Project Final Report:

- Project Title: Promoting BMPs in the nursery production systems for the Mid-South United States
- Grantee Name: Tennessee State University
- Project PD: Dharmalingam Pitchay
- Project start: and end date
- Award number (FAIN): 69-3A75-17-19

1. Project Summary:

Growing plants in containers for the nursery industry is a unique production system compared to field production. Container production requires careful management of limited water, nutrients, and space for root growth. Consequently, inputs like irrigation, fertilizers, and pesticides must be applied precisely and timed properly to maximize benefits while minimizing environmental impacts.

This funded Conservation Innovation Grant (CIG) project provides a framework to conserve natural resources and protect the environment from adverse effects in container plant nursery production. The project will enhance the current Southern Nursery Industry BMP Guide by offering modifications and new practices focused on resource concerns within the industry.

Some key activities of this CIG include demonstrating improved BMPs on nursery and university research station properties to promote wider adoption. The CIG project also trained the next generation of extension agents and technicians to plan, implement, and evaluate the benefits of BMPs and new techniques. Selected outcomes include modifications to existing management guides, as well as new BMPs and practices developed based on demonstration results and applied research. The project is able to establish permanent demonstration sites for future field days and training. This will help educate nursery growers about sustainably protecting natural resources through BMPs. Trained extension staff, growers and the next generation field state will share the of benefits from improved conservation practices. The project positions the industry to be environmental stewards while remaining economically viable for the long term. We believe the outcomes of this CIG project will significantly enhance sustainable resource management within the container nursery industry.

2. Project Goal and Objectives:

Clearly describe the project's goals and objectives. (Results will be described in #6). Consider numbering your objectives for easy reference in your Project Results section.

The overarching goal of this project is to develop a comprehensive, improved set of Best Management Practices (BMPs) to enhance sustainability in nursery production systems. We will provide planning assistance and technical support to growers.

A key activity is conducting one-on-one outreach to coordinate, promote, establish, and evaluate the effectiveness of conservation practices from the 2007 and 2013 BMP Guidelines developed by the Southern Nursery Association.
Focus areas of the new BMPs include location-specific irrigation, nutrient management, appropriate species selection, and mitigating nutrient and pesticide runoff. Additional focus will be on vegetative buffers, restoring previously disturbed lands, and optimizing soilless container media.
To accomplish our goal, we have the following objectives:
a) Evaluate the strengths and weaknesses of current BMPs and conservation programs in the nursery industry.
b) Address identified challenges by modifying existing practices or developing new environmentally-sound guidelines for inclusion in BMP manuals and NRCS standards.
c) Plan comprehensive, cost-effective, practical conservation strategies tailored to individual operations and addressing site selection, irrigation, nutrients, production, and runoff control.
d) Demonstrate associated economic benefits of implementing improved BMPs and practices.

By taking a collaborative, one-on-one approach and developing plans, we aim to enhance sustainability across nursery operations for long-term environmental protection and business viability.

3. Project Background:

This project aims to strengthen sustainable practices in the nursery industry through promotion and adoption of Best Management Practices (BMPs). In 2013, the Southern Nursery Association developed an updated set of BMPs which were supported by the USDA Natural Resources Conservation Service (NRCS) conservation standards.

Improvements were made to existing BMPs based on input from producers, evolving technology, and state agencies. Technical evaluations and analyses were conducted to establish feasibility. A proven methodology involves conducting comprehensive conservation practices with growers, field staff, and the next generation of conservationists (including minority students. The one-on-one planning approach is used to coordinate implementation of BMPs tailored to individual operations. Nursery production requires intensive resource use on small acreages to yield high plant quantities. Therefore, minimizing environmental impacts through BMPs is paramount.
Focus areas established in the updated BMP guidelines include:
a) Reducing contaminant runoff through vegetative buffers and updated irrigation/fertigation techniques; b) Harvesting and recycling rainfall and runoff to stretch water supplies; c)
Recuperating disturbed lands (liners/ ball & burlap nursery plant harvested areas) no longer suited for intensive production. As for fertility management the Adopting 4R Nutrient Stewardship -applying fertilizers at the right source, rate, time, and method -to boost efficiencies was promoted.
By promoting personalized conservation planning with growers and field experts, this project aims to strengthen the sustainability and resilience of nursery operations for

years to come. Ongoing technical support will ensure continuous BMP improvement.

4. Project Methods:

A short summary of methods that helps readers understand how the objectives were executed. Other publications can be referenced to keep this section short.
Following methodology was employed for the implementation of the project:

a) Comprehensive evaluation of current BMPs. We conducted a thorough review of the 2013 BMP Guide. Reach-out to producers to receive feedback through personal communication and focus groups on BMP effectiveness, challenges, and improvements. Our team noted BMPs implemented on nurseries to document strengths and limitations.

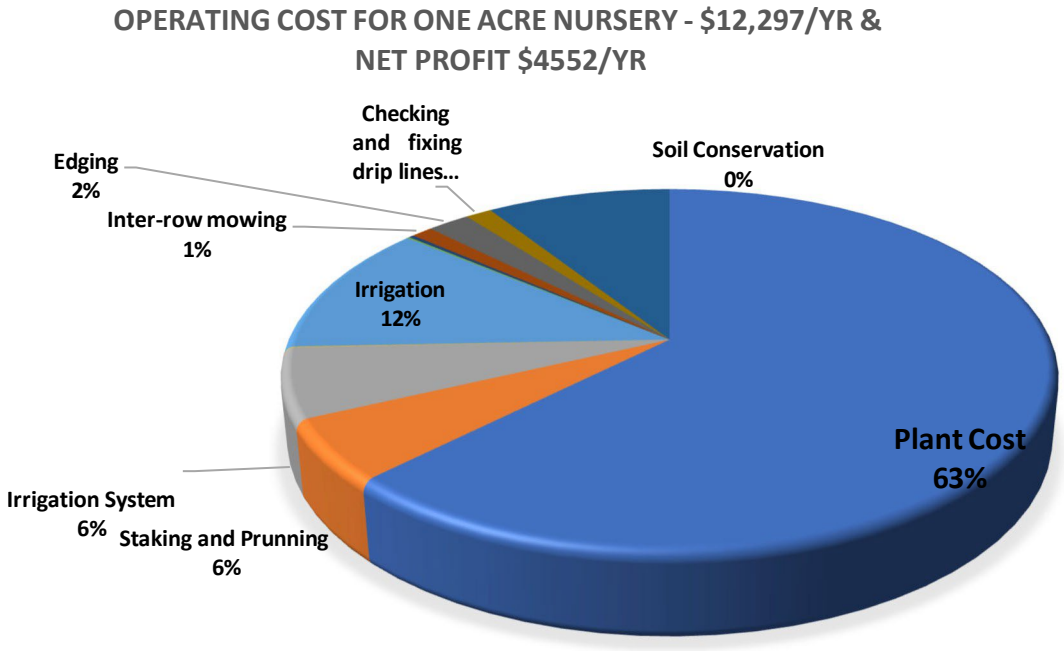
b) Develop new BMPs. Based on producer input and field observations, and Demonstrations at producer sites and research stations BMPs. Monitoring data will refine enhanced and new BMPs before inclusion in guides.

c) Create new and improved conservation plans by presenting new ways of nursery production in containers. The NRCS planning process one-on-one with producers to select BMPs for site planning, irrigation/nutrients, crops, and runoff issues. Training in planning and BMPs were carried out. Demonstrations at industry trade shows, field days to disseminate new approaches.

d) Build a production cost estimator. A web-based tool will help producers model costs and breakeven pricing for crops considering variable inputs. Producers can evaluate crop profitability and market mixes. The team will validate the tool with producer data before releasing it.

By engaging producers, evaluating current practices, testing new approaches, and providing easily accessible planning and cost analysis tools, we aim to continuously strengthen sustainable outcomes for nurseries and the environment. Comprehensive yet personalized solutions will bolster long-term industry resilience.

5. **Project Results Accomplishments and outcomes:**
   1. **Cost-Effective Production System:** One of the major achievements of the project was the development of a cost-effective container-grown production system. By promoting best management practices and optimizing nutrient management, water supply, and other inputs. The project aimed to reduce production costs while maintaining plant health and quality. This has significant implications for minority nursery and greenhouse growers, as it helps provide profitable income and in competitive market (figure 1). However, the startup and operating costs are the major costs for nursery business.



   2. **Economic Analysis:** The project included an economic analysis component that assessed the financial implications of implementing the recommended nutrient management practices. By considering the costs of inputs, labor, and potential yield improvements, the analysis provided growers with valuable insights into the economic feasibility and potential return on investment associated with adopting the recommended practices. This economic perspective further reinforced the practicality and benefits of implementing the project's findings.

   3. **Market Development for Sustainable Products:** The project facilitated market development for sustainable nursery products at farmers' market. It engaged directly with consumers to raise awareness about the environmental benefits of products locally grown using sustainable nutrient management conservation practices. By creating market demand for sustainable products, the project incentivized growers to adopt sustainable practices and provided them with opportunities to capture markets closed to their operation.

4. **Demonstrating Economic Benefits:** The project conducted economic analyses and demonstrated the potential economic benefits associated with sustainable backyard plant nursery. By quantifying the cost savings, efficiency gains, and market advantages associated with sustainable practices, the project team provided growers with a compelling business case for adopting these practices. Demonstrating the economic benefits helped overcome potential barriers and encouraged adoption.

5. **Adoption of Sustainable Practices:** The project aimed to promote sustainable practices in the nursery industry by focusing on nutrient management and conservation. By optimizing the use of appropriate inputs and synchronized source, rates, timing and placement for fertilizers and water with the physiological age of the plant, species and season. The project helped reduce environmental impacts such as nutrient runoff and water pollution. The adoption of sustainable practices not only benefits the environment but also enhances the long-term viability and resilience of the nursery industry.

6. **Environmental Benefits**: The project emphasized the importance of environmental sustainability in the nursery industry. By optimizing nutrient and irrigation management practices, the project aimed to minimize nutrient runoff into water bodies, reduce the leaching of nutrients into groundwater, and mitigate the negative impacts on ecosystems. These efforts contributed to preserving water quality, protecting natural habitats, and promoting overall environmental health.

7. **Climate Change Resilience:** The challenges posed by climate change and its potential impacts on nutrient management in the nursery industry. By studying the effects of changing climate variables on nutrient availability, uptake, and plant responses during unfavorable conditions (excessive heat), the project provided valuable information for growers to adapt their practices to changing environmental conditions. This resilience-focused approach helps ensure the sustainability and viability of nursery operations in the face of climate-related uncertainties.

8. **Technological Advancements:** The project explored and evaluated various technological advancements in the field of nutrient management and water quality for the nursery industry. This included the use of precision agriculture techniques, sensor-based monitoring systems, and data-driven decision-making tools. By integrating technology into nutrient management practices, the project aimed to improve accuracy, efficiency, and effectiveness in delivering the inputs- right nutrients and water to plants at the right time and in the right amounts. Overall, the industry able to conserve resources and minimize wastage which ultimately increase productivity and efficiency.

9. **Guideline Development:** The project generated important information that has

been used to develop guidelines for best management practices in container production systems for selected species. These guidelines serve as a practical and comprehensive resource for nursery /greenhouse growers, next gen-field staff providing recommendations on nutrient management, conservation of water supply, and other key aspects of container production. Helped ensure consistent and effective practices across the nursery and greenhouse industry, leading to improved productivity and sustainability.

10. **Educational Programs and Workshops:** The project offered educational programs and workshops tailored to different audiences within the nursery industry. These programs provided nursery / greenhouse growers, industry professionals, and next generation minority students with the knowledge and skills necessary to implement effective nutrient management practices. By empowering individuals with the necessary tools and information, the project aimed to create a culture of sustainable and efficient nutrient management throughout the industry.

11. **Training and Demonstration Program/activities**: The project included an ongoing training and demonstration program specifically focused on addressing the nutrient needs of selected species that the requirement of nitrogen form differs in blueberry, as opposed to raspberry, and rose crops in the nursery and greenhouse industry. By conducting training sessions and demonstrations, the project aimed to educate growers and industry professionals on the specific requirements of these crops needs and provide them with practical knowledge and techniques to optimize their production.

12. **Extension and Outreach Activities**: The project actively engaged in extension and outreach activities to disseminate the project's findings and recommendations to a wide range of stakeholders. These activities included workshops, field days, webinars, and the development of educational materials such as fact sheets and online resources. By reaching out to growers, industry professionals, and other interested parties, the project facilitated the transfer of knowledge and facilitated the adoption of best practices throughout the nursery industry.

13. Knowledge Dissemination through online website: The project leveraged technology to disseminate knowledge and information to a wider audience within the nursery industry. This included the development of online platforms, mobile applications, and web-based tools that provide access to research findings, best practices, and educational resources. By harnessing the power of technology, the project enhanced the accessibility and convenience of information, empowering growers to make informed decisions and adopt sustainable nutrient management practices.

14. **Publicity and Recognition:** The project's findings and outcomes gained significant publicity and recognition across the country. The project team was invited to present their work at various conferences, seminars, and industry

events, both within Tennessee and in other states. This recognition not only demonstrates the importance and relevance of the project but also helps disseminate the knowledge and best practices to a wider audience, contributing to the overall advancement of the nursery and greenhouse industry.

15. **Collaboration and Partnerships:** The project fostered collaboration and partnerships between researchers, growers, industry associations, and other stakeholders. By working together, the project team was able to leverage collective expertise, resources, and industry knowledge to address the challenges faced by the nursery and greenhouse industry. This collaborative approach ensures that the outcomes of the project are practical, applicable, and aligned with the needs of the industry.

16. **Continued Research and Innovation:** The project laid the foundation for continued research and innovation in the field of plant nutrient management in the nursery industry. The findings and insights generated by the project provided valuable starting points for further studies and explorations. This ongoing research and innovation contribute to the continuous improvement of practices, the development of new technologies, and the advancement of knowledge in the field.

17. **Collaborative Network Expansion**: The project contributed to the expansion of collaborative networks within the nursery industry. By bringing together researchers, growers, industry associations, and other stakeholders, the project fostered an environment of knowledge sharing, cooperation, and innovation. This collaborative network serves as a platform for future collaborations, partnerships, and the exchange of ideas, further advancing the nursery industry's practices and outcomes.

18. **Future Impact and Sustainability:** The project's accomplishments and outcomes have the potential for long-term impact and sustainability within the nursery industry. The adoption of the recommended practices and guidelines can lead to improved resource efficiency, increased profitability, and enhanced environmental stewardship. This, in turn, contributes to the industry's sustainable growth, the preservation of natural resources, and the provision of high-quality nursery products to meet market demands.

19. **Collaboration with Regulatory Agencies:** The project collaborated closely with regulatory agencies responsible for overseeing environmental regulations and policies related to nutrient management. By working together, the project team and regulatory agencies aimed to align practices with existing regulations, ensure compliance, and promote the adoption of sustainable nutrient management practices. This collaboration also facilitated the exchange of information and expertise between researchers and regulatory bodies, leading to more informed and effective policies in the future.

20. **Long-Term Monitoring and Evaluation:** The project recognized the importance of long-term monitoring and evaluation to assess the effectiveness and sustainability of the implemented nutrient management practices. By monitoring key indicators such as plant health, soil quality, water quality, and ecosystem health over an extended period, the project aimed to track the long-term impacts of the implemented practices and make necessary adjustments or improvements as needed.

21. **Knowledge Transfer and Scaling Up:** The project focused on knowledge transfer and scaling up of the implemented practices beyond the initial project scope. This included actively sharing research findings, guidelines, and best practices with other states, industry associations, and relevant stakeholders. The project team also provided technical assistance and support to growers and industry professionals seeking to implement similar nutrient management practices in their operations, facilitating widespread adoption and received good response from the growers and significant impact.

22. **Verification trials and Development of Nutrient Management Technologies**: The project invested in demonstration and development to advance nutrient management technologies specifically tailored for the nursery industry. This included the development of innovative fertilizers, soilless amendments, and application methods that improve nutrient uptake, reduce waste, and minimize environmental impacts. By investing in applied research and development, the project contributed to the continuous improvement and innovation of nutrient management practices in reference to the form of nitrogen (ammonium vs. nitrate) for species specific response.

23. **Demonstration of Best Management Practices at Agicultural Research and Education Center, Tennessee State University:** The project established demonstration pot-n-pot and above ground production and conducted on-farm demonstration to showcase sustainable nutrient management practices in real-world settings. The demonstration of nursery plant production served as living laboratories where growers could observe and learn from practical demonstrations. On-farm trials allowed growers to test and adapt sustainable practices to their specific conditions, fostering a culture of experimentation and continuous improvement.

24. **Empowerment of Women and Minority Growers:** The importance of empowering women and minority growers in adopting sustainable best management practices including 4R nutrient management and water use cannot be overlooked and the implementation of targeted training programs, capacity-building initiatives, and mentorship opportunities to ensure that these groups had equal access to knowledge and resources. The project fostered a more equitable and resilient nursery / greenhouse industry by encouraging inclusivity and diversity.

25. **Grower-to-Grower Knowledge Exchange**: The project facilitated farmer-to-farmer knowledge exchange programs among minority growers, where experienced growers shared their expertise and best practices with their peers. These programs included field visits, hands-on workshops, and initiatives, allowing growers to learn from each other's experiences and build a network of support. Farmer-to-farmer knowledge exchange promoted a culture of learning and collaboration within the nursery / greenhouse industry.

26. **Integration of Nutrient Management with Other Sustainability Initiatives**: The project recognized the importance of integrating nutrient management with other sustainability initiatives, such as energy efficiency, waste management, and carbon footprint reduction. By adopting a holistic approach, growers could optimize resource use, minimize environmental impacts, and enhance their overall sustainability performance. The project provided guidance and resources for growers to integrate nutrient management with other sustainability practices.

27. **Water and Nutrient Conservation Strategies**: The project focused on developing water conservation strategies within the nursery industry. Water is a valuable resource, and efficient water management is crucial for sustainable nursery operations. The project explored innovative irrigation techniques, unlike the weighted or stake ended drippers, the pressure compensated dribble rings use a removable ring to distribute the water evenly throughout the pot, allowing for larger containers to be watered evenly and easily. drip irrigation and precision irrigation (fertigation) systems, to optimize water and fertilizer use efficiency, minimize water and nutrient losses at same time ensuring adequate water for optimal plant growth. These strategies contribute to the conservation of water and nutrient resources and reduce the environmental impact of nursery /greenhouse operations.

28. **Integrated Pest Management (IPM):** The project integrated nutrient management with IPM strategies to promote holistic and sustainable pest control practices. Nutrient imbalances can make plants more susceptible to pests and diseases. By optimizing nutrient levels and providing plants with proper and optimal nutrition through 4R nutrient stewardship, the project enhanced plant health and resilience, reducing the need for chemical pesticides. Under this, Pesticide Certification Training Program was introduced in collaboration with the University of Tennessee, the Tennessee Department of Agriculture and the College of Agriculture, Tennessee State University. A total of 30 minority undergraduates, graduates, field staff and faculty participated in the Pesticide Training Certification Category 10. Eighty percent of the participants successfully passed the exam and received their Pesticide Certification. This has resulted in prudent and appropriate and unwanted scheduled pesticide application.

29. **Digital Tools and Decision Support Systems**: The project harnessed the power of digital tools and decision support systems to assist growers in making informed nutrient management decisions. It trained and developed user-friendly monitoring and management of online recommendations, and monitoring tools. By leveraging digital technologies, growers could streamline their nutrient management processes, improve accuracy, and optimize resource allocation.

Project Outputs:

a) *September 12 – 13 at Wilson County Exposition Center, Lebanon, TN.*
This was an important nursery industry event and a great place to demonstrate and display BMPs of conservation of resources for the nursery, landscape or garden center industry. We gladly participated at the Tennessee Nursery & Landscape Association and the Middle Tennessee Nursery Association Tennessee Green Industry Expo. At this event, we set up an exhibition booth to demonstrate and display 1) various ecofriendly substrate mixes such as coir, peat, and fresh and aged pine bark amended lime or gypsum as a calcium source for container production adjusted to the needs of the various container grown nursery crops, 2) the critical importance of monitoring the pH and EC of container leachate, irrigation water and nutrient solution for optimal plant growth and development, 3) the required adjustment to consider when using the fresh versus aged pine bark in terms water holding capacity, wettability and frequency of watering, 4) various types fertilizer sources and rates for application based on the 4R nutrient stewardship i.e. right rate, source, timing and placement methods to minimize leachate and runoff of nutrients and to conserve resources.

b) *June 26, 2019 at Tennessee State University, TN*
A hands-on workshop entitled 'The art and science of growing plants in containers' was conducted at the Barn Building, College of Agriculture, promoting and engaging minority groups to venture and develop career in nursery industry. The goal was to equip them with new and improved knowledge and technology for container grown nursery crops with conservation practices build into it.

c) *July 25, 2019 (Tennessee State University Nursery Field Day) at the Otis Floyd Research Station, McMinnville, TN*
We set up a booth and displayed various substrates, and live plants with nutritional disorders due to inappropriate use of fertilizer source and rate, and untreated alkaline water for irrigation. These types of issues could be resolved by demonstrating the selection and delivering the BMPs of proper nutrient management in their production system.

d) *July 28-31 participated and presented at the 74th Soil Water Conservation Society (SWCS) International Annual Conference, Pittsburgh, Pennsylvania.*
The title of the Presentation: Practicing 4Rs (Right: Source, Rate, Time and Place) Nutrient Stewardship Management and Conservation for Container

Grown Blueberry.
Abstract: Some species are more sensitive to sub/supra optimal nutrient supply than others. This is significant in species of Ericaceae family that prefer ammonical (NH_4) form nitrogen rather than nitrate (NO_3) nitrogen form for healthy growth and development. It can be a challenge to produce container grown blueberry plants in nurseries just by providing all the 14 essential nutrients, without any concern for the right source and rate of nitrogen fertilizer. Failure to deliver appropriate nitrogen source may result in imbalance in nutrient availability for uptake. This could result in poor growth and nutrient deficiency, which express the visual symptoms on shoots specific to that specific nutrient. Referring to the documented visual deficiency symptoms with description guidelines, nursery growers could develop a precise corrective measure that leads to conservation of resources. Once a nutrient deficiency has been confirmed, a consideration of the 4R's should be made before applying a corrective fertilizer treatment. The 4R concept of Nutrient Stewardship consists of determining the "Right" way to meet the needs of blueberry plants considering: The Right Source of nutrient applied at the Right Rate, the Right Time, and the Right Place. This process allows blueberry growers to consider the economic, environmental, and social impacts before applying any nutrient. The BMPs of 4R nutrient stewardship and the visual nutrient deficiency symptoms of macro and micronutrient for blueberry will be presented.

e) *September 4, 2019 (Small Farm Expo) at Tennessee State University, Nashville, TN.*
Best Management Practices of Container Production: An exhibition booth was set up to address various challenges and issues that could be rectified by practicing the basics of BMPs. There were discussions on individual growers' concerns, and shared insights on how to produce healthy plants with minimal inputs and making the necessary changes in their day-to-day operation and management.

f) *September 6, 2019, at the 9th Annual Symposium, National Women in Agriculture Association (NWIAA), Nashville, TN*
A presentation entitled 'Road to success Container Grown Cut-Flower Production for Women Farmers' was done followed by discussion, to encourage women growers to participate in the BMPs of container production and venture into lucrative nursery industry.

g) *April 5, 2019 in Memphis, Tennessee. Tristate (Arkansas, Mississippi and Tennessee) Panel discussion with the minority farmers*.
Engaged and promoted the prospects of container production of nursery entrepreneur program to the participants.

h) *April 1 - 5, 2019, at the 41st Annual University-Wide Research Symposium at Tennessee State University*
Symposium Presentation entitled " Non-destructive technique of diagnosing iron

deficiency symptom in Raspberry species cv. ‘Caroline. Glencoe and Natchez’". The Rosaceae species are sensitive to iron deficiency. Growers have little information about diagnosing iron deficiency at various stages including the early onset of symptoms. The participants were provided with information on how to diagnose the iron deficiency symptoms at different stages and rectify the issue with a given set of non-destructive protocols.

i) A draft fact sheet has been prepared on *Economics of adopting BMPs: Benefit:Costs of Alternate Nutrient Management Program (Illukpitiya, P and Pitchay, D)*. The fact sheet provides information about the importance of alternate nutrient management program and guide for producers to analyze their own additional costs for nutrient management program. Draft factsheet was updated during first half of the fall semester.

j) A spreadsheet has been developed to gather information about benefits: costs of starting small scale BMP project site. The information was based on the demonstration site established at TSU experimental station. This was done with the input from PI, Dr. Pitchay. Model includes startup costs and various operational costs for model BMP site. The data were gathered, and costs analysis has been completed. The analysis will be updated with additional components to be added for the model demonstration site at TSU, which include rainwater harvesting system and water filtration system.

k) The investment costs for water filtration system is in progress. Various filtration systems were identified. Based on the information gathered, the cost analysis is in progress.

l) Upkeep of the demonstration site - the pot-in-pot container production system at the TSU main campus for teaching and workshop trainings for growers, extension agents and students.

m) A show case unit of Nutrient Delivery System has been set-up at the demonstration site (Tennessee State University Main Campus Research and Education Center) for pot-in-pot container production system and above ground pots. The system provided precise nutrient that accurately dispenses the desired fertilizer rate to plants in the container. It saves and minimize the run-off from pots (containers) and improve plant growth. It runs on existing water pressure without using external power source. This nutrient delivery system also monitors the water pH and regulate the right water pH and by supplying the appropriate nutrient of right source, at the right rate, at the right time and using the right method of application. We demonstrated the 4R nutrient stewardship of plant nutrient management to synchronize the bioavailability of optimum rates of macro and micronutrients for plants grown in pots.

n) A new demonstration on the plant growth development influenced by sub and supra-optimal rates of fertilizer and nutrient run-off using various ratios of

Ammonium (NH_4): Nitrate (NO_3) form Nitrogen source for evergreen and deciduous species has been set-up.

o) Demonstrated different ratios of substrate component mix for large container of nursery crops to improve the overall water holding capacity, to minimize the run-off and drying of substrate for an extended period. This has resulted in improvement in plant growth and shorten the production cycle.

p) Setting-up of new techniques in container production practice focusing on the water conservation by improving the water-holding capacity of container substrates and minimizing the water run-off

Electronic Media Publication and Website:

1. Pitchay, P. 2019. Conservation Practices for Container Plant Production: Advocating Best Management Practices for Greenhouse and Nursery Production Systems https://www.tnstate.edu/4rconservation/
2. Pitchay, P. 2019. Growing Blueberries http://www.tnstate.edu/4rconservation/documents/growing-blueberries.pdf
3. Pitchay, P. 2020. Best Management Practices of Container Grown Blueberry Production https://www.youtube.com/watch?v=Ppy8H-lg4e0
4. Pitchay, P. 2020. Understanding Iron Nutrition in Container Plants https://www.tnstate.edu/4rconservation/ironnutrition.aspx
5. Pitchay, P. 2020. Better Management Practices to Conserve Inputs in Container Production https://www.tnstate.edu/4rconservation/containerbmps.aspx
6. Pitchay, P. 2021. Impact of nitrogen (N) form Fertilizers – Ammonium (NH4): Nitrate (NO3) https://www.tnstate.edu/4rconservation/knowledgebase.aspx
7. Pitchay, P. 2021. Blueberry Monitoring substrate pH, EC and Nutrient http://www.tnstate.edu/4rconservation/documents/Blueberry-Nutrient-Monitoring.pdf
8. Pitchay, P. 2022. Blueberry 4R-Nutrient Stewardship-Flowchart https://www.tnstate.edu/4rconservation/documents/blueberry-flowchart.pdf

Extension Posters: Macro and micronutrient deficiency symptom posters: To assist nursery growers, students, and extension agents to identify and make the appropriate corrective measures to conserve resources and reduce pointless inputs during production

1. Pitchay, D.S. and Mikkelsen, R 2022. NUTRIENT DEFICIENCIES: RASPBERRY MACRO AND MICRONUTRIENTS
2. Pitchay, D.S. and Mikkelsen, R 2022. NUTRIENT DEFICIENCIES: BLUEBERRY MACRO AND MICRONUTRIENTS

Selected documents attached below

- Patents –Two patents pending – 1) Fertilizer formulation for selected container

grown ornamental species;
2) Specially designed containers promotes robust plant growth in container grown plants.

- Copyrights- 1) Blueberry Nutrient deficiency poster (attached)
    - 2) Raspberry Nutrient deficiency poster (attached)

•Software – It is still at developmental stage and not fully developed for adoption

- Trainings or outreach events:

	Training / workshop title	Venue	Date
1	Container gardening for urban living	Massey Auditorium, Cheekwood, Nashville, TN	March 9, 2019
2	Symposium Presentation entitled " Non-destructive technique of diagnosing iron deficiency symptom in Raspberry species cv. 'Caroline. Glencoe and Natchez'". The Rosaceae species are sensitive to iron deficiency	*41st Annual University-Wide Research Symposium at Tennessee State University*	*April 1 - 4, 2019*
3	Urban Farming – Tristate (Arkansas, Mississippi & Tennessee)	Tom Lee Engagement Center Riverside Dr. Memphis, TN	Apr 5, 2019
4	Diagnosis of micronutrient deficiency - B, Cu, Fe, Mn, and Zn	ASHS Webinar Series at National level	Apr.9, 2019
5	Hands-on training workshop where participants were constructing and setting-up the 'T' frame growing day-neutral strawberry	Memphis, TN	May 24, 2019
6	The art and science of growing plants in containers	Barn Building, College of Agriculture	June 26, 2019
7	Day-neutral strawberry production best management practices	Memphis, TN	June 27, 2019
8	New Farm Academy – Presentation title: Visual Nutrient Deficiency Symptoms in Major Horticultural Crops	Zoom online	July 22, 2021
10	*Participated and presented entitled "Preference towards Nitrogen Forms Differs in Common Fig (Ficus carica) and Knockout*	*76th Soil Water Conservation Society (SWCS) International Annual Conference,*	*July 26-28, 2021*

	Rose (Rosa radrazz)."	*Pittsburgh, Pennsylvania.*	
11	Presentation title: Container Gardening Do's and Don't	Small Farm Expo at Tennessee State University, Nashville, TN.	Sept 2, 2021
13	Demonstration and display BMPs of conservation of resources for the nursery during Tennessee Nursery & Landscape Association and the Middle Tennessee Nursery Association Tennessee Green Industry Expo	*Wilson County Exposition Center, Lebanon, TN*	Sept 12-13, 2019
14	Garden Plant Nutrient Management & Fertilizers – Testing soil pH & EC	James Ward Ag. Center, Lebanon, TN	Sept. 24, 2019
15	Panel speaker during documentary "Pollinators"	Tennessee State University	Nov 6, 2019
16	Greenhouse and High Tunnels	Shelby County Extension Office 7777 Walnut Grove Road Memphis TN 38120	Nov. 15, 2019
17	Plant Nutrients & the Critical Diagnosis of Nutrient Deficiency	Cool Springs Marriott Convention Center	Feb 20, 2020
19	Transplanting a Seedling	Online - Zoom	May 14, 2020

	Traing workshop title	Venue	Date
1	New Farm Academy – Presentation title: Visual Nutrient Deficiency Symptoms in Major Horticultural Crops	Zoom online	July 22, 2021
2	Presentation title: Container Gardening Do's and Don't	Small Farm Expo at Tennessee State University, Nashville, TN.	Sept 2, 2021
3	Outreach Workshop Women in Agriculture. Presentation title: Greenhouse Management	Online -Zoom	Nov. 4, 2021
5	Small Farm Expo: Container production of Food Crops for Urban/Peri-urban Residents	Agriculture Research and Extension Center, Main Campus of Tennessee State University	Sept. 8, 2022 9.00 am – 12.00 noon
6	Advisory Board Meeting Presentation: Endless Possibilities of growing fruit crop and ornamentals in	Agriculture Research and Extension Center, Main Campus of Tennessee State	Sept. 30, 2022 10.00 am -12 noon

	Containers	University	
7	Outreach Workshop Women in Agriculture hands-on workshop : Growing crops hydroponically	Farrell-Westbrook Room 118, College of Agriculture	Nov. 4, 2022 9.00am – 12.30 pm
8	Hands-on Workshop Learn to Grow Healthy Seedlings for Your Farm / Garden	EverBloom Farms Nursery 6165 Benjestown Rd. Memphis, TN 37208	Feb 2, 2023 9.30am – 12.0 noon

Selected Images of Outreach Training Activities Promoting Best Management Practices

Appendices: Scroll down.

Appendices:

Figure 1: Growers interacting with the graduate students on container production during Small Farm Expo

Figure 2: Demonstration booth at trade shows Tennessee Nursery & Landscape Association Green Industry Expo - September at the Wilson County Exposition Center, Lebanon, TN

Figure 3: Drs. Prabodh (top) and Pitchay (bottom) Manning the booth Hands-*on workshop on The Art and Science of growing plants in at Tennessee* State University, Nashville, TN

Figure 4: Demonstration of potting plants

Figure 5: Students working on potting the plants in containers.

Figure 6 Training of Minority Grower in actual commercial production nursery area

Figure 7 & 8: Minority Growers participating in formal container production training.

FIGURE 9 & 10: INTERACTING WITH GROWER AND EXCHANGING NEW AND IMPROVED TECHNIQUES OF BEST MANAGEMENT PRACTICE.

Figure 11 &12. Demonstrating inter-row green cover to prevent erosion and leaching. Focusing on Significance of green cover along the rows in nursery.

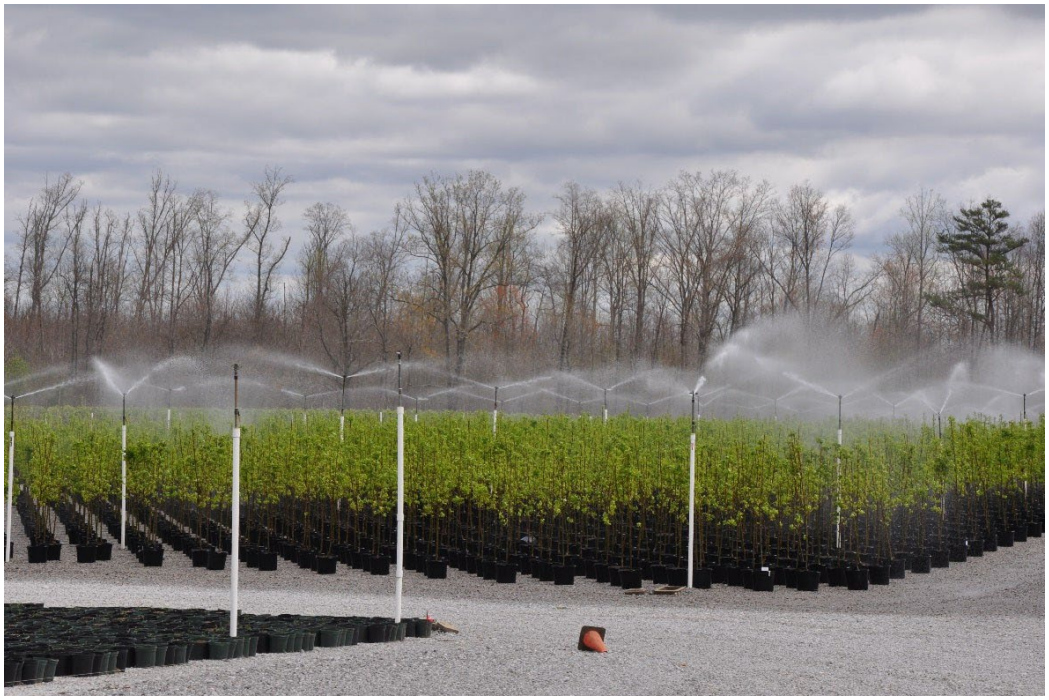


Figure 13. Focusing on the conservation water in nursery production.

Figure 14. Focusing on the conservation – recycling of water and nutrient runoff nursery.

Figure 15 & 16. Hand-on training of Promoting Best Management Practice at a training session next gen.

Electronic Visual Diagnosis of Macro and Micronutrient deficiency symptoms of Raspberry