphasize to identify virus-like diseases in tomato fields. Therefore, we propose to collect virus-like samples from tomatoes across the state wherever tomato is grown and determine the number and type of viruses and their impact on tomatoes production, and also determine sources of resistance against some of these viruses.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: To survey and collect samples from commercial tomatoes fields/greenhouse in various counties of Oklahoma and screen them for both RNA and DNA viruses.

Objective 2: To identify alternate hosts and vectors of these viruses in tomatoes fields.

Objective 3: To screen a range of commercial tomato cultivars against mechanically transmitted viruses (identified in Objective#1) for resistance.

The proposed research objectives in this proposal will provide important information about the known and unknown viruses infecting tomatoes in Oklahoma and determine sources of resistance in commercial cultivars of tomatoes against mechanically transmitted viruses. In any future epidemics, the known viruses identified in this project will serve as a starting point for timely identification and management of these viruses. This will allow for a cost effective and prompt response to future virus outbreaks rather than a costly reactionary panic, and at the same time, growers will have the resources of virus resistant tomatoes cultivars. Thus, the growers will sustain and even increase tomatoes cultivation to have more productivity than the expenses of managing tomato crops.

Methods/Approach

Objective 1- To survey and collect samples from commercial tomato fields/greenhouses in various counties of Oklahoma and screen them for both RNA and DNA viruses.

Survey of tomatoes fields: During the growing seasons of 2023 and 2024, we will make several field visits to various counties and meet the tomato growers directly or via agricultural County extension agent. We will document the time of tomato planting (early or late), name of specific variety sown and determine the severity and incidence of symptomatic plants due to virus infection. We will collect randomly unique symptomatic tomato plants which will also be photographed. Each sample will contain 2-3 young symptomatic leaves, which will be labelled with the sample number and name of variety, and then stored in an individual Ziploc bag with its appropriate name and location of the field/county. Information about each sample will also be recorded on a data sheet. Depending on the size of the field, we will approximately collect 10-20 samples per field that show unique virus-like symptoms. All samples will be individually processed further as below.

Extraction of total RNA and DNA: Total RNA and DNA will be extracted from each using an RNA kit from Sigma, which is more suitable to extract RNA from tomato tissues. Total DNA will be extracted using a DNeasy Plant Maxi Kit from Qiagen.

Detection of RNA viruses by Next generation sequencing (NGS): Over the last few years, next generation sequencing (NGS) has provided a newer and rapid detection method for plant viruses. It is a robust technology that does not require an antiserum or previous sequence information of a virus. NGS technology has proved to be a powerful and sensitive technology especially suited for detecting unknown or unsuspected viruses; identification is made mostly on similarity alignment against GenBank data. We are hopeful that we will determine the type of viruses in these tomatoes and confirm whether

these samples are infected by known reported viruses or previously unreported or new emerging viruses. NGS has proved to be an effective tool for the discovery of new tomato infecting viruses including mixed infections of viruses.

RNA from tomato tissue will be used in a NGS method, according to the manufacturer protocols. Sequences obtained from the NGS method from respective samples will be assembled using the Illumina software. Sequences will be analyzed by BLASTn and BLASTx searches against the viral reference genome database in GenBank. Specific sequence contigs will be determined from each tested sample, and the virus information will be obtained. In case the sequence contigs have no similarities with the database in GenBank, the sequences will be considered as new or unreported.

Reverse transcription-Polymerase Chain reaction (RT-PCR): The nucleotide sequences obtained above from NGS results will be further confirmed by specific PCR primers to test respective nucleic acid samples by RT-PCR to further confirm the presence or absence of the new virus sequences in the original samples. Once we reconfirm the sequence of potential virus by RT-PCR using specific primers, then we will sequence the complete genome of the virus and determine the relationship of the virus with the sequence of the known viruses available in the NCBI database. In case of a new virus identification, the sample(s) will be further characterized by selecting new tissues from the tomato plants.

Detection of DNA viruses by rolling circle amplification (RCA) method:RCA methods have been shown to amplify small circular DNA genomes which is also established in the PI lab. For example, plant geminiviruses have been identified by the RCA method. Total DNA from tomato symptomatic tissues will be used for the RCA method using TempliPhi 500 Amplification Kit according to manufacture instructions. The clone products will be sequenced and blasted against the NCBI database. Based on the nucleotide Blast results, the identity of the virus will be confirmed as a known or unknown virus infecting tomato in Oklahoma. Further confirmation of the virus will be done by PCR using sequence specific primers as mentioned above. Sequences from NGS will be analyzed by de novo assembly with CLC genomics. The assembled reads of the contigs will be used to deduce complete genomes of different viruses. Neighbor-joining and maximum likelihood trees will be constructed from the latest version of MEGA software. The assembled sequence contigs will be compared with GenBank sequences using the basic local alignment search tool (BLAST). Sequence alignment will be done using the Clustal X program and MEGAlign™ within the DNASTAR suite of programs.

Objective 2-To determine what hosts act as a reservoir for tomato viruses and what vectors are present in tomato fields, which could potentially transmit these viruses.

Collection of weeds/volunteer crops and aphid vectors: During surveys in Objective 1, we will collect leaf samples (10-15/field) from various volunteer weeds plants pre-existed before the tomato crop, naturally grown within or adjacent to tomato fields. We will also record nearby other agricultural crops to the tomato fields to determine whether they could harbor any viruses. In addition, all possible sources of weeds plants as well as tomato plants will be thoroughly observed for the presence of vectors before the crop and within the tomato fields when the crop is available in the field. Vectors will be collected and identified in the lab and may be tested for specific viruses by RT-PCR based on the viruses obtained in Objective #1.

Testing of weeds and aphids: The collected weed samples and aphids will also be tested for both RNA and DNA viruses using the following techniques (Next generation sequencing or rolling circle amplification methods) if needed.

Objective 3- To screen a range of commercial cultivars of tomato to identify natural resistance against the prevalent tomato viruses identified in Objective # 1.

In this objective, we will determine the level of susceptibility of commercial tomato cultivars to prevalent viruses present in Oklahoma. Most of the RNA viruses infecting tomato are mechanically transmissible. We prefer to use mechanical inoculation in order to provide uniform inoculum pressure. In addition, mechanical inoculation will be less time consuming, and we can get meaningful results during the duration of the project without the potential pitfalls of failed transmission from aphid vectors.

Seeds of at least 20-30 commercial tomato cultivars will be obtained from various sources including seed companies (DeWitt Seed Co, OK) or local markets. Seedlings (3-5/cultivar) of each tomato cultivar will be grown in plastic pots in growth chambers or the greenhouse at The University of Tulsa and will be challenged individually with various inoculum of tomato viruses. All inoculated plants will be scored for resistance and susceptibility approximately until 8 weeks post-inoculation based on severity of viral symptoms.

Ranking resistant varieties and confirmation of symptomless infection: Screening of those varieties that develop symptoms will be ranked visually according to symptom scoring mentioned above. In case of symptomless infection after sufficient time (4 weeks post inoculation) has passed for symptom development, samples of plant tissues will be taken and processed for virus detection by RT-PCR in order to confirm that plants have no virus. It is very important to check symptomless infection with a sensitive assay to detect small amounts of virus so that false negatives can be avoided.

Potential Impacts: We expect that the information obtained in this project will be critical for understanding the diversity of these viruses infecting tomato and their impact on yield in different counties, which will assist in the development of management practices to control these virus diseases. It will also provide useful information needed by growers to assist in variety selection of the specific tomato. This information will be crucial for effective management strategies against these viruses in tomato fields and will address our long-term goal of combating declines in tomato quality and quantity in local agriculture in Oklahoma. High and good quality crop yield could be achieved with good management strategies against plant virus disease.

During the last 15 years, the PI has established a partnership with growers and County extension agents. We will communicate the results of these viruses, and their potential effects on tomato production through email or the OneNet system. Project results will be communicated in the following ways:

1. Annual field days during the growing seasons organized by the County extension agents
2. Biannual Horticulture Industry Show held in Oklahoma and Arkansas
3. Annual meeting of the American Phytopathological Society
4. Annual meeting of the American Society of Virology
5. Email list of growers and informal talks

Knowledge of the specific tomato viruses and their diversity obtained in this project will further provide information which one is the dominant virus which threaten the tomato production in particular county of Oklahoma that is currently unknown. With this knowledge, appropriate management steps can be implemented in the future, such as making the change to resistant cultivars in the future. Technology derived from this research project will be critical for the future development of integrated management practices to manage virus diseases in tomato. In addition, tomato growers will be better prepared to understand how to combat the infection of these viruses by using resistant varieties in their field. During the project, we will communicate directly to growers in the implementation of future application of integrated pest management to support decision making at farm level. Moreover, the subsequent application of integrated pest management will assist the tomato industry in Oklahoma to increase the acreage after tomato growers regain the ability of identifying virus diseases in their field and potential resistant varieties against these viruses. Growers will be encouraged with the improvements in productivity and fruit quality, which overall, will contribute to the economy of all the growers and the state. It is expected that the consumers will have better quality tomato available for local consumption as well for exporting out of state.

Management Plan: Dr. Akhtar Ali will be the Principal Investigator to supervise this project. Dr. Ali will maintain communication with growers and county extension agents, communicate progress and reports to ODAFF, mentor the Graduate Research Assistant and assess the timely progress of activities and achievement of project goals. Dr. Ali will contact the county extension educators, take part in grower field days, and organize meetings with tomato growers.

Dr. Ulrich Melcher, Professor Emeritus, Oklahoma State University, who has more than 38 years of experience in plant virus research, will have an advisory and collaborative role. Dr. Melcher has agreed to have quarterly meetings (via telephone or skype) with Dr. Ali and Graduate Research Assistant and assess the progress of project activities and results.

During the past 15 years at the University of Tulsa, Dr. Ali has established a productive and successful research program and focused on virus ecology, epidemiology, and the characterization of viruses infecting important agricultural crops in Oklahoma. He is the only virologist in the state of Oklahoma who works on viral diseases in the field and has developed a unique niche by protecting important food crops from viral diseases. Dr. Ali helps growers, educators, researchers, and industry personnel with these diseases and has developed collaboration with several growers and researchers not only in Oklahoma, but also across the USA. Based on the above expertise and success, we fully expect the proposed objectives presented in this project will be successfully accomplished during the proposed timeline.

Expected Measurable Outcomes: The information obtained in this project is crucial for developing effective management practices for the control of tomato viruses. The results of the proposed research will provide the information, which is precisely needed by growers to assist in managing and minimizing the effect of these viruses on their tomato crop.

The broader impacts of this proposed research project are to assure consistent production of high yields and high quality tomato and prevent the possible consequences, both economic and social, of massive tomato crop failures because of crop failure by plant viruses. Knowledge and list of tomato virus

specific resistant varieties of tomato will be shared with the growers, tomato breeders, County Extension agents, and plant pathologists for future cultivation in Oklahoma and other states via publications, meetings, email or conference presentations in annual meetings or grower fields days.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 250

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☑ **No** ☐

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

The PI has worked and established working relation with a number of growers and county extension educators in Oklahoma. All of the growers are willing to cooperate and are optimistic to reduce the effects of these potential viruses on the quality and quantity of tomato yield.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes

- ☑ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☐ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 4, Indicator 4.1
Number of growers/producers and County extension agents that will gain knowledge about science-based tools through outreach and education programs 250

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

During our field surveys or fields days organized by County Extension agents in their respective counties, we will have opportunities to meet with various County Extension agents, tomato growers or other growers who wish to grow tomatoes in future. We will record the number of people, location and venue and talk about tomato viruses. We will inform them during these informal meetings about tomato viruses and their management.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$46,241.00
Fringe Benefits	$7,183.00
Travel	$6,500.00
Equipment	$0.00
Supplies	$27,000.00
Contractual	$0.00
Other	$0.00
Direct Costs Sub-Total	$86,924.00
Indirect Costs	$0.00
Total Budget	$86,924.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Akhtar Ali, Principal Investigator	2.0 summer months (1 month/year)	$18,336.00
2	TBD, Graduate Research Assistant	9 months, (2 years, 9 months/year @ 0.5 FTE)	$27,905.00

Personnel Subtotal: $46,241.00

PERSONNEL JUSTIFICATION

Personnel 1: Akhtar Ali, Principal Investigator - One month summer salary for a period of two years; $9,077 in Year 1 and $9,259 in Year 2. Total salary $18,336.

The University of Tulsa provides a portion of time during the academic year for faculty to conduct unfunded research. Dr. Ali's research conducted on this project during the academic year will be supported by TU from this allocation of effort.

Personnel 2: Graduate Research Assistant - We have requested salary for a Doctoral Graduate Research Assistant (GRA), ($27,905; $13,815 for Year 1 and $14,090 for Year 2).

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Akhtar Ali, Principal Investigator	27%	$4,951.00
2	TBD, Graduate Research Asst.	8%	$2,232.00

Fringe Subtotal: $7,183.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Atoka County	Per diem, tolls, hotel, mileage	2 days, 1 night	2	$341	2	$682.00
2	Blaine County	Per diem, tolls, hotel, mileage	2 days, 1 night	2	$353	2	$706.00

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
3	Creek County	Per diem, tolls, mileage	1 day	2	$110	2	$220.00
4	Carter County	Per diem, tolls, mileage	1 day	2	$250	2	$500.00
5	Cherokee, Mays and Rogers counties	Per diem, tolls, mileage	1 day	2	$105	2	$210.00
6	Cimarron County	Per diem, tolls, hotel, mileage	3 days, 2 nights	2	$841	2	$1,682.00
7	Jackson County	Per diem, tolls, hotel, mileage	2 days, 1 night	2	$270	2	$540.00
8	McCurtain County	Per diem, tolls, hotel, mileage	2 days, 1 night	2	$370	2	$740.00
9	McClain County	Per diem, tolls, mileage	1 day	2	$220	2	$440.00
10	Oklahoma County	Per diem, tolls, mileage	1 day	2	$150	2	$300.00
11	Pottawatomie County	Per diem, tolls, mileage	1 day,	2	$170	2	$340.00
12	Tulsa County	Per diem, tolls, mileage	1 day	2	$70	2	$140.00

Travel Subtotal: $6,500.00

TRAVEL JUSTIFICATION

The tentative list of counties are shown above in the table. However, it is not limited to this list because other counties located in the same direction may be covered in the same trip without making an extra trip and will save travel cost. For example, going to Cimmaron County, we will pass through several counties and we can visit the farms of tomato growers in the same trip without extra travel costs.

For all trips: The purpose of all trips is to collect leaf samples at least twice from the same tomato fields located in different counties of Oklahoma (see for project methodology for more details). All trips will be performed from June-September during the growing seasons of 2023 and 2024.

Year 1:

Dr. Ali requests $3,500 in Year 1 to cover travel expenses for the PI Akhtar Ali and GRA

(i) to collect samples from tomatoes fields located in various counties of Oklahoma.

(ii) to attend field days with the growers

The round-trip distance from TU to various counties will range from 250-450 miles. This includes personal mileage reimbursement at the current GSA rate of $0.585/mile. The per diem expenses for meals are, per person, $25 for single-day trips, and for multi-day trips, $50 per full day and $37.50 per travel days. Toll fees will be $10-15/trip. The cost per trip will average $305/trip for approximately 16-18 trips during the growing seasons.

Year 2:

Funds totaling $3,000 are requested in Year 2, for field work travel like that noted for Year 1.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
RNA extraction kits	$600/kit	4	Year 1 & 2	$2,400
Reverse transcriptase kits/ Taq polymerase and ligations kits	$800	4	Year 1 & 2	$3,200
Ribo-zero+library & quality	$2,166.66	3	Year 1 & 2	$6,500
Illumina sequencing kits	$4,250	2	Year 1 & 2	$8,500
5 and 3-Race kits	$800	2	Year 1 & 2	$1,600
Lab consumables, gloves, tips, chemicals etc. Detailed description is below				
10 ul tips	$734	5,000	Year 1 & 2	$734
20 ul tips	$734	5,000	Year 1 & 2	$734

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
250 ul tips	$734	5,000	Year 1 & 2	$734
1,000 ul tips	$734	5,000	Year 1 & 2	$734
Gloves-Medium	$150	1,000	Year 1 & 2	$150
Gloves-Large	$150	1,000	Year 1 & 2	$150
PCR 0.2 ml tubes	$190	1,000	Year 1 & 2	$190
1.5 ml tubes,	$420	2,000	Year 1 & 2	$420
Petri dishes	$100	500	Year 1 & 2	$100
Tris, EDTA, Boric acid	$300	One bottle each	Year 1 & 2	$300
Gel extraction kit	$150	One	Year1 &2	$150
Miscellaneous small items	$404		Year1 &2	$404

Supplies Subtotal: $27,000.00

SUPPLIES JUSTIFICATION

Year 1: $14,000
Materials and supplies requested for Year 1 include RT-PCR and Next Generation Sequencing consumables, as well as direct sequencing of preliminary DNA products. The consumables needed for testing rose viruses by Illumina Next Generation Sequencing include nucleic acid extraction kits (RNA to DNA), purification and labeling kits. Also, reagents and primers for RT-PCR confirmations.

Year 2: $13,000
Materials and supplies for Year 2 are requested for confirmation of the results of Year 1 and include RT-PCR and consumables.

CONTRACTUAL/CONSULTANT

N/A

OTHER

N/A

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 2: Insect Response To Regenerative Agriculture Practices In Pecan Orchards Under Cattle Grazing

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

Oklahoma State University will improve pecan production by quantifying beneficial and pest insects in grazed pecan orchards under regenerative agriculture management. Results will be shared with stakeholders at grower meetings, field days and scientific conferences. Currently, pecan orchards are managed to limit crop loss from insect damage, typically through application of insecticides. In addition, producers manage understory vegetation through mowing, or using herbicide. A growing number of farms use cattle grazing during the year to manage unwanted vegetation, improve soil fertility, and provide additional income. The complicating issue is that grazing cattle could introduce foodborne pathogens into the orchard environment (through fecal droppings) which may contaminate the pecans. Currently, we have an ongoing multiyear project monitoring the human pathogens survival (*Salmonella* and Shiga toxin-producing *E. coli*) in grazed pecan orchards as influenced by regenerative agriculture practices. Here we propose, leveraging the ongoing project, by assessing the insect community associated with grazing in pecan orchards under regenerative agriculture management. Such practices may have major impact on pecan weevil, a top pecan pest, and dung beetles, beneficial insects that can destroy fresh dung lowering its ability to support pathogens. We will sample dung beetles and pecan weevils in orchards with different management and quantify the potential of beneficial insects to increase grower profits while reducing disease risk. By maintaining beneficial insects, we believe that regenerative agriculture can increase consumer protection with grower profit.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Background

Adaptive multipaddock (AMP) rotational grazing is a newer practice in managing grazing animals, including cattle, on land in which portable fences are used to move/rotate grazing animals (in large number) in smaller areas (blocks) on a large grazing land. In doing so, each area (block) on a large grazing land is allowed to be grazed intensively for a short period time followed by a long period of recovery time without grazing. Studies on AMP grazing on rangelands have shown that, in comparison to conventional grazing (free ranging animal on a large land constantly), AMP enhances soil organic matter content (from animal fecal droppings), increases soil microbial diversity and activity, improves soil carbon and nitrogen stocks and stabilization, lowers soil greenhouse gas emission, and improves animal and forage (vegetation) production on the land. AMP is considered as one of the core regenerative agriculture practices that naturally improve ecosystem function while enhancing agricultural production, therefore, it is currently being considered for incorporation into the management of grazing cattle on native pecan orchards in Oklahoma.

Because AMP rotational grazing is still in its early stages of development, there are many gaps in our understanding of the roles of ecological interactions among invertebrate groups, including insects and microbes that utilize manure. Such knowledge is critical to obtain the best results. The intensive grazing for a short period time followed by a long period of recovery time without grazing under AMP management potentially influences population dynamics of several groups of insects that are import to pecan production, and food safety. Detritivore insect species are attracted to the dung and utilize it for both nutrition and reproduction. In particular, two groups, flies and the dung beetles, compete for the resources in fresh dung. In addition to these species, microbes including foodborne pathogens utilize the dung and may be transported to livestock or human foods by flies and directly to fresh nuts. Dung beetles can break up cattle feces and bury it in the soil. This action adds nutrients to the soil and reduces breeding areas for pest flies. Additionally, the breakdown of fresh cattle droppings reduces the moisture content in the droppings and therefore reduces the foodborne pathogens' survival in these droppings. Studies have shown that foodborne pathogens, if present in the cattle droppings, are sensitive to the moisture content of the fecal matter and persist in the droppings longer when the moisture content is high and thus may be reduced by the action of dung beetles. Lastly, trampling by high concentrations of cattle during AMP practices may cause soil compaction and direct mortality to insects inhabiting the soil layer. One such group is larvae of pecan weevils, a serious perennial pest of pecans.

An ongoing long-term project is monitoring the survival of the human pathogens (*Salmonella* and Shiga toxin-producing *E. coli*) in grazed pecan orchards. This project offers a unique opportunity to assess the response of these beneficial insect – dung beetles and pecan weevils under AMP relational grazing management on pecan orchard and determine interactions with pathogens. This knowledge could lead to improved management for beneficial dung beetles that sequester carbon, reduce methane production from microbial breakdown, and reduce the amount of resources available for potentially pathogenic microbes.

Research Questions

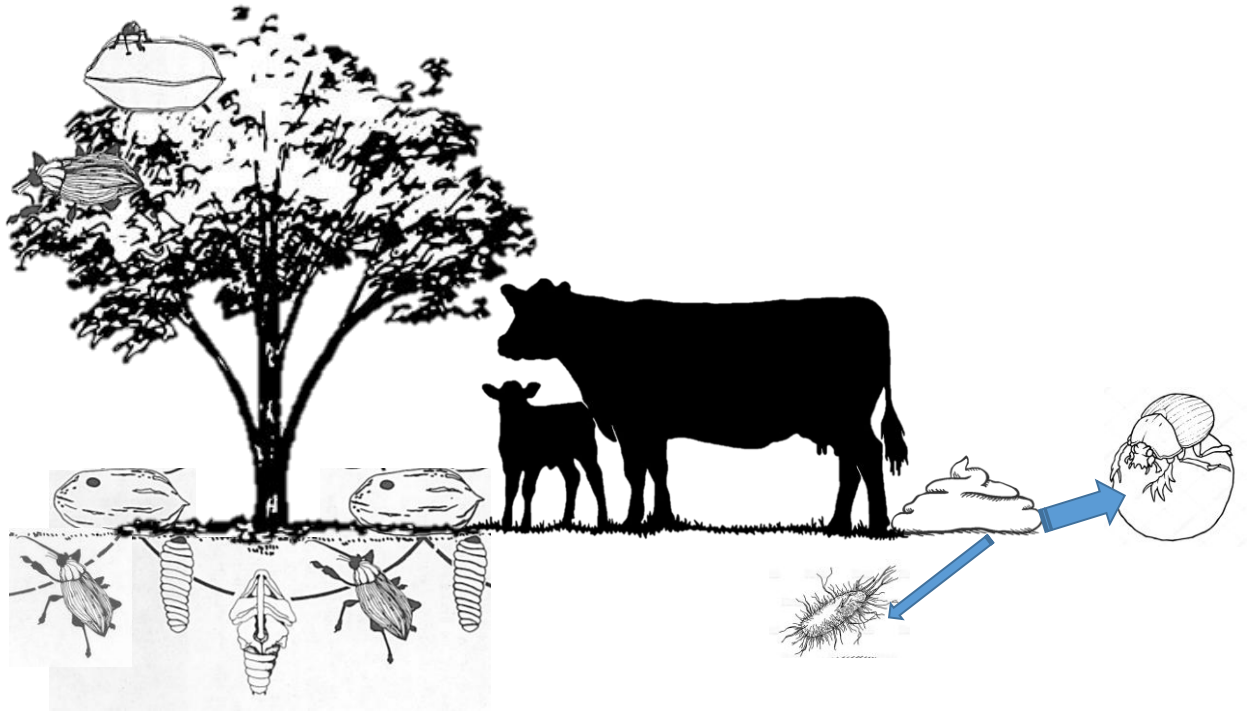
Working with the Noble Foundation, our plan is to conduct research on a 450 acre orchard near Ardmore Oklahoma. The orchard is grazed by 158 head of cattle will be grazed in 7 acre blocks managed using temporary electric fencing. Grazing is planned for a day at a time following a plan for Adaptive Multi-paddock (AMP) Grazing.

We will compare insect response to intense management in areas that have been intensely grazed for a short period. We will also quantify the amount of cattle feces and its breakdown. The main concern of using cattle grazing to manage understory vegetation is the production of cattle manure and potential of foodborne pathogens to contaminate pecans. Concentrating large numbers of animals in a small area may lead to excess manure or it may trigger the response of beneficial dung beetles that will be attracted to the manure and utilize it for their reproduction thereby naturally reducing the amount of pathogens, including *E. coli*.

This project seeks to examine three questions: 1) do dung beetles numerically respond to large quantities of dung and break up pats and remove resources for other insects; 2) do the presence of dung beetles significantly change dung pats by reducing their size and moisture content; 3) Does the trampling by high concentration of cattle lead to soil compaction and reduction of larval pecan weevils.

We propose the following hypotheses: 1) Cattle grazing will reduce pecan weevil through compaction and crushing. 2) Cattle grazing will create large amounts of feces that will increase dung beetle numbers 3) Dung beetles will also reduce the presence of pathogens by rendering fresh dung unsuitable through the actions of dung ball formation.

Figure 1. Anticipated interactions of grazed pecan orchards.



1. Dung beetle response. Dung beetles use fresh cattle manure for breeding. They arrive at pats, and depending on the kind of dung beetle, remove the dung by rolling it away or burying it beneath the pat. This has several potential positive effects- they remove breeding grounds for pest flies, they increase soil fertility and percolation, and they help to break up the dung leading to faster drying which reduces time for microbial growth.
    a. We have surveyed the counties of Oklahoma and identified the species of dung beetle present in the state. However, AMP rotational grazing is a relatively new technique and the presence and role of dung beetles in grazed pecan orchards is also currently unknown.

2. Pecan weevil response. Pecan weevils are a serious perineal pest of pecan production. They have a life cycle adapted to counter the pecan tree's "masting strategy" where trees produce large numbers of nuts every other year. Pecan weevils complete larval development and then stay in the soil for a year It is possible that cattle trampling and soil compaction reduces their numbers and intense cattle grazing in a small area for a few days could impact the population.

Pecan orchard and AMP rotational grazing (our study area)

The pecan orchard (Noble Research Institute) is over 450-acre in size. Under AMP management, the cattle (ca. 158 head) are grazing on an average of 7-acre areas each day (electrical fence) and are moved/rotated around the orchard daily. With the ongoing project, soil and pecan (trees) samples are collected in March, July, and November each year with a total 43 soil samples (along with pecan samples) are collected at each sample time to monitor the soil organic matter, pH, moisture content and

other physiochemical properties as well as the presence of two major foodborne pathogens- Shiga toxin-producing E. coli and Salmonella in the soils

Experimental design

Insects from the targeted groups will be sampled using standard best-practices for the target group. We will examine the response of dung beetles using baited pitfall traps placed in four paddocks during each visit (approximately every month between March and July). One paddock will have not had grazing for more than two months, one paddock will have had grazing within the past month, one paddock will have had grazing within the past two weeks, and one will be immediately after cattle are removed. We will examine the impacts of cattle grazing on pest pecan weevils using traps placed on tree trunks. Circle traps for pecan weevil will be placed in all of the paddocks used to sample beetles and dung decomposition rates.

In addition to sampling insect response, we will quantify the amount of cattle dung present in a paddock by taking counts of cow dung piles in six random one-meter areas per treatment. The focal areas will be determined by throwing a 1-meter ring and then counting all discrete piles within the area. Depth of dung will be measured and then a stake will be placed. A digital image of each location will be captured for comparison through time. On each subsequent visit, the dung stakes will be visited, and the amount of dung degradation will be determined. Observations of insect activity including breaking of the pats, tunneling, maggots, and round holes that indicate dung beetle activity in the dung will be made.

Dung Beetles

Dung beetles can be sampled using in-ground pitfall traps baited with moist feces mixed with maltose. In Oklahoma, pig dung obtained from OSU's swine production facility has proven effective. Pitfall traps, consisting of a two-liter container, are dug into the ground. A bait cup is attached by wire at the top of the trap and a lid consisting of plywood is propped above the trap with sticks. Attracted beetles fall in and are unable to fly back out. Traps are set in the afternoon and contents are collected the following day.

Pecan Weevil

The wire cone emergence trap has been shown to be effective for quantifying weevils per area. The traps are placed under pecan trees in late July and checked periodically, preferably daily, until October. They are not compatible with grazing. In areas that will be actively grazed, modified Circle traps attached directly to the tree can be used. The Circle trap is made of metal screen with an attached boll weevil trap at the top. this approach provides a simpler, less expensive, and effective means of detecting weevil emergence in pecan and can be used in conjunction with circle traps to assess weevil populations in an orchard.

Analyses

All dung beetle species will be determined and enumerated. Dung beetles belong to three behavioral groups, tunnelers that bury dung directly beneath the pat, rollers that move dung away prior to burial, and dwellers which are small species that use the dung in situ. We will analyze community composition

to determine response to AMP. To assess impacts of AMP on dung beetles and weevils, we will compare catch rates by treatment type using Analysis of Variance.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Assess pecan weevil response to grazing management in pecan orchards.

Objective 2: Assess dung beetle community response to grazing management.

Objective 3: Assess breakdown of cattle pats as a result of insect activity.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 1,000

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☑ **No** ☐

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

The project is supported by the Noble Research Institute and by the Oklahoma Pecan Growers Association which represents more than 2,000 farms and nearly 100,000 acres.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☐ **Outcome 6**: Expand Specialty Crop Research and Development
- ☑ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 7, indicator 7.1
Number of stakeholders that will gain knowledge about environmental sustainability best practices, tools, and technologies 200 growers

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

This research will provide data for best management practices leading to restorative agriculture (insect community) and support efforts to address climate smart (sink for carbon dioxide and reduction of methane from cattle feces) products- native pecan orchards maintaining beneficial insect communities and using alternatives to chemical control to manage pecan weevils. A Masters student will collect field data in conjunction with undergraduate field assistants. Dr. W. Hoback will compile data and create progress reports.

We will share the outcomes of the two-year project with growers. Dr. W. Wyatt Hoback will coordinate stakeholder meetings along with Dr. Maria Ma. Specific data collected will include number of attendees and results from surveys about current practices and intent to adopt new practices based on our results. Data will be compiled to determine the number of pecan acres adopting AMP and increases in interest about conservation of beneficial dung beetles. Result of pre- and post-survey data will also be shared at regional and national entomology meetings.

In addition, the research will support a MS thesis student and undergraduate research assistants who would gain valuable experiences. Because AMP has been infrequently studied in pecan orchards and the questions posed by this project have not been addressed, we anticipate two peer-reviewed publications.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$44,348.00
Fringe Benefits	$3,283.00
Travel	$9,300.00
Equipment	$0.00
Supplies	$6,000.00
Contractual	$0.00
Other	$1,000.00
Direct Costs Sub-Total	$63,931.00
Indirect Costs	$0.00
Total Budget	$63,931.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Masters Student	1	$33,848.00
2	Undergraduate	2	$10,500.00

Personnel Subtotal: $44,348.00

PERSONNEL JUSTIFICATION

Personnel 1: Masters student (to be identified). Masters student will work an average of 80 hours per month over a 12 month period at a rate of $18.75 per hour + benefits

Personnel 2: Undergraduate technicians. During summer, 2 students will assist with quantification of dung breakdown and trapping and identification of students. Undergraduates will work an average of 80 hours per month for 3 months and an additional 40 hours per month for 3 months. Total of 360 hours per student with a pay rate of $14.50 per hour + benefits.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Masters Student	8.67%	$2,935.00
2	Undergraduate	3.31%	$348.00

Fringe Subtotal: $3,283.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Bi-weekly sampling	Mileage, hotel, per diem	Days	24		1	$6,430.00
2	Stakeholder meeting	Mileage	Days	2		1	$232.00
3	Conference in-state	Mileage, hotel, per diem	Nights	4		2	$2,638.00

Travel Subtotal: $9,300.00

TRAVEL JUSTIFICATION

Trip 1 (Approximate Date of Travel 03/15-10/30/2023 and 2024**):** Travel will be from Stillwater to Ardmore to collect samples twice a month for 4 ½ months for two years (340 miles round trip x 2 trips per month x 4.5 months per year x 2 years x $.58 per mile = $3,550.00), hotel ($100 per night x 2 nights per month x 4.5 months a year x 2 years = $1,800.00) and per diem ($60 per day x 2 days per month x 4.5 months a year x 2 years = $1,080.00).

Trip 2(Approximate Date of Travel 3/30/2024): Funds are requested to travel to the annual meeting of the Oklahoma Pecan Growers Association in year two of the project to report on the results of the project. The location of the 2024 meeting has not been selected but it is estimated to be 400 miles round trip x $.58 per mile = $232.00.

Trip 3 (Approximate Date of Travel 4/12/2023-4/15/2023): Funds are being requested for the PI and graduate student to attend the Entomology Society meeting in Oklahoma City. Registration for event ($350 x 2 = $700.00), Milage (134 miles x $.58 = 78.00), hotel ($180 x 4 nights x2 people= $1.440.00, per diem $60 x 3 days + $30 x 1 day (one lunch and one dinner provided) x 2 people = $420.00).

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Dung beetle traps	$14	20	2/1/2023	$280.00
Pecan weevil traps	$40	45	6/1/2023	$1,800.00
Fly traps	$11	120	2/1/2023	$1,320.00
Curation supplies, alcohol, vials, pins, etc.	$2,500.00	1	2/1/2023	$2,500.00
Fecal degradation monitoring supplies (plastic rings for monitoring, disposable gloves, sample containers, swabs, ethanol and shipping cost)	$920.00	1	2/2/2023	$920.00

Supplies Subtotal: $6,000.00

SUPPLIES JUSTIFICATION

Supplies are requested for collection and monitoring of insects. Dung beetle traps are pitfall traps baited with pig dung. Fly traps are commercially available lures purchased from Trece. Curation supplies: 70% ethanol will be obtained from University Chemistry Stores ($257.5 per 5 gallons x 2), 500 ml nalgene vials for specimen storage will be obtained from Cole Palmer (2 cases $387.50 per case) and insect curating supplies (pins) will be obtained from Forestry Suppliers (10 packs of 100 for $9 per pack) and museum drawers will be obtained from Carolina Biological ($126.20 x 2) and shipping (estimated $300) will be used to create a reference collection and assess diversity and abundance. Materials to collect fecal microbe samples will be purchased from Fisher Scientific. Pecan weevil traps will be constructed from screen and placed around the trunks of trees.

CONTRACTUAL/CONSULTANT

N/A

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Publication costs	1000	1	2024	$1,000.00

Other Subtotal: $1,000.00

OTHER JUSTIFICATION

The research outcomes of this project will be used to produce one or two manuscripts for submission to peer-reviewed journals. We anticipate publishing in the Journal of Economic Entomology (page charges of $160 per page) and in the Journal of Crop Protection (page charges of $135 per page). Costs estimated and additional costs will be matched through departmental funds.

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 3: Improving Nitrogen and Nutrient Uptake Efficiency of Pecans Using Mycorrhizal Fungi

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

A surge in chemical fertilizer prices, especially for Nitrogen (N), has put a lot of pressure on pecan growers. While reducing fertilizer price is beyond our capabilities, scientists from Oklahoma State University seek to investigate a means to increase the uptake efficiency of N and perhaps other nutrients by pecan roots in different types of pecan orchards using mycorrhizal fungi. N is an essential nutrient that affects pecan growth and production. Mycorrhizal fungi form a symbiosis with plants widely in nature in which the plant provides sugars for fungi growth and, in return, the fungi provide enhanced soil N and other nutrient for root uptake. Certain types of mycorrhizal fungi are likely associated with pecan roots in numerous orchards already. Our research will target specific types of mycorrhizal fungi with abilities to increase N uptake and to identify the best bio-types for Oklahoma pecan trees. We will investigate rhizosphere microbial diversity in both improved pecan cultivar orchards and native pecan groves in Oklahoma, collect, isolate, screen, and identify mycorrhizal fungi bio-types with high N absorption efficiency. Then we will inoculate the bio-types to pecan seedlings to analyze N uptake, N metabolism enzymes, and seedling growth to select mycorrhizal fungi species. The long-term vision of this project is to increase pecan tree soil N uptake efficiency using the right bio-types of mycorrhizal fungi. Although beyond the scope of the present investigation, successful inoculation of existing pecan trees would increase their N uptake efficiency and reduce fertilizer costs for Oklahoma Pecan producers.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Oklahoma is one of the top five U.S. states for pecan production and is the number 1 or number 2 state (rotating with Texas) for native or self-rooted pecan production. Production in Oklahoma for 2019, a heavy crop year, was about 21 million pounds which added approximately $27 million to the state's economy. Pecan growers in Oklahoma commonly apply chemical fertilizers annually to satisfy nutrient needs in their improved orchards; less (sometimes no) fertilizer is provided to native pecan groves. The prices of traditional N fertilizers have increased significantly since 2019 (e.g., the price of ammonia is 3 times higher in 2022 compared to September 2019 according to the Agricultural Marketing Service data) and other fertilizer nutrients are following suit. In the face of unprecedented fertilizer price increases, we propose to investigate a means to increase efficiency of root fertilizer absorption in both improved pecan orchards and native pecan groves using mycorrhizal fungi. Although mycorrhizal fungi occur naturally and certain types are likely in association with roots in numerous orchards already, our work will prospect specific types which increase N and other fertilizer element uptake to identify the best bio-types for Oklahoma pecan trees. Mycorrhizal fungi represent an intriguing opportunity for enhancing pecan root uptake efficiency and thus enhance sustainable agricultural practices for our pecan producers.

Mycorrhizal networks form a mutualistic symbiosis formed by soil fungi and plant roots in which both fungi and plants can obtain benefits from each other. More than 90% of terrestrial plants can form this ubiquitous, symbiotic relationship with mycorrhizal fungi. Mycorrhizal fungi obtain carbohydrates from host plants and, in return, the increased surface area afforded by their sprawling hyphae help the host plants absorb nutrients and water from the soil. Continued nutrient uptake by plants and poor mobility of some nutrients can lead to intense depletion zones around the roots which limits the nutrient acquisition of plants. As an important bridge between plant roots and the soil, mycorrhizal fungi form a huge hyphae network that enables plants to absorb more water and nutrients from the soil.

N is the most limiting nutrient in the yield of pecans and previous research has shown that mycorrhizal fungi-plant symbiosis plays an essential role in the enhancement of N uptake of plants. Research found that maritime pine (*Pinus pinaster*) inoculated with the mycorrhizal fungus *Hebeloma cylindrosporum* absorbed nitrate twice as fast as uninoculated plants. It was also found that the inoculation of the mycorrhizal fungus *Rhizopogon roseolus* could improve the ability of marine pine to absorb nitrate regardless of the external N concentration (with lower soil N concentration). Pecan has been reported to form symbiosis with various types of mycorrhizal fungi including ectomycorrhizal and arbuscular mycorrhizal fungi. Several previous studies have reported the superiority of mycorrhizal fungi on pecan growth and water utilization by improving leaf biomass and stem height and diameter. However, little is known about their role in affecting N and/or other nutrient uptake efficiency in pecans, especially under various growth conditions (i.e., cultivar or native, with or without fertilizers).

1). Affecting rhizosphere microbial communities to improve nutrient uptake
Microbial communities adjacent to plant roots (the rhizosphere) are closely related to plant nutrient uptake and plant growth. Root mycorrhizal fungi may send out hyphae for direct N absorption, and they may form a synergistic network with beneficial bacteria to promote the absorption of applied N fertilizer, or mineralize organic N into plant-available forms, in the soil. They may also promote plant growth by displaying broad antagonism against soil-borne pathogens. Some studies suggest that mycorrhizal fungi, as well as the soil microbiological community as a whole, are reduced in number coincident with the amount of applied N fertilizer. This may require assessment of increasing the distribution ratio of advantageous mycorrhizal fungi in the rhizosphere of pecan may help stabilize the

beneficial microbial community, enhance N and nutrient uptake of pecan, and ultimately improve pecan growth. Thus, detailed analysis of microbial community diversity, including mycorrhizal fungi species, within the pecan rhizosphere under various N fertilizer treatments is needed to systematically understand the synergistic effect of microorganisms on soil N uptake.

2). Enzyme increasing bioavailable N

Most of the N in the soil exists in less plant-available organic forms with the more plant-available inorganic N only accounting for 1% of the total soil N. Mycorrhizal fungi are capable of degrading complex organic matter in the environment by secreting enzymes, which activate the nutrients held in the soil. The addition of mycorrhizal fungi increases soil N mobilization associated enzymes (such as soil nitrogenase, nitrate reductase, protease, and chitinase), releasing more plant-available N for plants. Once inside the host plant, mycorrhizal fungi will secrete signaling substances, which will activate plant enzymes to undergo the reactions of nitrate reductase (NR), nitrite reductase (NiR), glutamine synthase (GS), and glutamine oxalate aminotransferase (GOGAT). By increasing the activity of these plant enzymes related to N utilization, the N utilization efficiency of plants can be maximized. Determining the activity of these enzymes in pecan-mycorrhizal fungi systems can provide a selection tool for specific mycorrhizal fungi which can improve N uptake of pecans.

This project will focus on how to increase the efficiency of N uptake in pecans by surveying and selecting the native mycorrhizal fungi for enhanced N uptake from various pecan orchards and native groves in Oklahoma. We will isolate mycorrhizal fungi from the pecan root, and then screen and identify fungi which provide the most suitable fungal candidates to improve pecan N uptake. Then the selected fungi will be grown and introduced into pecan seedlings. The effect of fungal inoculation will be assessed by analyzing pecan N uptake and allocation (potential for enhanced N uptake by pecan roots in association with mycorrhizal fungi) and plant N metabolism-related enzymes (potential for enhanced pecan tissue N utilization). Our work will demonstrate introduction of the best bio-types of mycorrhizal fungi into pecan orchards as inoculated rootstock seedlings. Although beyond the scope of our proposed work, our goal is to apply our findings for inoculation of mature pecan trees in existing improved pecan orchards and native pecan groves as a sustainable agricultural practice for Oklahoma pecan producers, using promising bio-types documented from our proposed work.

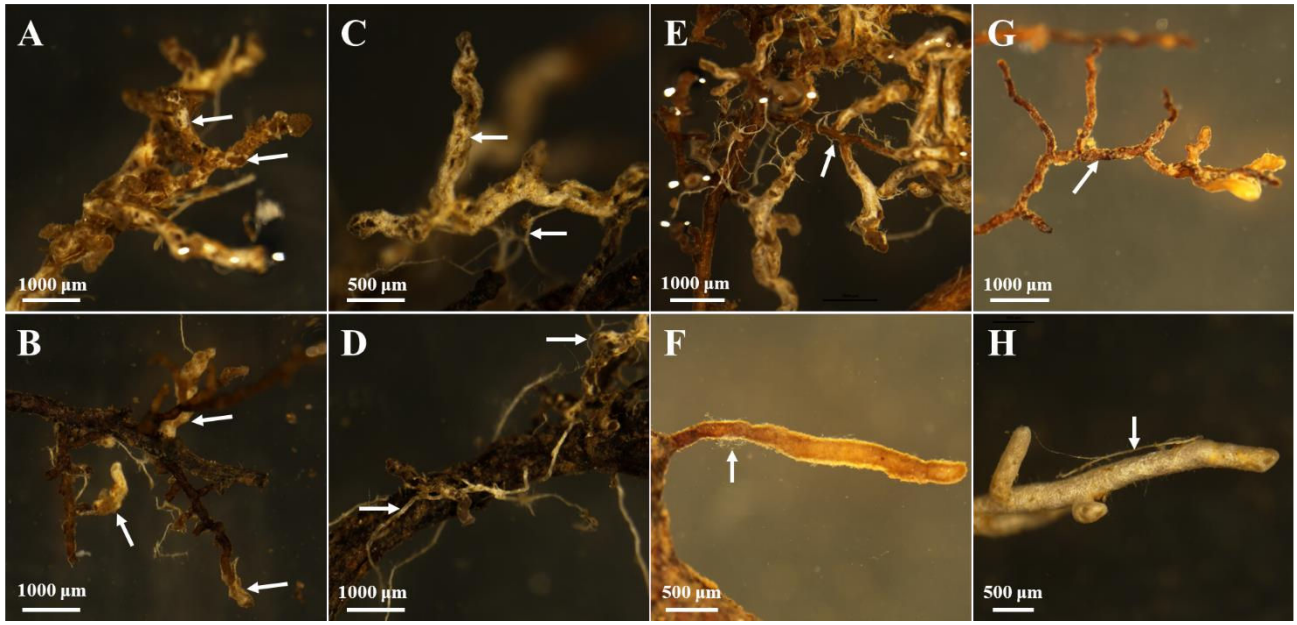


Figure 1. Microscopic images of the mycorrhizal pecan roots sampled from the pecan under various N fertilizer treatments from the OSU experimental pecan orchard

A-D represent the root tips from pecan with full N fertilization (the amount of N was determined through leaf nutrient analysis in the previous year); E-H represent the root tips from pecan without N addition. The swelling of the root tip in the figure is a special mycorrhizal structure formed after the infection of mycorrhizal fungi, and the arrows point to mycorrhizal fungi hyphae.

We have observed mycorrhizal pecan roots and obtained some candidate fungi from our initial sampling of pecan roots from the OSU improved cultivar experimental pecan orchard in Perkins **(Figure 1)**. We found that the morphologies of mycorrhizal roots were different in pecans with or without previous season N fertilizer, indicating distinct types of mycorrhizal fungi. Previous literature suggests that N fertilization of various degrees will induce changes in dominant beneficial mycorrhizal fungi. These candidate mycorrhizal fungi (isolated from pecan under different N fertilizer treatment) could have different potential for N absorption and pecan nutrient uptake. We now propose to determine N uptake potential in mycorrhizal fungi predominating in different soil fertility environments within Oklahoma pecan orchards and groves, select the bio-types with greatest N uptake potential in each fertility environment and assess improved growth of pecan seedlings as a result of the symbiotic relationship.

Project Synopsis

In this project, we will isolate natural-occurring mycorrhizal fungi from pecan roots, screen for high-efficiency N-absorption capacity from fungi growing media and recombine the best performing mycorrhizal fungi candidates with pecan seedling roots and select those types which demonstrate high N uptake/high seedling N utilization potential. Pecan N uptake will be documented through leaf tissue analysis and any differences in N utilization efficiency will be determined by documenting activity of N metabolizing enzymes. Root and shoot biomass, and relative mycorrhizal fungi root colonization density, will be determined at the conclusion of each seedling trial to document pecan growth characteristics and colonization potential for the mycorrhizal fungi biotypes under investigation.

1. Sample mycorrhizal fungi diversity from both improved pecan cultivar orchards and native pecan groves in Oklahoma

This project will first survey the natural mycorrhizal fungi diversity for pecan roots from different types of orchards: grower native pecan groves, grower improved cultivar orchards and the OSU improved cultivar experimental orchard. Isolated mycorrhizal fungi will be bio-typed by DNA fingerprinting so that high-efficiency N-absorbing mycorrhizal fungi biotypes can be selected in objective 2 and assessed for improved seedling performance after seedling tree inoculation in objective 3.

a. Sampling: Five pecan trees of similar age from different type of orchards will be sampled. Using the five-point sampling method, the roots and rhizosphere soil mixture from each tree will be collected from the 5-20 cm soil layer in five directions and mixed as one sample. Partial root samples sifted from each specimen will be used for isolating mycorrhizal fungi in objective 2 and a subset of roots will be stored in FAA fixation solution for documentation of mycorrhizal fungal colonization degree. The remaining soil sample will be dried and used for soil elemental analysis.

b. Soil elemental analysis: Water content of fresh soil samples will be measured by oven-drying fresh soil to a constant weight at 105 °C, and the pH will be measured by a pH meter. The remaining soil samples will be dried naturally in air and then sieved by 0.15 mm to measure organic matter, organic carbon, available phosphorus, total phosphorus, available potassium, total potassium, total N, ammonium N and nitrate N and trace elements. The soil elemental information will be key in classifying mycorrhizal fungi bio-types as to root fertility environment which is known to influence N uptake efficiency in symbiosis with plant roots.

c. Microbial diversity (including mycorrhizal fungi diversity) analysis*:* The total microbial DNA from the root and soil samples will be extracted using the FastDNA™ SPIN Kit for soil. The V4 region of bacteria 16S rDNA which amplified by primers 515F (5'-GTGCCAGCMGCCGCGGTAA-3') and 806R (5'-GGACTACHVGGGTWTCTAAT-3') as Castrillo et al. (2017), the ITS2 region of fungi which amplified by primers fITS7 (5'-GTGARTCATCGAATCTTTG-3') and ITS4 (5'-TCCTCCGCTTATTGATATGC-3') as Nilsson et al. (2019), and the SSU region of arbuscular mycorrhizal fungi which amplified by primers NS31 (5'-TTGGA GGGCAAGTCTGGTGCC-3') and AML2 (5'-GAACCCAAACACTTTGGTTTCC-3') as Davison et al. (2015). Then the DNA will be sequenced by Illumina MiSeq platform at the Center for Genomics & Proteomics in OSU to analyze the microbial diversity to reveal the dominance of mycorrhizal fungi in different environments.

2. Isolate, screen, and identify mycorrhizal fungi bio-types with inherent high N absorption capacity

Root-associated mycorrhizal fungi will be isolated from samples obtained in objective 1, DNA fingerprinted to assign to bio-type and then cultured and assessed nutrient solution N uptake efficiency as follows:

a. *Isolating and screening mycorrhizal fungi:* We will collect the fresh root tips of pecans and surface-sterilize them by blanching to remove the saprophytic fungi attached to the root surface. The surface-sterilized root tips will be placed into potato dextrose agar to cultivate mycorrhizal fungi. Mycorrhizal fungi colonies will be transferred to Pachlewski medium and cultured for DNA fingerprinting and N uptake efficiency.

b. *Identifying fungi and analyzing their inherent N absorption potential:* The inherent N absorbing potential of candidate mycorrhizal fungi will be evaluated by growth status and uptake kinetic curves on Pachlewski medium of different N source (ammonium, nitrate, arginine and glutamine) to determine inherent N absorption capabilities and to screen out fungi with no abilities to absorb N. We will evaluate N absorption at different temperature (20 °C, 25 °C, 30 °C, 37 °C, and 45 °C), pH (4.0, 6.0, 7.0, 8.0, and 10.0), salinity (0, 0.5%, 1%, 2%, 3%, and 5%), and N/P ratio (1/3, 2/3, 1 and 4/3) to find the suitable N absorbing conditions as Liu et al. (2021). This knowledge will be important for determining how flexible each bio-type might be in differing Oklahoma soils. After these, the fungal DNA will be extracted using Qiagen AllPrep Fungal DNA/RNA/Protein Kit and then amplified fungal ITS2 by primers ITS1F (5′-TCCGTAGGTGAAC CTGCGG-3′) and ITS4 (5'-TCCTCCGCTTATTGATATGC-3') for molecular identification and bio-typing at Core Facilities in the Department of Biochemistry & Molecular Biology at OSU (Simister et al., 2015).

3. Evaluate performance of N-absorbing mycorrhizal fungi bio-types to improve growth characteristics of seedling pecan trees

Seedling pecans (twelve trees per treatment) will be placed into a greenhouse trial with different N levels (full N of 50 lb/acre according to Conner (2007), half N, quarter N, and no additional N) and with or without candidate mycorrhizal fungi inoculation (Table 1). The pecan seeds (two commonly used rootstocks in OK: Peruque and Giles) will be purchased from nurseries and germinated into seedlings in the laboratory and then transplant to pots (9×9×13 cm) with the sterilized substrate (sand: vermiculite =1: 1, v: v) in a greenhouse with 28 °C/24 °C day/night temperatures under 16 h daylight and 40-60% humidity. Hoagland's nutrient solution will be added twice a week to maintain plant growth and help form a symbiosis with mycorrhizal fungi. The candidate fungi will be grown in a liquid PDA medium for 2 weeks. Then they will be concentrated by centrifuge, washed with sterile water, crushed by a beater, and then inoculated on the roots of germinated pecan seedlings in equal amounts (5 g/pot). A proportion of this inoculum will be autoclaved (121 °C for 2 h) twice with a time interval of 48 h and will be added to the control treatment as blank. After one month, the mycorrhizal colonization rate of seeding pecan (two trees per treatment, these trees are used to confirming their symbiosis formed and will not be used for further experiment) will be measured under a microscope after staining by trypan blue as Phillips and Hayman (1970) to confirm the colonization status. The number of colonized root segments will be counted to calculate the colonization rate, which can reflect the ability of these candidate mycorrhizal fungi to infect pecans. Since only fungi capable of infecting pecans can establish a symbiotic relationship with pecans and help pecans take up N, those combinations (other than the control) that fail to show colonization will be discontinued from the experiment. For seedlings demonstrating mycorrhizal fungi colonization (and the control, non-inoculated seedlings), the different N treatments will be imposed (added twice a week) to change the N status (Table 1) and seedlings will be grown for four weeks.

Table 1. Experiment design: the treatments of mycorrhizal fungi and different N fertilizer level in two rootstocks: Peruque and Giles

Treatment	Mycorrhizal fungi				
	Control	Candidate 1	Candidate 2	Candidate 3	Candidate 4
Full N	12 seedings	12 seedings	12 seedings	12 seedings	12 seedings
Half N	12 seedings	12 seedings	12 seedings	12 seedings	12 seedings
Quarter N	12 seedings	12 seedings	12 seedings	12 seedings	12 seedings
No additional N	12 seedings	12 seedings	12 seedings	12 seedings	12 seedings

We anticipate that seedling evaluations will begin six to nine months after the start of this project, allowing time for initial root isolation and inherent N absorption potential for bio-type selection described in objectives 1 and 2. Not counting time to germination for the seedlings, each seedling trial should last 2 to 3 months, allowing for four to five seedling growth cycles for this project. Within successive growth cycles we will test any additional mycorrhizal fungi bio-types identified as candidates in objective 2. In the final growth cycles we will include the best performers isolated from roots in the first growth cycle and from cultures used in the previous growth cycles to confirm our previous results and provide a comparison between our best performers.

a. Select mycorrhizal fungi through pecan growth: Four weeks after N treatment, pecan height and stem diameter at ground level will be measured to determine the plant growth status. Leaf chlorophyll content will be determined by a spectrophotometer after N, N-dimethylformamide extraction. Leaf discs (1 cm in diameter) will be punched from each sample leaf. Half of the discs will be dried at 80 °C for 48 h to determine moisture content. Leaf dry mass per area will be calculated and used to provide a normalized chlorophyll content measurement. The mycorrhizal fungi with great ability to promote pecan growth and leaf chlorophyll content will be recorded and maintained in culture for continued experimentation. After sampling for N enzyme levels described in b, we will sacrifice the seedlings to measure root, stem and leaf biomass. A proportion of the roots will be saved for microscopic analysis, mycorrhizal fungi isolation and re-culture for inoculation of other seedlings, and for bio-typing as previously described. The remaining tissues will be dried at 80 ℃ and dry mass will be calculated.

b. Select mycorrhizal fungi through pecan N status and N allocation: Prior to harvest for plant mass determination in a) above, fresh leaf samples (the middle three leaflets for three compound leaves per pant) will be weighed and then taken for enzyme activity determination/N determination to evaluate mycorrhizal fungi on pecan N status. Half of the leaf samples will be frozen by liquid N and stored at −80 ℃ for protein and enzyme analysis, the other half will be dried and ground for N analysis. Leaf area prior to freezing or drying will be determined. Leaves for N analysis will be washed in consecutive rinses of tap water, 0.1 N HCl, soapy water, and deionized water. Then the samples will be dried at 80 ℃ and ground to a powder (using MIXER MILL MM 500 CONTROL) through a 20-mesh screen and digested by microwave digestion with HNO_3 (MILESTONE DRN-41, Italy). Then, the N content of each part will be determined using the Kjeldahl method in a Kjeltec™ 8400 Analyzer Unit (FOSS-Tecator, Hoganas, Sweden) (Kong et al., 2015).

   The remaining leaf frozen in liquid N will be powdered in liquid N as fresh samples prior to each extraction process. The powdered sample will be used to extract enzyme and protein by modified sodium phosphate buffer. A subset of each leaf powder will be used for soluble protein determination using the ninhydrin method with Bovine serum albumin as standard. N in the protein fractions will be calculated assuming 16% N in proteins. The pellet from the soluble protein determination will be utilized for N determination by Kjeldahl to evaluate the fractions of leaf N allocated to cell structure-related protein and photosynthetic apparatus to estimate N allocation strategy which can show whether pecan seedlings differ in N absorption in relation to specific mycorrhizal fungi symbiotic relationships.

   The other proportion of powdered leaf will be extracted as above and used to analyze the activities of plant N metabolism enzymes (nitrate reductase, nitrite reductase, glutamine synthase, and glutamine oxalate aminotransferase). Results will show whether N absorption

capacity was impacted by mycorrhizal fungi symbiosis and, in combination with total leaf N and leaf N allocation strategy, will be a selection criteria for those bio-types which impact seedling N absorption capacity and seedling growth the most.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Sample mycorrhizal fungi diversity from both improved pecan cultivar orchards and native pecan groves in Oklahoma**.**

Objective 2: Isolate, screen, and identify mycorrhizal fungi bio-types with inherent high N absorption capacity.

Objective 3: Evaluate performance of N-absorbing mycorrhizal fungi bio-types to improve growth characteristics of seedling pecan trees.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 50 growers

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☐ **No** ☑

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

Oklahoma Pecan Growers' Association (OPGA) and the many pecan growers/stakeholders it represents have shown their support to this project and believe the success of this project could have a positive impact on generations of pecan growers in Oklahoma. For this project, four growers whose pecan

orchards or groves represent the N-S and E-W regions of Oklahoma and have agreed to be collaborators of this project to provide soil and plant tissue materials for the survey of rhizosphere microbial diversity and mycorrhizal fungi.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☐ **Outcome 6**: Expand Specialty Crop Research and Development
- ☑ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 7, Indicator 7.1
Number of stakeholders that gained knowledge about environmental sustainability best practices, tools, or technologies. 50.

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

PI Dr. Lu Zhang will prepare reports and give presentations to growers at Oklahoma Pecan Growers' Association Annual Conferences (150-200 grower attendees each year) and Pecan South magazine, and at least 50 pecan growers will directly benefit from this research.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$53,072.00
Fringe Benefits	$11,573.00
Travel	$1,600.00

Expense Category	Funds Requested
Equipment	$0.00
Supplies	$10,010.00
Contractual	$2,000.00
Other	$6,450.00
Direct Costs Sub-Total	$84,705.00
Indirect Costs	$0.00
Total Budget	$84,705.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Graduate student	20 h/week	$24,720.00
2	Donna Chrz	2 h/week	$9,207.00
3	Tingying Xu	4 h/week	$19,145.00

Personnel Subtotal: $53,072.00

PERSONNEL JUSTIFICATION

Personnel 1: We will seek one graduate student interested in a two-year master's degree program focusing on this proposed project. The request for graduate student support for 18 months' salary ($24,720) and fringe benefits ($2,143). This student will be a critical participant in this project, mainly assisting with experiment design and conducting field trips and in-lab experiments.

Personnel 2: Donna Chrz is a Senior Research Specialist at the Department of Horticulture and Landscape Architecture, OSU. Donna Chrz will assist with lab management. We request 3 months of salary ($9,207) and fringe benefits ($3,626) for year 1.

Personnel 3: Dr. Tingying Xu is an Assistant Professor of geochemistry and geomicrobiology at Boone Pickens School of Geology, OSU. Dr. Tingying Xu will assist with field sample collection, mycorrhizal fungi isolation and identification, experiment design and analytical assessments, particularly with fungal symbiosis analysis. Dr. Xu will be responsible (4 hours/week) together with Dr. Zhang for the project's overall management and co-advising student. We request 1 month of salary ($9,431 for year 1 and $9,714 for year 2) and fringe benefits ($2,860 for year 1 and $2,944 for year 2).

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Graduate student	8.67%	$2,143.00
2	Donna Chrz	39.38%	$3,626.00
3	Tingying Xu	30.32%	$5,804.00

Fringe Subtotal: $11,573.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Perkins	Mileage	40 miles	38	$24	1	$912.00
2	Cleveland	Mileage	100 miles	2	$60	1	$120.00
3	Sapulpa	Mileage	140 miles	2	$84	1	$168.00
4	Skiatook	Mileage	130 miles	2	$78	1	$156.00
5	Claremore	Mileage	203 miles	2	$122	1	$244.00

Travel Subtotal: $1,600.00

TRAVEL JUSTIFICATION

The budget of $1,600 is to pay milage for multiple round-trip to the experimental orchard in Perkins ($912 for 38 round trips) and growers orchard in Cleveland ($120 for 2 round trips), Sapulpa ($168 for 2 round trips), Skiatook ($156 for 2 round trips), and Claremore ($244 for 2 round trips) to conduct experiments including sampling soils/roots, surveying soil physicochemical properties, surveying microbe diversity, collecting flower, leaf, and fruit samples, collecting shoots for laboratory-based treatments.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Fungi isolation-DNA sequencing	$12.50	320	Feb 2023, 2024	$4,000.00

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Fungi isolation-qPCR instrument use	$20	20	Feb 2023, 2024	$400.00
Nucleic Acid Gel Stain	$388	1	Feb 2023, 2024	$388.00
Agarose	$213	2	Feb 2023, 2024	$426.00
TAE Buffer	$108	1	Feb 2023, 2024	$108.00
DNA Ladder and Gel loading buffer	$115	2	Feb 2023, 2024	$230.00
Hoagland solution for fungi	$110	1	Feb 2023, 2024	$110.00
Ethanol	$150	2	Feb 2023, 2024	$300.00
N analysis	$5	400	Feb 2023, 2024	$2,000.00
N analysis related chemicals	$448	1	Feb 2023, 2024	$448.00
Pipette tips	$400	2	Feb 2023, 2024	$800.00
Centrifuge tubes	$200	2	Feb 2023, 2024	$400.00
Lab gloves	$200	2	Feb 2023, 2024	$400.00

Supplies Subtotal: $10,010.00

SUPPLIES JUSTIFICATION

We request $5,952 in total for fungi identification. It includes $2000/year for DNA sequestration of fungi related to pecan roots and $200/year for the use of qPCR at Core Facilities in OSU. Chemicals needed for fungi isolation/identification include Nucleic Acid Gel Stain ($388), Agarose ($416), TAE Buffer ($108), DNA Ladder, and Gel loading buffer ($220), Hoagland solution ($110), and ethanol ($300)

For N analysis, we request $2,448 in total for two years including N analysis by Lachat Flow Injection Auto—analyzers at a rate of $5/sample for 200 samples/year and chemicals related to N analysis assay (Ethyl iodoacetate, polyvinylpyrrolidone, Phenylmethanesulfonyl fluoride, DTT dithiothreitol, barium hydroxide octahydrate, sodium dodecyl sulfate) at a total price of $448 for two years.

We request $1600 in total for two years for general lab consumable to conduct bench-top laboratory experiments including fungi isolation/purification, fungi DNA extracting, glass slides preparation for fungi infected rate to pecan root, and all sample preparations for DNA sequencing and N analysis. Supplies include pipette tips ($800), centrifuge tubes ($400), and lab gloves ($400).

CONTRACTUAL/CONSULTANT

ITEMIZED CONTRACTOR(S)/CONSULTANT(S)

#	Name/Organization	Hourly Rate/Flat Rate	Funds Requested
1	Chad Selman/Selman Farms	10 h/week	$500.00
2	Mike Smith/Cedar Creek Pecan Farms	10 h/week	$500.00
3	Mike Spradling/Flying Ranch	10 h/week	$500.00
4	Robert Knight/Knight Creek Farms	10 h/week	$500.00

Contractual/Consultant Subtotal: $2,000.00

CONTRACTUAL JUSTIFICATION

Contractor/Consultant 1: Mr. Chad Selman, owner of Selman Farms will provide and assist the research team to collect soil, pecan root and leaf samples in their orchard once a year. The salary is $25/hour for 10 hours each year.

Contractor/Consultant 2: Dr. Mike Smith, owner of Cedar Creek Pecan Farms will provide and assist the research team to collect soil, pecan root and leaf samples in their orchard once a year. The salary is $25/hour for 10 hours each year.

Contractor/Consultant 3: Mr. Mike Spradling, owner of Flying Ranch will provide and assist the research team to collect soil, pecan root and leaf samples in their orchard once a year. The salary is $25/hour for 10 hours each year.

Contractor/Consultant 4: Mr. Robert Knight, owner of Knight Creek Farms will provide and assist the research team to collect soil, pecan root and leaf samples in their orchard once a year. The salary is $25/hour for 10 hours each year

CONFORMING WITH YOUR PROCUREMENT STANDARDS

By checking the box to the right, I confirm that my organization followed the same policies and procedures used for procurements from non-federal sources, which reflect applicable State and local laws and regulations and conform to the Federal laws and standards identified in 2 CFR Part 200.317 through.326, as applicable. If the contractor(s)/consultant(s) are not already selected, my organization will follow the same requirements. ☑

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Publication charges	$2,450	1	Jan-24	$2,450.00
Greenhouse rental (OSU internal service vendors)	$2,000	2	March 2023, 2024	$4,000.00

Other Subtotal: $6,450.00

OTHER JUSTIFICATION

Publications funds are requested to cover the publication costs in high quality peer reviewed journals in second year. $2,450 is requested to publish two papers paying 50% for one paper with HortScience ($2,000/article) and 50% for another paper with Scientia Horticulturae ($2,900/article). The balance of the publication fees will be covered by J.D. Scott pecan research professorship held by Dr. Lu Zhang.

Greenhouse rentals are requested to conduct pecan seedling-fungi experiments through Oklahoma State University internal services (Controlled Environmental Research Lab in OSU) ($2,000 each year)

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 4: Fertility Management in Soilless Growth Media for Vegetable and Ornamental Crop Production

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

Fertility management in the soilless growth media plays an essential role in crop quality and yield. The use of soilless growth media for specialty crop production has been increasing rapidly, among both commercial producers and home gardeners. There is a critical need to evaluate the effects of fertilization in soilless growth media on vegetable and ornamental crop quality and yield. Researchers from the Department of Horticulture and Landscape Architecture at Oklahoma State University will partner with The Soil, Water and Forage Analytical Laboratory from Oklahoma Cooperative Extension Service, with the goal to generate reliable interpretations of soilless growth media test results and recommendations for fertilization based on crops specified. Eight specialty crops representing the general crops grown in soilless growth media will be included in this project: spinach and lettuce representing leafy vegetables, radish and beet representing root vegetables, tomato and cucumber representing fruiting vegetables, and petunia and geranium representing ornamental crops. Their performance under different fertility management will be evaluated. Research results will be disseminated to stakeholders through Extension workshops, grower meetings, and publications. The practical information and educational resources developed from this project will support Oklahoma growers to make informative decisions on nutrient

management for optimal crop performance, problem prevention, or diagnosis, and facilitate the adoption of soilless growth media for enhancing specialty crop production.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Soilless growth media, also called greenhouse growth media, are used for specialty crop production in containers and raised beds with restricted volume. Their primary components typically include some of these materials, peat, pine bark, perlite, vermiculite, compost, and sand, with little or no regular soil in the mix. Therefore, soilless growth media have distinctly different chemical and physical properties from regular field soils, and thus require different management protocols. Soilless growth media have good moisture-holding and aeration properties, but limited nutrient-holding capacities. Therefore, fertility management in the soilless growth media is even more important than soil-based production, playing an essential role in crop quality and yield.

Specialty crop production is under the transition from soil-based to soilless culture according to a recent survey of North American needs assessment for soilless substrate science. Specialty crop growers are transitioning their production to soilless growth media to improve pest management, increase crop yield and quality, and ultimately enhance the sustainability of specialty crop production. The survey identified research needs for soilless growth media over the next 10 years including 1) fertility management, 2) education for growers, suppliers, and consumers.

In Oklahoma, we have seen a consistent trend of increasing use of soilless growth media for specialty crop production. Commercial producers of specialty crops benefit from using soilless growth media to achieve better crop performance due to more precise crop management in the artificial substrates under protected structures such as greenhouses and high tunnels. Home gardeners also demonstrate a rapidly increasing interest in using soilless growth media for growing vegetables and ornamental crops. The pandemic has inspired many to garden and soilless growth media is an obvious choice when people don’t necessarily have access to good soil, and coupling with container production, soilless growth media provide more flexibility of where to grow crops.

Oklahoma Cooperative Extension Service has received frequent requests for information on how to use soilless growth media, specifically its fertility management in recent years. Responding to this need, the PI and co-PI of this project has developed a new factsheet addressing greenhouse growth media sampling, testing, and interpretations. The Soil, Water and Forage Analytical Laboratory (SWFAL) at Oklahoma State University is preparing to offer and expand its service for soilless growth media testing and interpretations. However, due to the lack of research on fertility management in soilless growth media using the media testing procedures of SWFAL, the factsheet only contains fertility recommendations based on results from other media testing laboratories out of Oklahoma. There is a critical need to conduct research using SWFAL testing procedures to evaluate the effects of fertilization in soilless growth media on vegetable and ornamental crop quality and yield, and thus to generate reliable testing result interpretations and fertility recommendations for growers who use SWFAL for routine soilless growth media test. In the absence of such information, the adoption of soilless growth media for enhancing specialty crop production will remain difficult for Oklahoma growers.

The objective of this project is to refine the interpretations of the greenhouse growth media test results and the recommendations for fertilization based on crops specified, as well as to provide educational resources for growers. Eight specialty crops representing the general crops grown in soilless growth media will be included in this project: spinach and lettuce representing leafy vegetables, radish and beet representing root vegetables, tomato and cucumber representing fruiting vegetables, and petunia and geranium representing ornamental crops. Therefore, this project will generate research-based recommendations on fertility management for the general specialty crops grown in soilless growth media. The practical information will be used directly by Oklahoma growers to make informative decisions on nutrient management for optimal crop performance, problem prevention, or diagnosis.

Approaches for each specific objective:

Objective 1: Evaluate vegetable and ornamental crop performance in soilless growth media under different fertility management.

The responses of 8 specialty crops to a range of pH, EC, nitrogen (N), phosphorus (P), and potassium (K) in soilless growth media will be tested in a two-year study. The experiment will be conducted in a hood house located at the botanical garden at OSU in Stillwater, OK, and repeated in the research greenhouse in Stillwater, OK. A randomized complete block design will be used for each crop in each location. Twenty treatments including 4 levels of each of the 5 fertility parameters (pH, EC, N, P, K) will be applied to each crop (Table 1). One plant grown in a pot will be used for each treatment per block with 10 blocks. Therefore, 200 plants grown in 200 separate pots will be included for each crop in the hood house, and the same study using 200 plants for each crop will be repeated in the greenhouse. Four crops will be tested in 2023 and the other four crops will be tested in 2024 (Table 2).

Table 1. Twenty treatments applied to each crop to evaluate the effects of fertilization on crop performance.

Treatment	pH	EC (µS/cm)	N (mg/kg)	P (mg/kg)	K (mg/kg)
1	**5-5.5**	1500	120	10	150
2	**5.5-6**	1500	120	10	150
3	**6-6.5**	1500	120	10	150
4	**6.5-7**	1500	120	10	150
5	6.0	**250-750**	120	10	150
6	6.0	**750-2000**	120	10	150
7	6.0	**2000-3500**	120	10	150
8	6.0	**3500-5000**	120	10	150
9	6.0	1500	**20-40**	10	150
10	6.0	1500	**40-100**	10	150
11	6.0	1500	**100-200**	10	150
12	6.0	1500	**200-300**	10	150
13	6.0	1500	120	**0-3**	150
14	6.0	1500	120	**3-10**	150
15	6.0	1500	120	**10-15**	150
16	6.0	1500	120	**15-25**	150
17	6.0	1500	120	10	**0-60**

18	6.0	1500	120	10	**60-150**
19	6.0	1500	120	10	**150-250**
20	6.0	1500	120	10	**250-350**

The levels of other nutrients in the nutrient solutions are sulfur at 100 mg/kg, calcium at 100 mg/kg, magnesium at 50 mg/kg, boron at 0.5 mg/kg, iron at 15 mg/kg, zinc at 15 mg/kg, copper at 1 mg/kg, and manganese at 15 mg/kg.

Nutrient solutions will be applied to each pot manually once a week. Irrigation will be delivered by one drip emitter per pot and the irrigation scheduling will be adjusted to meet a 20% leachate level by measuring leachate from the containers to meet the water demand of specific crops throughout the experiment period. The temperature and relative humidity conditions will be monitored throughout the study period using a Hobo data logger. Other crop maintenance and data collection are described below for each specified crop.

Leafy Vegetables: Spinach and Lettuce
The seed will be directly sown in the hood house and greenhouse around February 1 in 4" plastic pots with two seeds per pot and then thinned to one plant per pot after emergence. To evaluate the crop performance under different treatments, plant height, canopy cover, SPAD measurement of chlorophyll content, and a visual rating of the plant health (e.g. discoloration in leaves) will be measured weekly after emergence. Six weeks after seeding, leaves will be harvested at the soil line and the fresh weight and dry weight of the aboveground produce will be measured.

Root Vegetables: Radish and Beet
The seed will be directly sown in the hood house and greenhouse around March 15 in 4" plastic pots with two seeds per pot and then thinned to one plant per pot after emergence. To evaluate the crop performance under different treatments, plant height, canopy cover, SPAD measurement of chlorophyll content, and a visual rating of the plant health (e.g. discoloration in leaves) will be measured weekly after emergence. Four weeks after seeding, shoots aboveground and roots underground will be harvested. Roots will be graded and the primary defect will be recorded if applicable. The fresh weight and dry weight of the aboveground shoots and the underground roots will be measured.

Fruiting Vegetables: Tomato and Cucumber
Tomato seed will be sown in 6-packs around March 15 in year 1 and placed in the research greenhouse with standard fertigation for transplant propagation. Around April 15, healthy and uniform tomato transplants will be selected, hardened, and transplanted into 10-gallon plastic pots in the hood house and greenhouse, with one plant per pot. Cucumber seed will be directly sown in 10-gallon plastic pots in the hood house and greenhouse around April 15 in year 2. Tomato cages will be installed in each pot for trellising. Fertility treatments will be implemented in each pot after transplanting for tomato and after emergence for cucumber. Pruning will be performed along the growing season using the standard practices. To evaluate the crop performance under different treatments, plant height, canopy cover, SPAD measurement of chlorophyll content, and a visual rating of the plant health (e.g. discoloration in leaves) will be measured weekly after transplanting or emergence. Fruit will be harvested twice a week, and the number and weight of marketable and non-marketable fruit will be recorded. The primary fruit defect will be documented. After the final fruit harvest, the aboveground shoot will be cut off the soil line to measure its fresh and dry weight.

Ornamentals: Petunia and Geranium
Petunia and geranium seed will be sown in 6-packs around August 1 and placed in the research greenhouse with standard fertigation for transplant propagation. Around September 1, healthy and uniform petunia transplants will be selected, hardened, and transplanted into 6" plastic pots in the hood house and greenhouse, with one plant per pot. Fertility treatments will be implemented in each pot after transplanting. Plant performance will be assessed by measuring both vegetative growth and flowering parameters. Plant height, two perpendicular widths, and SPAD measurement of chlorophyll content will be measured 2, 4, 6 weeks after transplanting. A visual rating of plant architecture (pot coverage), a visual rating of the color quality (leaf chlorosis), the number of flowers and buds, bud dry weight, flower dry weight, and shoot dry weight will be measured 6 weeks after transplanting.

Objective 2: Create educational resources to facilitate the adoption of soilless growth media for enhancing specialty crop production

Research results will be delivered to growers, Extension educators, and other stakeholders through presentations at the Horticulture Industries Show in both 2023 and 2024, with proceedings from the conference available to a wide audience. After completing the two-year experiment, conclusions will be drawn to develop guidelines for fertility management for leafy, root, and fruiting vegetables and ornamentals in soilless growth media. A workshop will be organized by the end of the project to provide training to stakeholders, demonstrate crop performance under different fertility management, and improve their understanding and skills for fertility management for specialty crop production in soilless growth media. Two manuscripts will be submitted for publication in peer-reviewed journals. The Extension factsheet developed by the PI and co-PI on soilless growth media sampling, testing, and interpretations will be updated with refined test result interpretations and fertility management recommendations.

Table 2. Timeline of the proposed project activities.

2023	Jan	Order supplies; set up production systems
	Feb-Mar	Spinach study
	Mar-Apr	Radish study
	Mar-Aug	Tomato study
	Aug-Oct	Petunia study
	Oct-Jan	1st-year data summary; HIS meeting
2024	Feb-Mar	Lettuce study
	Mar-Apr	Beet study
	Mar-Aug	Cucumber study
	Aug-Oct	Geranium study
	Oct-Dec	Workshop; Factsheet update and manuscript publication; HIS meeting

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Evaluate vegetable and ornamental crop performance in soilless growth media under different fertility management

Objective 2: Create educational resources to facilitate the adoption of soilless growth media for enhancing specialty crop production

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 200

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☑ **No** ☐

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

Commercial producers and home gardeners who grow specialty crops in soilless growth media are the stakeholders of this project. Even though no exact number of such growers are reported, we estimate the number is huge and will continue to rise, based on the increasing requests for information on how to use soilless growth media received at the Oklahoma Cooperative Extension Service and the predicted double demand of soilless growth media. Murray State College has expressed their interest in supporting this project by collaborating with the PI to incorporate the research and Extension activities of this project with their FFA programs and undergraduate training. Besides, we have communicated with county Extension educators and they indicated that the information generated from this project is very much needed and will be very beneficial for supporting growers and improving specialty crop production. The major commercial producers using soilless growth media for specialty crop production in Oklahoma have indicated that they are very interested in this project and will benefit from the information developed from this project.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☑ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 6, Indicator 6.2c
Yielded findings that allow for implementation of new practice, process, or technology 1.

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

The findings on crop performance under different fertility management will improve the implementation of soilless growth media for specialty crop production. Data on crop performance will be collected during the two-year study including the vegetative plant growth, crop quality, and yield.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$44,733.00
Fringe Benefits	$4,816.00
Travel	$1,432.00
Equipment	$0.00
Supplies	$25,260.00
Contractual	$0.00
Other	$6,329.00

Expense Category	Funds Requested
Direct Costs Sub-Total	$82,570.00
Indirect Costs	$0.00
Total Budget	$82,570.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Graduate student, to be named	20 h/week	$29,280.00
2	Undergraduate hourly worker	800 h	$8,400.00
3	Dr. Bizhen Hu	3 h/week	$7,053.00

Personnel Subtotal: $44,733.00

PERSONNEL JUSTIFICATION

Personnel 1: A graduate research assistant will be recruited to conduct this project under the direction of the PI Dr. Hu. This student will participate in the experimental design, implementation, data collection, and publication. Funding is requested for year 1 and year 2 of this project.

Personnel 2: An undergraduate hourly worker will assist with crop maintenance and data collection.

Personnel 3: Dr. Hu, PI of this project will oversee the whole project. She will order supplies, direct the graduate student's research, oversee experimental design, implementation, data collection and analysis, supervise day-to-day activities of the graduate student and undergraduate student included as personnel request in this project, develop Extension programs and outreach publications to distribute the knowledge generated from this project. A one-month summer salary is requested. Dr. Hu's research and Extension conducted on this project during the academic year will be supported by OSU from this allocation of effort and will average 3 hours per week for the two years.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Graduate Research Assistant	7.15%	$2,094.00
2	Undergraduate hourly worker	3.46%	$290.00
3	Dr. Bizhen Hu	34.48%	$2,432.00

Fringe Subtotal: $4,816.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Horticulture Industries Show, Fayetteville, AR	Car rental, hotel, perdiem	364 miles round trip, 1 night, perdiem	3	$150 car rental, $95 motel ($285 total), $51 per diem ($306 total)	3	$741.00
2	Horticulture Industries Show, Tulsa, OK	Car rental, hotel, perdiem	140 miles round trip, 1 night, perdiem	3	$100 car rental, $95 motel ($285 total), $51 per diem ($306 total)	3	$691.00

Travel Subtotal: $1,432.00

TRAVEL JUSTIFICATION

Trip 1 (Approximate Date of Travel 01/2024): Funds are requested for two of the investigators and the graduate student to participate in the annual Horticulture Industries Show in 2024 to share the first year's research results and provide fertility management recommendations for vegetable and ornamental crop (spinach, radish, tomato, and petunia) production in soilless growth media. This information will be available to attendees and to all producers as a proceedings paper published after the conference.

Trip 2 (Approximate Date of Travel 01/2025): Funds are requested for two of the investigators and the graduate student to participate in the annual Horticulture Industries Show in 2025 to share two years' research results and provide updated factsheet information on greenhouse growth media sampling, testing, and interpretations using the OSU Soil, Water and Forage Analytical Laboratory.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Drip irrigation supplies	$250	14	2023	$3,500.00
Irrigation timer	$60	4	2023	$240.00
Mulch for weed control	$150	2	2023	$300.00
6-pack seed trays	$0.50	400	2023	$200.00
4" plastic pots	$0.1	1,600	2023	$160.00
6" plastic pots	$0.15	800	2023	$120.00
10-gallon plastic pots	$7	400	2023	$2,800.00
Spinach seed	$5	4	2023	$20.00
Radish seed	$10	4	2023	$40.00
Tomato seed	$35	4	2023	$140.00
Petunia seed	$5	4	2023	$20.00
Lettuce seed	$5	4	2024	$20.00
Beet seed	$10	4	2024	$40.00
Cucumber seed	$35	4	2024	$140.00
Geranium seed	$30	4	2024	$120.00
Soilless growth media	$30	200	2023 and 2024	$6,000.00
Fertilizers	$200	40	2023 and 2024	$6,000.00
Pesticides	$200	8	2023 and 2024	$1,600.00
Tomato cages	$6	400	2023	$2,400.00
Paper bags for sampling	$30	30	2023	$900.00
Digital scale	$250	1	2023	$250.00
PPE (gloves, suit, etc.)	$25	10	2023	$250.00

Supplies Subtotal: $25,260.00

SUPPLIES JUSTIFICATION

Drip irrigation supplies and timers will be used to provide automatic irrigation for the crops throughout the study period. Mulch will be used to cover the ground in the hood house for weed control. 6-packs seed trays will be used to grow tomato, petunia, and geranium transplants. 4" plastic pots will be used to grow spinach, lettuce, radish, and beet, 6" plastic pots will be used to grow petunia and geranium, 10-gallon plastic pots will be used to grow tomato and cucumber. About 2,000 Seeds of each of the 8 crops are requested to grow the plant materials for research. Soilless growth media will be used for transplant propagation and crop production for the study. Fertilizers, pesticides, and tomato cages will be used to maintain crop health. Paper bags will be used for collecting the plant tissue samples. A digital scale will be used to measure the fresh and dry weight of plant tissues. PPE will be used when handling chemicals such as fertilizers and pesticides.

CONTRACTUAL/CONSULTANT

N/A

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Soilless growth media test	$25	40	2023 and 2024	$1,000.00
Publication page charges	$2,000	1	2024	$2,000.00
Workshop supplies	$1,129	1	2024	$1,129.00
Greenhouse rental	$100	18	2023 and 2024	$1,800.00
Data logger data plan	$200	2	2023 and 2024	$400.00

Other Subtotal: $6,329.00

OTHER JUSTIFICATION

Soilless growth media testing will be performed before and during the experiment to adjust fertility management and achieve the target treatment levels.

Publication charges are requested for publishing research results in refereed journals (HortScience) to ensure wide distribution. The flat fee to publish in HortScience will be $2000.

Workshop expenses are requested in the second year to cover the meeting room rental fee of $355 for the day of workshop. Due to the location of the meeting and an effort to maintain the continuity of the workshop a working lunch will be provided. $674 is being requested to cover the cost of a boxed lunch for the participants (50 lunches will be purchased x $13.48 each lunch = $674). Printing fees are for a 8

page colored factsheet ($1 per copy with 50 copies = $50) and presentation handouts ($1 per copy with 50 copies = $50).

Greenhouse rental expenses are requested for both years ($100/month × 9 months/year × 2 years). This project will utilize greenhouse space for crop propagation and production around February to October each year.

Data logger data plan costs are requested for both years to record the temperature and relative humidity conditions in the hood house and greenhouse during the study period.

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 5: Oklahoma Gardening QR Code Signage

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

Oklahoma State University Department of Horticulture and Landscape Architecture has a premier television show, Oklahoma Gardening. For the past several decades, Oklahoma Gardening has provided research-based horticulture information to Oklahomans. This grant will enable OSU Extension to further its horticulture education outreach by providing information directly to the public who visit botanic gardens and demonstration gardens around the state. The public is seeking alternative methods to receive their information rather than just television, and at the same time, looking for a more immersive experience. This grant will provide QR code signage for public gardens to present seasonally relevant plant information to visitors as they are viewing the plants. Many public gardens are open at no charge. This makes it difficult to know how many visitors may be frequenting the garden. These signs will track the number of scans and time of day visitors access the QR code information at each participating garden. The QR codes will take visitors directly to Oklahoma Gardening video segments that are related to the identified plants. Eleven public gardens across the state, in both rural and urban locations, are interested in partnering to develop this signage. The signs will be developed and distributed to the partner gardens seasonally. The signs will change seasonally (quarterly) and the most asked about plants will be selected during their peak season to provide visitors with the most relevant information.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Each year, thousands of people visit public gardens and see a large number of plants. If there isn't proper signage, the average person is unable to identify the plant. This project would provide signage to 11 public gardens throughout Oklahoma. A large variety of gardens will be participating, including public gardens and educational demonstration gardens across the state in rural and urban settings. These signs would link visitors directly, via QR codes, to an Extension fact sheets or a horticulture, educational video featured on *Oklahoma Gardening*. Most people are familiar with this technology due to QR codes recently becoming adopted worldwide. As people walk through the participating public gardens, they can simply scan the code with their smartphone and have instant access to an informative video about the selected plant at their fingertips. The project would create a virtual, educational experience for visitors of these gardens.

It is important to provide more information to those who are seeking it without distracting from the garden with a lot of signage and text. In this era of technology, QR codes and videos will provide the opportunity for those seeking the information in a unique way. Because the selected plants will be evaluated seasonally, plants no longer in-season or grabbing the attention of the visitors will have their signs removed and the dynamic QR code will be linked to a new URL to provide data for a different plant in its peak season.

Many of the selected gardens provide free entrance to the public, offering horticulture to anyone. However, this can reduce their overall budget and limit their ability to provide signage and plant information. One objective of this project is to help these public gardens increase their signage in an informative way. QR code signs would not only provide gardens with additional seasonally appropriate signage but would offer visitors research-based information about growing the identified plant in Oklahoma. Oklahoma Proven is a long-standing program that identifies four plants each year that have proven to do well in the Oklahoma climate. Several individual *Oklahoma Gardening* videos have been developed to feature these plants over the years. This is just an example of the various plant highlight videos that can be linked directly to the plants as they are being viewed by visitors in these public gardens. Often, people visit public gardens to obtain ideas for their own gardens. These signs will allow people to identify plants, learn about the plant from a reliable source, and save the video link to refer to later.

Furthermore, while an open access garden allows the public to enjoy horticulture, it can be difficult to quantify the visitation. Each garden will have 5-15 signs depending on the garden size, the availability of in-season plants, and the availability of video content. While it will be difficult to evaluate the usage, by utilizing dynamic QR codes the quantity and time of scans will be captured. This will allow us to see the usage of the signs statewide and provide participating gardens with information on how visitors interact with this new type of signage.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Expand OSU Extension outreach by providing horticulture information to the public in various garden venues around the state.

Objective 2: Assist gardens with interpretation that they might not otherwise be able to provide to visitors.

Objective 3: Collect visitor information regarding number of scans and time of day at each garden. This information will be provided to the gardens to improve their understanding of visitation and visitor interaction.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 11 public/demonstration gardens and 5000 visitors

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☐ **No** ☑

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☐ **No** ☑

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

Eleven public gardens support the effort of this grant. With a combined annual visitation total of over 400,000 people, these signs will further carry out their horticulture education mission by providing valuable interpretation about their plants to numerous visitors.

The Oklahoma Nursery and Landscape Association (ONLA) supports this grant as it will promote plants that are proven to do well in Oklahoma. Educating consumers about these plants will then improve plants sales for their nurseries and garden centers members.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☑ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☐ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 1, Indicator 1.1a

Total number of consumers who gained knowledge about specialty crops, Adults 5,000.

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

Data will be collected by using a dynamic QR code. Each garden will have their own signage with specialized codes for each plant. Every time a code is scanned, the data can be tracked. The measurable data will be the time of day and quantity of scans. This will allow the gardens to know what time of day is the busiest at the garden as well as the most popular plants. By knowing the most visited times, gardens can cater to the needs of the visitors. These signs will be placed on in-season horticulture around the garden and allow for an ease of identification as well as informative, research-based information. While there are a lot of variabilities, size of garden, location of garden, placement of signs, etc., we are anticipating at least 5000 scans from people wanting to access the plant information over the two-year grant period.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$12,281.00
Fringe Benefits	$4,836.00
Travel	$2,980.00

Expense Category	Funds Requested
Equipment	$0.00
Supplies	$1,739.00
Contractual	$1,176.00
Other	$0.00
Direct Costs Sub-Total	$23,012.00
Indirect Costs	$0.00
Total Budget	$23,012.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Bailey Lockhart	0.20%	$12,281.00

Personnel Subtotal: $12,281.00

PERSONNEL JUSTIFICATION

Personnel 1: Bailey Lockhart will be the project coordinator to manage garden relationships. She will be responsible for developing and ordering signs, developing QR codes, and identifying available OKG videos and other OSU resources that would be pertinent to gardens. Lockhart will correspond with partner gardens to identify the plants that are best suited for the gardens based on available content information. She will work with partners quarterly to identify best plants to showcase as they change through the seasons. Lockhart will manage the dynamic QR code system to update QR codes to ensure they are working properly and manage QR analytics regarding number of scans and time of day and provide this information to partner gardens.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Bailey Lockhart		$4,836.00

Fringe Subtotal: $4,836.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Tulsa gardens	OSU motor pool	Day visits	8	69.5	1	$556.00
2	Oklahoma City gardens	OSU motor pool	Day visits	8	67.2	1	$537.60
3	Surrounding OKC area gardens	OSU motor pool	Day visits	8	89.74	1	$717.92
4	Rogers Co.	OSU motor pool	Day visits	8	80.08	1	$640.64
5	Garfield Co.	OSU motor pool	Day visits	8	66.05	1	$528.40

Travel Subtotal: $2,980.00

TRAVEL JUSTIFICATION

The 11 partnering gardens have been grouped based off their geographical proximity to be most efficient with time and budget when visiting seasonally. Each trip was budgeted based on OSU motorpool's $35.00 daily rental rate plus $0.23 charge per mile.

Trip 1: Tulsa gardens will include visiting Tulsa Garden Center at Woodward Park and Tulsa County Master Gardener's Demonstration Garden. These eight (quarterly) visits will occur March, June, September, December of 2023 & 2024.

Trip 2: Oklahoma City gardens will include visiting Scissortail Park and Oklahoma County Master Gardener's Demonstration Garden. These eight (quarterly) visits will occur March, June, September, December of 2023 & 2024.

Trip 3: Surrounding Oklahoma City area gardens will include visiting Pottawatomie, Cleveland, and Canadian County Master Gardener's Demonstration Gardens. These eight (quarterly) visits will occur March, June, September, December of 2023 & 2024.

Trip 4: These eight trips will be quarterly for two years (March, June, September, December of 2023 & 2024) to the Rogers County Master Gardener's Demonstration Garden.

Trip 5: These eight trips will be quarterly for two years (March, June, September, December of 2023 & 2024) to the Garfield County Master Gardener's Demonstration Garden.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
metal signs (5x7")	6.2	165	Jan. 2023	$1,023.00
3M tape	10	5	Jan. 2023	$50.00
9" stakes for signs	3	55	Jan. 2023	$165.00
15" stakes for signs	4.1	55	Jan. 2023	$225.50
20" stakes for signs	5	55	Jan. 2023	$275.00

Supplies Subtotal: $1,739.00

SUPPLIES JUSTIFICATION

The all-weather black metal signs will be engraved with information and provide the QR code to the garden visitor. The signs will be mounted onto stakes of varying heights that are appropriate for the plant that will be featured. Shrubs will need taller stakes, so the sign is not lost underneath their growth. Smaller stakes will be used for raised beds or containers that may feature small plants such as bedding annuals. There are 15 signs budgeted for each of the 11 participating gardens. The number of signs displayed at any one garden may vary depending on the size of the garden and the availability of plants and corresponding content during each season.

CONTRACTUAL/CONSULTANT

ITEMIZED CONTRACTOR(S)/CONSULTANT(S)

#	Name/Organization	Hourly Rate/Flat Rate	Funds Requested
1	Beaconstac	$49/month	$1,176.00

Contractual/Consultant Subtotal: $1,176.00

CONTRACTUAL JUSTIFICATION

Contractor/Consultant 1: Beaconstac is a QR code platform. While there are free QR code generators, for the purposes of this grant we will need to utilize dynamic QR codes, that will enable us to change the URL associated with various QR codes. The free QR codes cannot change once it is associated with a URL. This platform will also provide the evaluation of how many scans and the time of day visitors utilized the QR codes.

CONFORMING WITH YOUR PROCUREMENT STANDARDS

By checking the box to the right, I confirm that my organization followed the same policies and procedures used for procurements from non-federal sources, which reflect applicable State and local laws and regulations and conform to the Federal laws and standards identified in 2 CFR Part 200.317 through.326, as applicable. If the contractor(s)/consultant(s) are not already selected, my organization will follow the same requirements. ☑

OTHER

N/A

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 6: Investigating Novelty Trees for Their Edible and/or Ornamental Potential for the Oklahoma Green Industry

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

A great deal of anecdotal evidence exists regarding the feasibility of Pomegranate (P. *granatum*), Citrumelo (X *Citronirus* spp.), Citrange (*Citrus sinensis x Poncirus trifoliata*), Citrangequat (X *Citrofortunella spp.*), Loquat (*Eriobotrya japonica*), and Satsuma (*Citrus unshiu*). Researchers at Oklahoma State University will conduct a study to determine if plants considered marginally cold hardy will be at least ornamental or ideally be able to set fruit for fresh consumption and/or for other culinary uses. Deliverables and expected research-based outcomes include but are not necessarily limited to 1) recommendations to Oklahoma specialty nurseries, regarding plants that met OSU trial standards, for

varieties for Oklahoma and surrounding green industry professionals to expand their specialty fruit tree inventory, 2) suggested varieties that could be marketed and sold as edible ornamentals also for Oklahoma and surrounding regions including Texas and states southeast of Oklahoma. Because species/hybrids being tested do not demand extraordinary maintenance, it is plausible that these crops could be considered by early career farmers. General tasks to be completed during the two-year project include tree establishment, routine cultural management tasks including weed and pest control, irrigation and visual ratings for tree vigor and overall winter hardiness and the monitoring and assessment of fruit set.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Pomegranate, assorted citrus and loquat in this study have all been reported to be cold hardy in Oklahoma but from anecdotal sources. Furthermore, all crops proposed for this study are reportedly self-fertile or in the case of certain loquat cultivars, at least somewhat self-fertile. Because three cultivars of each plant will be replicated six times, there will be ample opportunity for cross pollination to encourage even larger and more abundant fruit set. This project will help address the possibility of the six plants* below thriving in Oklahoma. In summary, this study would confirm or disprove anecdotal references regarding vegetative hardiness potentially making these pants suitable as an ornamental tree in Oklahoma but also shed light regarding successful flower set and subsequent fruit set and maturation.

Pomegranate (*Punica granatum*). Both dwarf and standard sized pomegranate, ranging in growth habits from tree, or nearly tree-like, are already found occasionally for sale at Oklahoma garden centers and nurseries. Already enjoyed in Oklahoma for its showy orange flowers and glossy foliage, it may also reliably set fruit when afforded proper cultural practices and when appropriate cultivars are chosen. Pomegranate is reported by mail order nurseries to tolerate at least 5 F and sometimes touted for tolerating at least short-term cold snaps down to Zone 6 with protection. Researchers have read of many anecdotal reports of their fruiting within the State of Oklahoma. A dwarf selection already readily flowers and sets fruit annually throughout much of Oklahoma. It is believed that most varieties will be vegetatively hardy (wood) in Oklahoma with the hope that most would set fruit on a seasonal basis. Researchers will seek out three cultivars for this study with their preference being 'Punica Russian 26', 'A.C. Sweet Pomegranate', and 'Salavatski'. Fruits range from brownish-yellow to red and may mature at 4" in diameter or larger (will be smaller than California varieties). Other cultivars exist and could serve as alternative selections should insufficient inventory occur in Spring 2023. Mature tree height will vary from 8-12' high. No significant pests or diseases are anticipated based on experience from dwarf plants already in state. Indigenous to Iran and surrounding countries, this species can tolerate a wide variety of soils but prefer good drainage. Growers with clay soils should plant them above grade to facilitate adequate drainage and aeration.

Loquat (*Eriobotrya japonica*). They indeed can vegetatively overwinter in our state but have yet to be trialed for their full potential as both an ornamental but ideally an edible ornamental tree ultimately reaching 18-20' high. Loquat reports from industry leaders tout vegetative cold hardiness down to 0F but fall short of guaranteeing fruit set in the coldest area of this study which is USDA Hardiness Zone 7a(0-5F). Their attractive evergreen foliage makes them "pop" in the landscape and thus their merit

assuming trialed cultivars remain aesthetically pleasing (little dieback) throughout the study and beyond. Loquat has been shown to tolerate a variety of soils but ideally prefers well drained locations that have a slightly acidic soil pH. Schnelle has seen small plants however tolerate clay soils and not chlorotic in pH values well above 7.0. Native to southeastern and central China, they are grown throughout the world especially in Asia, North Africa, Australia, New Zealand, and North, Central and South America. The species is commercially grown in various subtropical and Mediterranean areas of the world with growing commercial acreage in California. Loquat has great potential in the Oklahoma nursery industry. The challenge will be to find cultivars and cultural practices to allow flowers to escape injury from winter/spring frosts since they can be sensitive to temperatures below 27F. The pear-shaped fruits may range from 1-2" long with yellow to orange to red-blushed skin. Commercially available cultivars preferred by OSU researchers are 'Advance', 'Big Jim', and 'Vista White'. No appreciable pests or diseases have been noted or anticipated in Oklahoma.

Satsuma (*Citrus unshiu*) is a mandarin and first introduced to the U.S. via the Satsuma region of Japan in the late 19th century. Growers in Texas found Satsuma at least 9 F hardy. It likely is a hybrid and was developed from genetics both from China and Japan (*Citrus kinokuni*) and (*Citrus nobilis var. kunip)*, respectively. This plant stays relatively small and thus matures only to 8-12' tall. This small stature makes it ideal for the ornamentals industry that still has demand for small accent ornamental trees but also for a candidate as an edible ornamental for homeowners with limited sized yards. Schnelle and Zhang have chosen 'Arctic Frost', 'Orange Frost' and 'Owari' selections. Like virtually all citrus, satsuma has pleasingly fragrant white flowers in April yielding showy orange fruit less than 2" in diameter by late September to the end of October. Fruit is described in the literature as juicy, sweet and "melting" and nearly seedless with a rind easy to peel. Aphid and scale infestations on occasion can be expected according to popular press literature. Satsuma can grow in a number of soil types.

Citrumelo (X *Citroncirus* spp.) is a cross between 'Duncan' grapefruit (*Citrus paradisi*) and trifoliate orange (*Poncirus trifoliata*). Often referred to as hardy grapefruit, the plant stays relatively small maturing to only 6-8' tall in most cases. Citrumelo is cold hardy down to 5 F with the cultivar 'Dunstan' even lower to 0 F for short periods of time. This is a showy species with evergreen foliage (likely will be semi-evergreen or even deciduous under Oklahoma conditions). Citrumelo's fruits have been likened to a cross between lemon and grapefruit ultimately yielding smooth skinned fruits, white semi-sweet flesh, that expand to about 4" across. Many cultivars are grafted on *Poncirus trifoliata* 'Flying Dragon' keeping them small statured and very precocious with fruit often forming the first growing season. Fruit is known to ripen late in the season, early November, so cultivar evaluations will hopefully find types that flower even earlier under Oklahoma conditions or accept them as an edible ornamental that may not have successful yields every year. No serious pests are reported in the literature short of slugs on occasion which are already encountered in Oklahoma with a number of effective control measures available. Cultivars of choice are 'Five Star', 'Dunstan', and 'Swingle'. McKenzie Farms reports that trees have been known to bear fruit as far north as Tennessee. Trees are known to grow in both sandy and heavy soils (clay) but ideally prefer good drainage. Again, producers should grow them above grade when areas are slow to drain. Slugs, mites and aphids may attack trees on occasion but can be scouted for and treated accordingly.

Citrange (*Citrus* sinensis x *Poncirus* trifoliata). This plant was hybridized between sweet orange and trifoliate orange. Trees mature at 8-12' tall with evergreen foliage and somewhat thorny stems (genetics from trifoliate/hardy orange parent). Numerous citations refer to this hybrid as an attractive ornamental.

The 3-5” fruits have few seeds and have a more acid flavor and heightened aroma than sweet orange. Some nurseries tout immature fruit serving as an excellent lime substitute while other reports vary from very ripe fruit being palatable for fresh consumption (tasting like a kumquat/orange flavor) to many suggesting the fruit with orange yellow flesh be used to flavor beverages or for other culinary purposes (pies, marmalades and jellies) given its acidic/bitter taste. Others report that when used with sweetener, it makes a very desirable breakfast fruit. Cultivars ‘Rusk’, ‘Troyer’ and ‘Carrizo’ will be utilized in this study. This hybrid is well documented to grow vigorously as well as being disease and pest free. It should tolerate Oklahoma soils with an ideal pH slightly below 7.0 (acidic). However, it can tolerate slightly alkaline soils when pH cannot be lowered or proven to be cost prohibitive.

Citrangequat (X *Fortucitrocirus* spp.). This 15’ tree according to some references imply that this citrus cross is even cold hardier than citrange since adding the cold hardiness of trifoliate orange and kumquat. Citrangequat is referred to as hardy to -3 F (zone 6a reported by Woodlanders Nursery which is even colder than our proposed study). Fragrant flowers are followed by yellow orange to red orange fruits about 1-2” in diameter with orange to red flesh ranging from tasty to quite sour. Fruits often resemble kumquats and are somewhat pear-shaped ripening in late October or early November. Trees have showy evergreen foliage often with glossy trifoliate leaves. Cultivars planned for this study include ‘Telfair’, ‘Thomasville’ and ‘Sinton’. Trees prefer slightly acidic soils and will grow in a number of soil types.

The project itself will be conducted outside Perkins, Oklahoma at The Cimarron Valley Research Station, Oklahoma State University. Trees will be planted Spring 2023 (between April 1-April 30 – depending upon availability) on 10 x 10’ spacings utilizing a randomized complete block design. Trees will grow in full sun which is ideal for all species and hybrids being trialed. Six replicates will be utilized to represent each type of plant within the trial. Three cultivars will be selected for each plant bringing the total number of specimens in the study to 108 (six plants x six replicates x three cultivars). All plant materials will be afforded drip irrigation throughout the initial study which terminates Spring 2025. All six types of trees require good drainage and slightly moist soils. Pomegranate is actually tolerant of drought upon establishment.

Researchers will allow trees to establish the first growing season, 2023, but the graduate student will begin data collection, including recording the following information: 1. Cold hardiness in winter and spring; 2. Dates of trees with 20%, 60%, and 100% bud break and bloom in spring; 3. Tree height and trunk diameter at the end of summer; 4. Current year shoot growth numbers and length at the end of summer; 5. Any pest challenges or unforeseen environmental (abiotic) problems during this experiment will be “treated”; researchers have access to plant pathologists and entomologists for any unusual pest that might appear.

We will evaluate cold hardiness using three strategies for trees at different ages. For 2-3 year old trees, trees will be protected using tree wraps and be closely monitored, and hourly temperature data will be downloaded from Oklahoma Mesonet during their first and dormant seasons expected in November 2023 – March 2024; November 2024 – March 2025. Upon spring, percent dieback, if any, will be calculated, measuring affected stem length/total stem length x 100. For citrus trees, percent defoliation will be calculated using (#remaining leaves/total node numbers) x 100. For trees starting to bloom (planted for at least two years), three flowers will be selected randomly from each direction (south, north, east and west) for each tree to check flower health where brown or dark color in pistils indicates

that the flowers are dead. In the second growing season, shoots will be sampled for a cold hardiness test in the lab. Three one-year-old shoots per cultivar and replication at the length of 30 cm will be sampled in November, January, and February, separately. Shoots will be cut into 1-cm long segments and treated by a range of freezing temperatures from -10 F to 20 F. Electrolyte leakage will be measured using a Crison 524 conductivity meter. The lethal freezing temperature of different cultivars and species will be established accordingly.

In addition to all trees having tree wraps on their trunks from October – March of each year, frost cloth may be used on trees going into cold weather late 2023 into early 2025 if conditions warrant. Researchers will employ such protective measures if a forecast predicts temperatures dropping below 0F for over 12-24 hours. Many anecdotal references suggest that cold hardiness increases upon tree establishment and thus researchers are poised to intervene with tree wraps and possibly frost cloth if necessary, years one and two.

All data acquisition will occur every two weeks or more intensively, when necessary, such as times of flowering, fruit development, etc. Graduate student will prune accordingly which could range from no dieback to selecting a new leader in extreme cases. Growth performance data will be collected to determine any negative performance consequences based on weather events or the contrary that plants indeed responded well in respect to low temperatures. In other words, researchers will determine if chosen cultivars and/or species are appropriate as ornamentals and/or edible ornamentals based on Oklahoma's climate.

Positive results (species and cultivars that excelled in our experiment) will be shared through workshops, field days and any invitations to lecture at various Oklahoma Green Industry events.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Implement a randomized complete block design study that has six different types of underutilized trees for Oklahoma.

Objective 2: Determine if specialty trees selected exhibit ornamental traits under Oklahoma field conditions.

Objective 3: Determine if specialty trees grown will set fruit under Oklahoma field conditions.

Objective 4: Determine industry "buy in" via 2023 and 2024 field days and conference presentations.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 50 Commercial Growers

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? Yes ☐ No ☑

Does this project directly benefit beginning farmers as defined in the RFA? Yes ☑ No ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? Yes ☐ No ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

Oklahoma Nursery and Landscape Association (ONLA), current membership of at least 107, supports the efforts of this project since they are comprised of ornamental growers and retailers interested in tree crops for their ornamental and/or edible ornamental value.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☑ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 6: Indicator 6.1
Number of research goals accomplished: two (2).

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

At least two workshops/field days and two presentations for ONLA and HIS will be presented to highlight anticipated research goals: (1) crop(s) with ornamental promise; (2) crop(s) with edible ornamental value.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$33,600.00
Fringe Benefits	$2,914.00
Travel	$1,488.00
Equipment	$0.00
Supplies	$13,418.00
Contractual	$0.00
Other	$3,730.00
Direct Costs Sub-Total	$55,150.00
Indirect Costs	$0.00
Total Budget	$55,150.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Graduate student	20 h/week	$33,600.00

Personnel Subtotal: $33,600.00

PERSONNEL JUSTIFICATION

Personnel 1: We will seek one graduate student interested in a two-year master's degree program focusing on this proposed project. The request for graduate student support of each year is for 12 months' salary ($16,800) and fringe benefits ($1,457). This student will be a critical participant in this project, mainly assisting with planting, data collection and orchard management.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Graduate student	8.67%	$2,914.00

Fringe Subtotal: $2,914.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Perkins	Mileage	20.5 miles	124 trips	$.585	3	$1,488.00

Travel Subtotal: $1,488.00

TRAVEL JUSTIFICATION

Trip 1: The budget of $744 per year is for Dr. Mike Schnelle, Dr. Lu Zhang, and the graduate student weekly visits to the experimental orchard to collect data, apply fertilizers, herbicides, fungicides, pesticides and manage irrigation. The work involves multiple roundtrips of 20.5 miles each at the rate of $0.585/mile.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Trees	$45	108	March-2023	$4,860.00
2-in x 2-in x 3/4-in dia Tee PVC Fitting	$6.98	25	Spring 2023	$174.50

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
3/4 in. Solvent x 3/4 in. Solvent x 3/4 in. SOLVENT Schedule 40 PVC Tee	$0.98	110	Spring 2023	$107.80
Pipe 3/4-in x 10-ft 480 Psi Schedule 40 White PVC Pipe	$5.96	110	Spring 2023	$655.60
PVC Pipe 2-in dia x 10-ft L Plain End Schedule 40 Pipe	$19.98	25	Spring 2023	$499.50
4-in x 2-in dia x Hub Schedule 40 Sanitary Tee	$21.64	2	Spring 2023	$43.28
3/4-in x 2-ft 480 Psi Schedule 40 White PVC Pipe	$4.45	110	Spring 2023	$489.50
3/4" Senninger 40 Series Impact Sprinkler 23° - #10-14	$12.85	110	Spring 2023	$1413.50
3/4-in x 3/4-in x 1-1/2-in dia Coupling PVC Fitting	$0.98	110	Spring 2023	$107.80
Handy Pack 8-fl oz Purple and Clear PVC Cement and Primer	$10.68	5	Spring 2023	$53.40
2 In PVC Cutter	$26.58	1	Spring 2023	$26.58
Multipurpose Pipe Cutter	$10.98	1	Spring 2023	$10.98
PVC Sch 40 3/4-in Socket PVC x 3/4-in Socket PVC Ball Valve	$3.98	110	Spring 2023	$437.80
Smart Hose Faucet Timer with Wi-Fi Hub	$79.98	12	Spring 2023	$959.76
Electric Fencing w/Solar Charge	$500	1	March-2023	$500.00
Fertilizer	$100	2	March 2023, 2024	$200.00
Herbicide	$100	2	March 2023, 2024	$200.00
Tree wrap	$2.00	216	March 2023, 2024	$432.00
Mulch	$90.00	5 cubic tons	March-2023	$450.00
Office supplies	$676 (See below)	Y1: $341 Y2: $335	March 2023, 2024	$676.00
Field sampling supplies	$250	2	March 2023, 2024	$500.00
Other orchard supplies	$235 (See below)	2 Years	March 2023, 2024	$470.00

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Backpack sprayer	$150	1	Spring 2023	$150.00

Supplies Subtotal: $13,418.00

SUPPLIES JUSTIFICATION

To establish the orchard, we request $4,860 to purchase trees from the nursery, $4,980 to install irrigation system, and $450 to buy mulch. Electrified fencing, $500.00 total, will help to deter/mitigate hog and deer damage.

Orchard management costs include fertilizer ($200), herbicide ($200), tree wrap ($432) and mulch ($450). We request $235 in each year to purchase orchard supplies such as pruning shears and gloves. The field sampling supplies, $250 each year, are to buy sampling bags, labels, and rulers to assess tree growth and cold hardiness. Funding is also requested in each year for office supplies is to purchase printer paper, pens, and other supplies for data collection (CAS Exception). We request $150 in first year to purchase a backpack sprayer for pesticide applications.

CONTRACTUAL/CONSULTANT

N/A

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Publication costs	$2,000	1	10/1/2024	$2,000.00
Workshop/Conference Costs	$865	2	Y1/Y2, TBD	$1,730.00

Other Subtotal: $3,730.00

OTHER JUSTIFICATION

Publications funds are requested to cover the cost to have research published in HortTechnology at a flat rate of $2,000 at the end of year 2 of the project.

We will conduct a no-charge field day in 2023 (date TBA) and no-charge field day/workshop in 2024 (date TBA); $1,730 is requested for two years; it includes $880 printing fees of brochures and banners; $850 for miscellaneous educational/extension materials.

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 7: Development of a Turf Management Curriculum for Secondary Education in Oklahoma

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

Oklahoma State University seeks to enhance sustainability of the turfgrass industry through workforce development targeted at secondary education levels. The project will develop, publish, and disseminate a Turf Management teaching curriculum for FFA, 4H, and STEM classes in Oklahoma. Materials will be delivered through hands-on training sessions and communicated through teaching conferences throughout the state. The project will contribute to increased enrollment of students in turf management AS and BS degrees, resulting in qualified turf managers entering the industry in subsequent years. Beneficiaries of the project include golf courses and sports field facilities, as well as ancillary industries such as sod producers and chemical distributors.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

The turfgrass industry consists of golf courses, sports fields, lawncare services, highway right of way, parks and grounds, sod production, seed production, seed/chemical/fertilizer sales and distribution, private research and development, and equipment manufacturing and sales, as well as governmental agencies and university research and extension programs. These sectors are highly interconnected, and each rely on a pipeline of skilled labor, managerial positions, and advanced technical positions in order to maintain a thriving industry. Over 90% of students who earn a 2-year or 4-year degree in turf management have a job waiting for them when they graduate. There are often more jobs available than there are applicants. Recent estimates suggest the sports field sector alone will grow by 39,000 jobs (5-8%) over the next 10 years, nationally. This has resulted in a significant labor shortage across most sectors of the turf industry. In particular, unavailability of skilled labor and qualified managers has hampered the golf course and sports field management sectors. Facilities employing educated and well-trained individuals as superintendents or field managers are primary clients of many of the other sectors including seed and sod producers, chemical distributors, and equipment sales companies. Thus,

supporting the training and development of qualified managers is critical to the success of each sector within the turf industry.

A good metric for evaluating availability of personnel for higher level positions is enrollment in 2-year and 4-year turf management programs. A survey conducted by the *Golf Course Management* magazine determined 70% of schools had lower enrollment in their turf management degree than compared to 10 years ago. In Oklahoma, we estimate enrollment in such programs has declined by 75% since its peak 20 years ago, which is consistent with several other states who have either reduced in enrollment by more than 50% or have terminated programs entirely due to poor enrollment. Both the Sports Field Manager Association (SFMA) and the Golf Course Superintendent Association of America (GCSAA) have identified this as a major limitation to the growth and health of their industry and have further increased efforts at recruiting students at the middle and high school level through various outreach programs.

The SFMA in a recent white paper specifically identified several key problems with student recruitment at the high school level: 1) many students are unaware of turf management as a career path, 2) golf courses no longer hire minors due to liability issues, and 3) agriculture teachers report population dynamic and course of study has shifted at the secondary level. In response to these findings, the SFMA has identified several solutions for improving awareness of turf management career options to high school students. This project aims to address two of the solutions identified by SFMA: FFA programs and STEM curriculum.

The SFMA is promoting a coordinated effort to create Turf Management FFA Career Development Events (CDE's) that could eventually serve as a launching pad for a national contest. The goal of developing these events is to directly increase student awareness of turf management careers and thereby contribute to increased enrollment at both 2-year and 4-year programs across the country. This approach seeks to capitalize on School-based agriculture education (SBAE) teaching programs that are within close proximity to metropolitan and micropolitan areas or otherwise have a portion of their enrollment that is disinterested in conventional agricultural commodities. Oklahoma has four metropolitan and 18 micropolitan statistical areas that hold potential for this project. Previously, the PI Fontanier and CoPI Ramsey identified logistical needs for implementing a state contest for Oklahoma, and in 2019, the first Turf Management CDE was held with four teams competing. A subsequent CDE was held in 2021 with two additional teams competing. In conversations with team coaches, PI Fontanier has noted student excitement for the contest and was pleased to hear teams were interacting with golf course superintendents and lawncare specialists in their local communities. As an example, the Edmond FFA chapter is scheduled to visit the Kickingbird Golf Course this spring, while the facility is undergoing a $18.5 million renovation. Students will be able to witness the multitude of industries involved in a large renovation, and it is our opinion that these are the sort of activities that will invigorate the youth entry into the turf industry.

As a goal of this project, we would like to increase participation in the CDE, so we can reach more students, either directly through the contest or as a component of their agriculture training. In order to facilitate recruitment of new teams, the process of training students for the contest needs to be simplified. Presently, there is no formal curriculum available for teachers and without a national contest there is no formal template that can be easily used to guide CDE development or teacher curriculum development. For the six teams that have already competed in the Oklahoma Turf Management CDE,

teachers have been largely in the dark on how to best prepare their students. This project aims to create a series of online and print resources that could be used by SBAE teachers for introducing students to careers in the green industry, training high school students in introductory turf management, preparing them for the state Turf Management CDE, and potentially providing them a head start into an entry level position in the green industry. To prepare SBAE programs to highlight and integrate the green industry into their courses, we propose development of a curriculum guide (~40 pages) consisting of industry validated activities, lab practicums, and in-class case studies and experiential learning activities that would culminate in a detailed reference featuring green industry resources and rubrics aligned with the Agriculture, Food and Natural Resources (AFNR) Standards that support the Turf Management CDE. This suite of publications is similar to what is provided for other career development events including floriculture, which routinely has over 40 teams competing at the state FFA Interscholastic hosted by Oklahoma State University. To support this effort, we will recruit one MS graduate student in Agricultural Education to lead development of the curriculum and communication with Oklahoma agriculture teachers. Initially, we propose to survey existing FFA CDE's across the country (at present the PI is aware of 7 states hosting turf management CDE's) and develop a research article detailing variation in approaches used across states. We believe coordination with these other programs is critical to developing a national contest at some later date. The CDE and newly developed curriculum will be publicized at key SBAE teaching events including the Big 3 Field Days, Career Tech Summit, and state FFA Convention each year.

In addition to development of a state CDE and associated curriculum, the SFMA has identified outreach to non-ag teachers through development of turfgrass science modules that fit within the framework of existing state teaching standards for general sciences at either high school or middle school levels. Turf management has excellent potential to be implemented in several basic courses. Examples include obvious plant and soil science topics as well as more novel concepts in engineering (retractable football fields), physics (player to surface interactions), environmental science (ecosystem services of turfgrasses), art (golf course architecture), technology (GPS painters and mowers), and chemistry (logo paint formulas). This outreach effort would target STEM teachers but also coaches who would likely be motivated to turn their fields into an outdoor working laboratory. In addition to creation of an easy-to-use curriculum, we propose to conduct a considerable number of outreach activities at state youth events and teacher conferences to encourage adoption (see Travel). CoPI Shelley Mitchell, youth horticulture specialist, will lead efforts to develop the STEM teaching modules and attend several state conferences including the Oklahoma Environmental Education Expo, ScienceFest, OERB Community STEM nights, Oklahoma Ag in the Classroom and Women in Science. These conferences provide exposure to career fields to students (Women in Science, ScienceFest) and parents (OERB) and professional development for teachers (OK Environmental Education Expo, OK Ag in the Classroom Conference

As a final component of this project, CoPI Mitchell will use her existing program with 4-H to develop turf management-themed teaching materials and a state competition at the junior and senior 4H levels. The publication will be similar to those created for the FFA competition but allow for flexibility to use with non-FFA members and regular classroom and club teaching.

Timeline:

- Spring 2023
    - Recruit graduate student, survey other state FFA CDE's, survey Oklahoma ag teachers, begin initial draft of CDE guideline and activity book (Objective 1&2)
    - Identify list of state teaching standards that can be taught using turf as a theme, begin drafting teaching modules, recruit STEM teacher focus group (Objective 3)
    - Attend conferences and publicize project, recruit input from stakeholders (Objective 4)

- Summer 2023
    - Complete draft of FFA study guide and activity book, recruit feedback from stakeholders (Objective 1&2)
    - Focus group evaluates STEM teaching modules (Objective 3)
    - Attend conferences and publicize project, recruit input from stakeholders (Objective 4)

- Fall 2023
    - Publish FFA study guide and activity book, Begin development of comprehensive reference text for FFA (Objective 1&2)
    - Publish STEM teaching modules (Objective 3)
    - Attend conferences, distribute publications (Objective 4)

- Spring to Summer 2024
    - Publish FFA reference textbook, Develop and publish 4-H guidelines (Objective 1&2)
    - Attend conferences, distribute publications (Objective 4)
    - Provide professional development for SBAE teachers and 4-H Youth Educators (Objective 4)

- Fall 2024
    - Publish manuscript comparing state CDE's across the US (Objective 1&2)
    - Host a fall CDE in conjunction with the Oklahoma State Fair (Objective 4)
    - Attend conferences, distribute publications (Objective 4)

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Develop online and print Turf Management curriculum aligned with applicable AFNR standards.

Objective 2: Develop a resource guide supporting the Turf Management CDE.

Objective 3: Develop Turf Management-themed teaching modules for Oklahoma teaching standards in biology, chemistry, environmental sciences at the middle school and high school level.

Objective 4: Disseminate and promote new curriculum to teachers and administrators at state conventions.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: over 9,110 employees of the Oklahoma Turf Industry including producers of sod and fine turf.

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☑ **No** ☐

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

The Oklahoma Turf Research Foundation (OTRF) and its board consisting of representatives from golf, sports, lawncare, sod/seed production, and ancillary services (eg, chemical/fert sales), strongly support this project (see letter). Additional support is derived from ag teachers who are interested in developing high school curriculum or FFA competition teams.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☑ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☐ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 2, Indicator 2.1
Number of stakeholders that gained technical knowledge about producing, preparing, procuring, and/or accessing specialty crops 100.

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

We will document numbers of attendees at various workshops and convention sessions, wherein training modules are disseminated and promoted. We will also track the number of downloads and site visits for digital media created as part of this project. Beyond the duration of this project, we will continue to track the number of teams competing in the state CDE and those enrolling in postsecondary turf management degree programs.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$42,642.00
Fringe Benefits	$6,701.00
Travel	$10,644.00
Equipment	$0.00
Supplies	$1,000.00
Contractual	$0.00
Other	$8,750.00
Direct Costs Sub-Total	$69,737.00
Indirect Costs	$0.00
Total Budget	$69,737.00

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Shelley Mitchell	0.7 FTE (1-month per Year)	$11,442.00
2	GRA (TBD)	0.50 FTE (12-months per Year)	$31,200.00

Personnel Subtotal: $42,642.00

PERSONNEL JUSTIFICATION

Personnel 1: Dr. Shelley Mitchell, youth horticulture specialist, will lead curriculum development and dissemination to various workshops in the state. We are requesting 0.7 FTE for one summer month in each year to support Dr. Mitchell's effort on the project.

Personnel 2: A 0.5 FTE MS graduate research assistant will work with CoPI Jon Ramsey (Ag Education) to develop curriculum for the FFA contest CDE.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Shelley Mitchell	34.91%	$3,995.00
2	GRA (TBD)	8.67%	$2,706.00

Fringe Subtotal: $6,701.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	OK Ag in Classroom (OKC)	Mileage, Registration	Miles (170)	2	$0.585 per mile, $500 registration	1	$1,199.00

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
2	OK Environ Ed Expo H2Oklahoma (TBD) – lunch provided	Mileage, Hotel, Per Diem, Registration	Miles (230) 1 night, per diem	2	0.585 per mile, $130 hotel, $48 per diem, $500 registration	1	$1,622.00
3	ScienceFest (OKC)	Milage	Miles (170)	2	$0.585 per mile	1	$199.00
4	OERB Community STEM Night (various, TBD) – dinner provided	Mileage, Hotel, Per Diem	Miles (250) 1 night, 1 per diem	4	0.585 per mile, $130 hotel, $35 per diem	1-2	$2,020.00
5	Women in Science (OKC)	Milage	Miles (170)	2	$0.585 per mile	1	$199.00
6	FFA Convention (Tulsa) – No meals provided	Mileage, Hotel, Per Diem, Registration	Miles (170) 1 night, per diem	2	0.585 per mile, $130 hotel, $64 per diem, $620 registration	1-4	$3,190.00
7	CareerTech Summit (OKC) – No meals provided	Mileage, Hotel, Per Diem, Registration	Miles (170) 1 night, per diem	2	0.585 per mile, $130 hotel, $64 per diem, $620 registration	1-2	$2,215.00

Travel Subtotal: $10,644.00

TRAVEL JUSTIFICATION

Trip 1 (Approximate Date of Travel 07/2023, 07/2024**):** Funds of $1,199 are requested for CoPI Shelley Mitchell to travel to the OK Ag in Classroom Conference in OKC each year. Teachers of all grades from Oklahoma public schools attend workshops to learn about ag concepts they can use in their classrooms. Mitchell would present a workshop each summer about turf curriculum and career opportunities.

Trip 2 (Approximate Date of Travel 02/2023, 02/2024)**:** Funds of $1,622 are requested for CoPI Shelley Mitchell to travel to the OK Environmental Education Expo H2Oklahoma in OKC each year. Teachers from across Oklahoma attend keynotes and workshops on environmental issues and how science and technology can be used to keep the environment cleaner and be sustainable. Mitchell would present a workshop on the ecosystem services provided by turfgrasses in urban watersheds.

Trip 3 (Approximate Date of Travel 04/2023, 04/2024): Funds of $199 are requested for CoPI Shelley Mitchell to travel to ScienceFest in OKC each year. Students from across Oklahoma attend to interact with science booths staffed by science and technology professionals. Mitchell would provide a hands-on demonstration related to turfgrass science and technology used by researchers and industry practitioners.

Trip 4 (Approximate Date of Travel – Fall 2023, Fall 2024 - varies): Funds of $2,219 are requested for CoPI Shelley Mitchell to travel to 4 OERB Community STEM Night (various, TBD). Parents and students from the local and surrounding communities attend and interact with science booths staffed by science professionals. Mitchell would provide a hands-on demonstration related to the turf management and careers.

Trip 5 (Approximate Date of Travel 10/2023, 10/2024): Funds of $199 are requested for CoPI Shelley Mitchell to travel to Women in Science in OKC each year. Middle and high school students and teachers interact with booths of science professionals to engage in hands-on activities and learn about career opportunities in that industry. Mitchell would provide a hands-on demonstration related to the turf management and promote new curriculum.

Trip 6 (Approximate Date of Travel 10/2023, 10/2024): Funds of $3,190 are requested for PD Fontanier, CoPI Mitchell, CoPI Ramsey, and a GRA to travel to the Oklahoma FFA Convention in Tulsa each year. The project team will manage a booth and discuss the newly developed curriculum and promote the CDE.

Trip 7 (Approximate Date of Travel 10/2023, 10/2024): Funds of $2,215 are requested for PD Fontanier, CoPI Mitchell, CoPI Ramsey, and a GRA to travel to the CareerTech Summit in OKC each year. The project team will manage a booth and discuss the newly developed curriculum and promote the CDE.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Demonstration Supplies for Workshops	$500	2	Each Year	$1,000

Supplies Subtotal: $1,000

SUPPLIES JUSTIFICATION

Funds are requested in the amount of $500 each year for various small items used in demonstration of hands-on activities, lab exercises, and teaching modules as developed in the proposed curriculum. These items may include plant materials, fertilizer, PPE, potting supplies, and other items as determined by the developed curriculum. CoPI Shelley Mitchell will create demonstrations that showcase teaching modules to teachers during workshops and conventions and illustrate how to implement curriculum into existing classrooms in order to meet student learning needs and state teaching standards.

CONTRACTUAL/CONSULTANT

N/A

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Primary Reference Book	$50	50	Each Year	$2,500.00
Assessment Guide	$15	50	Each Year	$750.00
Study Guide	$15	50	Each Year	$750.00
STEM Module Catalog	$50	50	Each Year	$2,500.00
4H Study Guide	$15	50	Each Year	$750.00
Page Charges – Peer-reviewed Journal	$1500	1	Year 2	$1,500.00

Other Subtotal: $8,750.00

OTHER JUSTIFICATION

Funds are requested in the amount of $4,000 for a primary reference book, assessment/activity book, and study guide for a Turf Management FFA or other career technical training program. Funds of $2,500 are requested for publication of unique turf-related modules that meet state teaching standards for general STEM courses. Funds of $750 are requested for a study guide publication aimed at developing a 4H training program and state contest. Funds of $1,500 (flat rate fee charged by publishing body) are requested for publication of an article in academic journal such as *HortTechnology*, aimed at identifying national trends in development of a Turf Management high school and FFA curriculum..

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A

PROJECT TITLE

Project 8: Woody and Luminescent Cut Flowers as a Value-Added Product

DURATION OF PROJECT

Start Date: 9/30/2022 **End Date**: 9/29/2025

PROJECT PARTNER AND SUMMARY

The pandemic has opened-up new markets for cut flower production in the state because of supply chain issue and shortages of cut flowers production in other countries that have lead production. Research at Oklahoma State University will evaluate use of woody nursery crops as potential cuts for cut flower growers. Most growers focus on annuals for cut flower production, but woody cuts offer great long term and even off-season potential. A premium is given for longer stems, so use of gibberellic acid on stem elongation will also be investigated to maximum the number of quality stems. In addition, use of glow-in-the dark products will be evaluated on a popular herbaceous cut flowers to increase market interest in cut flowers by developing a value-added product. This research will evaluate multiple species across two different specialty crop groups. Quantitative data on number and size of cut stems produced with and without gibberellic acid application and brightness in terms of application rates of glow-in-the-dark products will be used to make recommendations to growers. Outcomes include providing information on woody species and luminescent flowers that could be used to increase sustainability and expand markets. Information will be provided to stakeholders through a factsheet, journal publications, site visits, and word of mouth of those supporting growers that will do on farm evaluations too. Tasks to be completed include installing plant material, running experiments, data collection, and disseminating results.

PROJECT PURPOSE

PROVIDE THE SPECIFIC ISSUE, PROBLEM OR NEED THAT THE PROJECT WILL ADDRESS

Cut flower production can be a viable business venture for small farms due to increasing demand for local products and a lack of access to flowers that do not ship well long distances. For operations that have sales greater than $100,000, the current wholesale value of cut flowers is estimated to be $375 million (USDA, 2019). Although only accounting for less than 10% of cut flowers woody cuts are

increasing in popularity, as enterprising cut flower growers are looking for new species to provide their customers with different products and enhance sales. Woody cuts or woodies come from perennial shrubs, trees or woody vines used for floral or decorative purposes. Woody cuts have the ability to fill a niche in the industry that has been incapable of being filled by standard herbaceous material.

In addition to season extension, woody cuts generally have few pest problems, can be grown on unsuited land, and generally require less care. Ideal species are ones that grow well in our climate, regrow rapidly after pruning, produce numerous stems over different seasons, produce stems at least 18" long, retain flowers, foliage, and berries, have a long vase life, produce harvestable branches early in plant's life, and extend the business harvest season. Marketing channels for woody cuts are similar to cut flower markets and include farmers market, roadside stands, U-pick, Community Supported Agriculture (CSA), florists, supermarkets, and craft stores. Woody cuts provide novel colors, textures, shapes, flowers, and fruits when used alone or as components of a traditional flower arrangement.

Plant growth regulators (PGRs) consist of a large group of naturally occurring or synthetically produced organic chemicals and are considered as helping tools in the modern production of ornamentals. The effects of PGRs in plants depend on various factors which play an important role in achieving expected growth results. These factors include the application method, time of application, concentration of PGRs, plant species and also the environmental conditions in which plants are grown. The intensity of applications is also considered an important factor affecting the efficacy of PGRs, as some plants respond well to a single application, but in most of cases, multiple applications are beneficial to attain good results.

Gibberellic acid (also called Gibberellin A_3, GA, and GA_3) is a hormone and PGR found in plants. Plants produce low amounts of GA_3, therefore this hormone is available commercially. Gibberellic acid is a very influential hormone by controlling plant development, promoting growth, and elongating cells. This hormone produces bigger leaves and longer stems, establishes robust root systems, enhances photosynthesis, stimulates seed germination, and triggers transitions from the vegetative to the flowering stage. Applications of very low concentrations can have a profound effect like stem elongation, while too much will have the opposite effect.

Common problems of woody cuts include unacceptably short stems, long production times, or lengthy flower-initiation procedures. Growers may be able to alleviate some of these issues by applying gibberellic acid to their crops. For example, a recent study showed that gibberellic acid increased stem elongation in nine herbaceous species commonly used for cut flower production. With other species tall stems can be produced without GA_3 but using the growth regulator can produce the desired height in a shorter time period.

Florists and cut flower growers today still use methods like dip dying, spraying, and stem absorption to get novel colors as flower color is one of the most attractive characteristics of ornamental plants. Value-addition techniques like artificially coloring white flowers can increase crop value by 5 to 10-fold. In addition to changes in hue, horticultural industries may be able to increase crop value by creating photoluminescent plants and flowers. One approach to creating photoluminescence in plants uses genetic modification.

Specifically, the green fluorescent protein (GFP) from jellyfish (Aequorea victoria) has been widely used as a recombinant protein tag in vivo. However, generation and commercialization of luminescent flowers has been mostly limited to studies related to gene expression, protein localization, protein-protein interactions, plant-bacterial interactions, and cell-to-cell communications due to opacity to ultraviolet (UV) and blue light used to excite GFP and regeneration of transgenic tissues is still difficult.

A more practical approach to creating photoluminescence in horticultural plants involves exogenous application of phosphorescent materials. Phosphorescence, a type of photoluminescence, is when a molecule absorbs a photon of a shorter wavelength leading one of its electrons to a higher energy level and radiates it at a longer wavelength over a longer period of time as the electron returns to the original state. Most glow-in-the-dark materials use the phosphors zinc sulphide or the newer strontium aluminate. Glow-in-the-dark or photoluminescent materials carry phosphors that absorb low energy light and then re-emit visible light as luminescence or glow. Addition of UV light excites the phosphors resulting in ordinary luminescence and persistent luminescence as charge carriers are transferred from the activator to the traps and those traps are gradually filled storing excitation energy.

Low energy light (red light) can be used to excite some phosphors, but high energy photons, found in the UV band, are most effective at charging the traps and properties like depth, type, number, and capacity can affect luminescence persistence. Khattab et al. (2019) incorporated phosphorescent strontium aluminate into globe artichoke (Cynara cardunculus L.) roots by soaking roots in a nutrient solution with a luminescent chemical to cause roots to glow. McCarty et al. (2019) applied glow-in-the-dark paint to peace lily (Spathiphyllum wallisii Regel) 'Petite' leaves reporting phosphorescence for more than 4-weeks after application. Pace et al. (2022) used glow-in-the dark paint and yellow highlighters on white carnations to create a green luminescent carnation in the dark. No studies have research other species or flower colors as a value-added product.

To date, there is very limited information, less than five studies, for growers throughout the U.S. including Oklahoma on the feasibility and production potential of growing woody ornamentals for cut branches. In addition, general recommendations for postharvest treatments is species dependent with limited research only investigating water temperature, ethylene inhibitor, and a sucrose pulse preservative. Floral preservative solution and chlorine are common treatments for herbaceous cut flowers but have not been investigated for woody cuts. Because GA_3 effects can vary greatly among different taxa, information to quantify the effects of GA_3 on woody cut stems production is needed to see if the number of quality cuts can be increased.

Research on woody cuts, gibberellic acid, and flower luminescence is necessary for sustainable and market-oriented cut flower specialty production in the future. This research enhances the competitiveness of specialty crops by addressing the focus priority areas of "Specialty Crop Research" with increased market potential by developing new production information.

PROVIDE A LISTING OF THE OBJECTIVES THAT THIS PROJECT HOPES TO ACHIEVE

Objective 1: Determine which woody nursery species would make for good cut flower production.

Objective 2: Establish optimum gibberellic acid rates for selected ornamental species.

Objective 3: Evaluate effects of different glow-in-the-dark colors and rates on vase life of several cut flower species.

Objective 4: Disseminate research findings to expand the cut flower industry.

PROJECT BENEFICIARIES

Estimate the number of project beneficiaries: 60

Does this project directly benefit socially disadvantaged farmers as defined in the RFA? **Yes** ☑ **No** ☐

Does this project directly benefit beginning farmers as defined in the RFA? **Yes** ☑ **No** ☐

STATEMENT OF ENHANCING SPECIALTY CROPS

By checking the box to the right, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by the Farm Bill. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp. ☑

CONTINUATION PROJECT INFORMATION

Does this project continue the efforts of a previously funded SCBGP project? **Yes** ☐ **No** ☑

OTHER SUPPORT FROM FEDERAL OR STATE GRANT PROGRAMS

The SCBGP will not fund duplicative projects. Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

Yes ☐ **No** ☑

EXTERNAL PROJECT SUPPORT

Because this grant covers several different areas of specialty crop production, growers in the Oklahoma Nursery and Landscape Association (ONLA) and Association of Specialty Cut Flower Growers (ASCFG) support and are stakeholders in this research. Each of these organization have a diverse group of over 150 growers that utilize either field and greenhouses to meet market demands now and look to expand into new markets in the future to address changing consumer wants and changing environmental pressures. The Oklahoma State Florists' Association would indirectly benefit from research that addresses new products or value-added products. Besides making recommendations for implementing new practices, they promote marketing of new products that may serve other industries too.

EXPECTED MEASURABLE OUTCOMES

SELECT THE APPROPRIATE OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

- ☐ **Outcome 1:** Increasing Consumption and Consumer Purchasing of Specialty Crops
- ☐ **Outcome 2**: Increasing Access to Specialty Crops and Expanding Specialty Crop Production and Distribution
- ☐ **Outcome 3**: Increase Food Safety Knowledge and Processes
- ☐ **Outcome 4**: Improve Pest and Disease Control Processes
- ☐ **Outcome 5**: Develop New Seed Varieties and Specialty Crops
- ☑ **Outcome 6**: Expand Specialty Crop Research and Development
- ☐ **Outcome 7**: Improve Environmental Sustainability of Specialty Crops

OUTCOME INDICATOR(S)

Outcome 6: Indicator 6.1
Number of research goals accomplished: 3.

MISCELLANEOUS OUTCOME MEASURE

N/A

DATA COLLECTION TO REPORT ON OUTCOMES AND INDICATORS

Woody cuts

The study will be conducted at the Cimarron Valley Research Station in Perkins, OK. At least 10 different species will be evaluated depending on availability. Species could include smokebush, ninebark, photinia, pearl bush, dogwood, honeysuckle bush, hydrangea, lilac, vitex, butterfly bush, willow, beauty berry, flowering quince, nandina, hypericum, forsythia, and blue mist bluebeard. There will be five plants in each treatment per replication and two replications. Black fabric mulch will be used to control weeds. Water will be delivered by a drip irrigation system. Plant performance will be measured including plant height, width, number of branches, number of cuts, length of cuts, and dry weight. In addition, five plants per species will be given to cooperating growers to evaluate.

Gibberellic acid

The experiment will be conducted at the Research Greenhouses located in Stillwater, OK. We will evaluate at least three different woody species from the list of wood cut species above in 3 or 5 gal pots. Treatments will be 25, 50, and 75 ppm gibberellic acid and a control. All experiments will have 10 single plant replicates and the experiment will be replicated. Data collected will include number of stems, length of stems, number of leaves, SPAD, damage rating, and fresh weight. All statistical data analyses will be performed using SAS General GLIMMIX.

Glow-in-the-dark

The experiment will be conducted at the Greenhouse Learning Center at Oklahoma State University in Stillwater, OK. Cut flower stems of either roses, chrysanthemums, or zinnias will be cut to 40 cm at a 45° angle with leaves removed from the lower 10 cm of the stem. Stems will be placed into fluted glass bud vases, one flower per vase, filled with 240 ml deionized water and 2 g of floral preservative.

Treatments of 4 g of three different colors of glow-in-the-dark powder will be mixed with 240 ml of deionized water to be sprayed for 4 seconds using a standard spray bottle along with a control. Each treatment will be applied to a set of three stems and replicated five times resulting in 15 vases per treatment arranged in a completely randomized design. Data will be taken daily on stem weight (combined weight of stem and flower), vase weight, average flower diameter (average of two perpendicular measurements with a ruler), and visual deterioration. For quantification of brightness, images will be taken of flowers in darkness using a camera before and after UV exposure. Once concluded, flowers will be dried for 3 d at 60°. Data will be used to calculate water relations too. Statistical analysis will be performed using SAS/STAT software (Version 9.4; SAS Institute, Cary, NC). Tests of significance will be reported at the 0.05, 0.01, and 0.001 level. The data will be analyzed using GLIMMIX. Tukey multiple comparison methods were used to separate the means.

BUDGET NARRATIVE

BUDGET SUMMARY

Expense Category	Funds Requested
Personnel	$37,200.00
Fringe Benefits	$5,682.00
Travel	$724.00
Equipment	$0.00
Supplies	$13,758.73
Contractual	$0.00
Other	$5,500.00
Direct Costs Sub-Total	$62,864.73
Indirect Costs	$0.00
Total Budget	$62,864.73

PERSONNEL

#	Name/Title	Level of Effort (# of hours OR % FTE)	Funds Requested
1	Graduate student, to be named	20 hours a week	$29,200.00
2	Technician, Stephen Stanphill	5 hours a week	$8,000.00

Personnel Subtotal: $37,200.00

PERSONNEL JUSTIFICATION

Personnel 1: Graduate student will be responsible for all three studies and will be supervised by Dr. Dunn. This includes plant woody ornamentals (05/2023), running gibberellic acid experiment (05/2023), and glow-in-the-dark study (08/2023) analyzing and disseminating results (10/2024). The graduate student will work on this project from the beginning to end over the 2-year period.

Personnel 2: Stephen will be responsible for ordering supplies (03/2023), spraying weeds (06/2023), maintaining irrigation (06/2023 and 06/2024), and helping with planting (05/2023) and data collection (08/2023, 10/2023, 08/2024). He will be supervised by Dr. Dunn. Stephen will work on this project from the beginning to end over the 2-year period.

FRINGE BENEFITS

#	Name/Title	Fringe Benefit Rate	Funds Requested
1	Graduate student, to be named	8.67%	$2,532.00
2	Technician, Stephen Stanphill	39.38%	$3,150.00

Fringe Subtotal: $5,682.00

TRAVEL

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
1	Horticulture Industries Show	registration	registration	1	$100	2	$200.00
2	Horticulture Industries Show	mileage	mileage	360	$0.58	2	$207.00
3	Visit cooperators	mileage	mileage	350	$0.58	1	$202.00

#	Trip Destination	Type of Expense (airfare, car rental, hotel, meals, mileage, etc.)	Unit of Measure (days, nights, miles)	# of Units	Cost per Unit	# of Travelers Claiming the Expense	Funds Requested
4	Visit research plots	mileage	mileage	200	$0.58	1	$115.00

Travel Subtotal: $724.00

TRAVEL JUSTIFICATION

Trip 1 (Approximate Date of Travel 01/2024): Purpose of the trip is to disseminate results per objective 4 at the regional horticulture show that brings in professionals and industry. Funds are requested for the P.I. and graduate student to travel to the meeting, pay for registration in Fort Smith OK. The mileage rate charged is the GSA approved rate of $0.575 per mile.

Trip 2 (Approximate Date of Travel 03/2023): Purpose of the trip is to setup a trial at cooperators sites.

Trip 3 (Approximate Date of Travel 05/2023): Purpose of travel to plant trial, irrigate, control weeds, and collect data.

CONFORMING WITH YOUR TRAVEL POLICY

By checking the box to the right, I confirm that my organization's established travel policies will be adhered to when completing the above-mentioned trips in accordance with 2 CFR 200.474 or 48 CFR subpart 31.2 as applicable. ☑

EQUIPMENT

N/A

SUPPLIES

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Woody plant material	$25	430	03/2023	$10,750.00
Cut flowers	$3.50	150	05/2023	$525.00
Flower vases	$1.25	150	04/2023	$187.00
Floral preservatives	$20	2	04/2023	$40.00
Glow-in-the-dark powder	$25	3	04/2023	$75.00
Scale	$112.73	1	04/2023	$112.73

Item Description	Per-Unit Cost	# of Units/Pieces Purchased	Acquire When?	Funds Requested
Irrigation tubing, fittings, controllers	$130	4	04/2023	$520.00
Herbicide	$70	2	06/2023	$140.00
Fertilizer	$80	3	05/2023	$240.00
Pruners	$14	2	06/2023	$28.00
Gibberellic acid	$40	6	04/2023	$240.00
Pump-up spray bottles	$7	3	04/2023	$21.00
Paper bags	$20	3	04/2023	$60.00
Soap	$4	25	04/2023	$100.00
Landscape fabric	$120	6	04/2023	$720.00

Supplies Subtotal: $13,758.73

SUPPLIES JUSTIFICATION

Woody plant material will be used for replicated trials, cooperator trials, and gibberellic acid experiments. Cut flowers are for the glow-in-the-dark study. Floral preservative is needed to maintain vase life of cut flowers. Glow-in-the-dark powder is the experimental treatment. A scale is needed to weigh cut flower stems for water relations related to vase life. Irrigation supplies are needed to keep wood plant material alive. Herbicide may be needed to control weeds in the field. Fertilizer is needed to keep plants growing health to maximize plant growth. Pruners are needed to encourage more lateral branches. Gibberellic acid is used as a treatment to increase stem elongation for woody cuts. Spray bottles are needed to apply the gibberellic acid. Soap is used to keep deer form eating plants at trial locations. Paper bags for collecting stems and dry weights. Landscape fabric will be used to help reduce weeds and competition for water and nutrients.

CONTRACTUAL/CONSULTANT

N/A

OTHER

Item Description	Per-Unit Cost	Number of Units	Acquire When?	Funds Requested
Greenhouse rental	$250	6	05/2023	$1,500.00
Publication costs	$2,000	2	08/2024	$4,000.00

Other Subtotal: $5,500.00

OTHER JUSTIFICATION

Greenhouse space can be rented for $250 a month. HortScience and other journals charges a flat rate of $2,000 to publish research. Expenses support objectives and outcomes.

INDIRECT COSTS

N/A

PROGRAM INCOME

N/A