UF/IFAS Fertilizer Rate and Nutrient Management Studies
Addressing SB 2500 (SA 1510A), FY 2023-24

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First Quarterly Report to FDACS-AES
Period covered: August 1 to September 30, 2023
Report date: October 30, 2023

Scope of work

To conduct a study designed to examine the appropriate rate for applying fertilizer on tomatoes, potatoes, citrus, corn, green beans, and any other crop identified by (UF/IFAS) as needing further research for normal and economical crop production. The study shall include recommendations on best management practices for supplying fertilizer to the crop to achieve maximum yield and quality goals of the grower while doing so in a manner that minimizes nutrient inefficiencies to the environment.

First quarter state-level highlights

We continued 14 projects from FY 2022-23 and added 5 new projects for FY 2023-24.

Activities and accomplishments

- Field work (fertilizer applications; soil and plant sampling; collected crop response data; soil moisture measurements; prepared sites; planted new experiments; collected water samples; planted cover crops; harvested crops).
- Data analysis (crop yield, quality, and nutrient content; drone images; plant sensor data; soil test results).
- Research and extension planning (research teams collaborated ; met with grower-cooperators; selected field sites; collaborated with state agencies; develop surveys).

Significant findings and/or events occurring during the quarter

- Crop response (first-year nutrient application rate responses revealed for dryland corn, irrigated corn, snap bean, watermelon, peaches, and limpograss; described crop response to the other 3 of the 4Rs).
- Grower, stakeholder, and colleague education (field days; BMP Summit; Citrus & Specialty Crop Expo; Florida Tomato Conference; UF/IFAS Plant Nutrient Oversight Committee; ASHS conference; manuscripts submitted; articles published).
- Soil testing revelations related to analytical procedures.
- Models improving.

Activities planned for the subsequent quarter

- Field work (field plot preparation; soil and plant sampling; collect crop response data; install field sensors; apply fertilizer; harvest crops).
- Data analysis (soil testing; crop yield and quality; other crop response data).
- Planning (meet with grower-cooperators; plan fall, winter, and spring research; identify stakeholders).
- Education and information sharing (field days; Tri-Societies conference; prepare publications; distribute survey).

Progress made towards overall project objectives

- Foundational work accomplished.
- Building capacity through equipment acquisition.
- Successful completion of first-year experiments.
- Expanding research scope.
- Well-connected and coordinated with growers and other external participants.

Identified obstacles or challenges

- Hurricane Idalia damaged some Suwannee Valley grower-cooperators.
- Delays (supply chain, lab analysis, equipment repair, soil sampling, hiring qualified personnel).
- Difficult to find suitable experimental sites on commercial farms.

Individual investigator quarterly reports (from north to south)

1. **Optimizing Nitrogen Management by Improved Fertilizer Placement and Utilizing Enhanced Efficiency Fertilizers** – Hardeep Singh – WFREC, Jay

Activities and accomplishments

- Harvested corn and industrial hemp trials.
- Collected data in cotton trials.
- Progress on nutrient management studies in cotton was discussed during the Extension Farm Field Day on August 24th, 2023.
- The research team met weekly to discuss the progress on the trials and data collection.
- All cotton trials were defoliated.
- The Rapidscan C-45 was received from Holland Scientific and it was used to measure NDVI/NDRE vegetation indexes.
- We demonstrated the lysimeters used to account for leaching losses and acid traps that account for ammonia volatilization.

Significant findings and/or events occurring during the quarter

- For different controlled release fertilizers, the highest corn grain yield of 10,021 lbs/acre (179 bushels/acre) was obtained with the urea + Anvol (urease inhibitor) treatment at

an application rate of 180 lbs N/acre). This yield was not significantly different from yields obtained using conventional urea and methylene diurea. Polymer-coated urea (PCU; 41-0-0) did not perform well, as yield (95 bushels/acre) was significantly lower compared with conventional urea at all N rates.

- For the "right placement" experiment, the highest grain yield of 189 bushels/acre was obtained with urea surface broadcast at application rate of 180 lbs N/acre. However, this yield was not significantly different from that obtained by a banding the fertilizer at the same application rate (185 bushels/acre).
- We organized an Extension Farm field day on August 24th, 2023, where we demonstrated and discussed our nutrient management cotton trials with producers and shared some preliminary results.
- Visually, we saw little to no difference when comparing plants receiving controlled release fertilizers vs. water-soluble (urea) nitrogen.

Activities planned for the subsequent quarter

- Cotton trials will be harvested.
- Graduate students and PI will work together on analyzing the data from all trials.
- The results from the first-year trial will be presented at 2023 ASA-CSSA-SSSA meeting in St Louis on Oct 29-Nov 1.
- The preliminary results will be discussed with the producers during the extension meetings in different counties.

Progress made towards overall project objectives

- We made progress on the foundational work needed to enable evaluation of N fertilizer management for agronomic row crops in North Florida that will lead to improved BMPs for crop fertilization.
- Field trials for corn and industrial hemp are harvested and cotton trial will be harvested within the next 2 weeks.
- Excellent progress was made on sourcing and purchasing equipment and hiring the required personnel for the project.
- We are on target to achieve the project objectives.
- The FY 2023-24 plan of work is **20% complete**.

Identified obstacles or challenges

- None.

2. **Developing Site-Specific Recommendations on Nitrogen Application Rates and Timing for Cold Hardy Citrus Production in North Florida** – Muhammad Shahid – NFREC, Quincy

Activities and accomplishments

- Application of final fertilizer treatments for 2023.
- Soil and tissue were sampled and prepared for analysis.

- Data were collected on SPAD (leaf greenness) and physiological attributes.
- Soil moisture data were collected through moisture sensors.
- Hired additional employees to help in data collection.

Significant findings and/or events occurring during the quarter

- Tissue and soil sample analysis results were statistically analyzed.

Activities planned for the subsequent quarter

- Fruit harvesting for yield and quality evaluation.
- SPAD, tree canopy, and physiological data collection.
- Citrus field day will be held in October 2023.
- Meeting with participating growers to update project progress.

Progress made towards overall project objectives

- Project activities are going in the right direction to achieve the set objectives.
- All project activities planned for the 2022-23 growing season were successfully accomplished.
- Tissue and soil sampling for 2022-23 are complete and results of analysis have been compiled. Data collection for the next phase (2023-24) is in progress.
- All the participants, students, postdocs, extension agents, growers and investigator are very well connected to achieve the targeted objectives.
- The FY 2023-24 plan of work is **10% complete**.

Identified obstacles or challenges

- The severe freeze in December 2022 and the late freeze in March 2023 caused 70 to 80% yield loss in the 2022-23 season. We had to remove about 40 to 50% of the wood that died due to freeze damage. But the trees are recovering well and should produce yield in 2024 barring more freezes.

3. **Precision Ag Research to Fill Knowledge Gaps and Increase Adoption in North Florida Nutrient Best Management Practices** – Robert Hochmuth – NFREC Suwannee Valley, Live Oak

Activities and accomplishments

- Continued acquiring equipment, including field plot ATVs and a John Deere 6R 120 Tractor. We have purchase orders in place for two pick-up trucks still being delayed due to supply chain issues.
- The research team completed two snap bean fertilizer trials in the spring 2023 season. Data were analyzed in the first quarter and is now being assimilated into a final report.
- The new Veris rig was used at one high tunnel vegetable farm in Hamilton County to support ongoing research and extension activities.

- For several trials bridging the spring and summer months, soil moisture probes were used as part of on-farm demonstration trials at 12 farms evaluating controlled release fertilizer on watermelons, grain corn, and sweet corn in Gilchrist, Levy, and Alachua counties. Soil moisture probes are also being utilized in other demonstration projects such as on-farm corn N rate studies and comparing "Everlizer" poultry manure and controlled release fertilizer in Madison and Dixie counties.
- Fertigation equipment was used this past spring and summer to implement a watermelon BMP study on nitrogen.
- Our NFREC-SV team has continued discussions with the leadership group from FDACS-OAWP, FDACS-AES, and the Suwannee River Water Management District. These discussions have led to the planning of a large regional cost-share project proposal for the Suwannee Valley. Numerous tours and meetings at NFREC-SV and in the region on farms have been held to communicate activities being led by UF/IFAS County and State faculty to further the progress of BMP adoption in this region.

Significant findings and/or events occurring during the quarter

- The research team has summarized previous N rate and source studies with snap beans in north Florida during the past 3 years. This summary has identified gaps in N fertilizer research for the region's sandy soils is guiding research plans for spring 2024 snap bean trials.
- A snap bean CRF N research update was presented by Robert Hochmuth at a "BMP Summit" held in Citra this quarter. The 3-year project showed no snap bean yield increase above 50 lbs N/acre when following peanut (legume) the previous year. In addition, there was no significant difference in snap bean yield or quality in response to how 100 lbs CRF N/acre was placed (broadcasting vs. banded at planting).
- Controlled release fertilizer demonstrations were successfully implemented on seven watermelon and three corn farms. One clear finding is the impact of N use under various irrigation management strategies.
- Several other on-farm BMP demonstrations have been implemented. This project has led to further discussions between UF/IFAS, FDACS-OAWP, and Florida DEP to develop and potentially fund a large regional BMP project in the Suwannee Basin in the upcoming year.
- A watermelon N fertilizer trial was conducted in the spring of 2023 to compare various N sources and delivery methods, including two controlled release N programs, a season-long "all liquid" fertigation program, and a conventional program of dry fertilizer applied to the plant bed followed by fertigations. Data are currently being summarized, but it appears there were no significant yield differences between any of the four N treatments that each delivered the recommended rate of 150 lbs N/acre.

Activities planned for the subsequent quarter

- Starting October 10th, Sydney Williams begins a Research Coordinator II position. Sydney will document and communicate BMP research and extension activities conducted in NE Florida. The plan is to develop one-page summaries of BMP activities being conducted

at NFREC-Suwannee Valley and on-farm projects in surrounding counties in the Suwannee Valley region. In addition, we envision developing a web site to geographically link on-farm projects through a regional map where web page visitors will be able to see a brief description of ongoing projects.

- The snap bean team will meet in October to review all previous and current research projects and develop a plan for publications (EDIS or journal articles) of the CRF rate work and placement work. We will also discuss further snap bean research that may be needed, including N rate trials on fields where a legume was the previous crop.
- Watermelon data are being compiled and will be shared with individual growers in the next quarter. A final report on the watermelon N program trial will be developed and presented to the Florida Watermelon Association and at the Suwannee Valley Watermelon Institute.

Progress made towards overall project objectives

- The five quarters of this project have been focused on building capacity through equipment purchases and completion of snap bean research trials. Great progress has been made on identifying sources of the equipment and following protocol toward the purchase of the equipment.
- Snap bean N treatments in the spring 2023 trial (two locations) included CRF broadcasted pre-plant and CRF banded in a 15-inch over the row. This trial was harvested with the new harvester, and yield and quality data were collected. This project will help fill in research gaps on a broad range of snap bean fertilizer aspects and will build upon recent IFAS snap bean research in North Florida including nitrogen rate, source, and methods of application.
- Equipment purchases have increased the capacity to do further nutrient management research and extension activities in this region, both at the NFREC-SV and on farms. Target crops in addition to snap beans for which BMP related activities continue include corn, cotton, watermelon, carrot, and potato.
- The FY 2023-24 plan of work is **25% complete**.

Identified obstacles or challenges

- The main challenge has been in equipment purchases with supply chain issues delaying delivery times. Otherwise, this project has proceeded well.

4. **Quantifying Nitrogen and Phosphorus Losses Using Advanced Tools to Estimate Nitrogen and Phosphorus Requirements** – Lakesh Sharma – Soil, Water, and Ecosystem Sciences, GNV

Activities and accomplishments

- Corn was harvested on August 15 from the nitrogen rate study plots and on August 23 from the lysimeter plots.

- Final biomass and soil samplings were performed at harvest. Plants were divided into six parts (roots, stem, leaves, husks, cobs, and grains) for N removal analysis.
- A cover crop trial was planned for the same plots where the corn was planted to evaluate the biomass production and N mineralization by the cover crop mix (Arugula, mustard, sorghum sudangrass, and sunn hemp) resulting from different N rates applied to the corn crop.
- Cover crop seeds were blended and planted at the rate of 25 lbs/acre on September 13th to the whole quarter of the center pivot irrigation circle where the N rate study was conducted. Alleys between plots and blocks were cleared out to delineate the study plots.
- A PhD student was recruited and will begin work on the cover crop trial employing use of sensors previously purchased for this project.

Significant findings and/or events occurring during the quarter

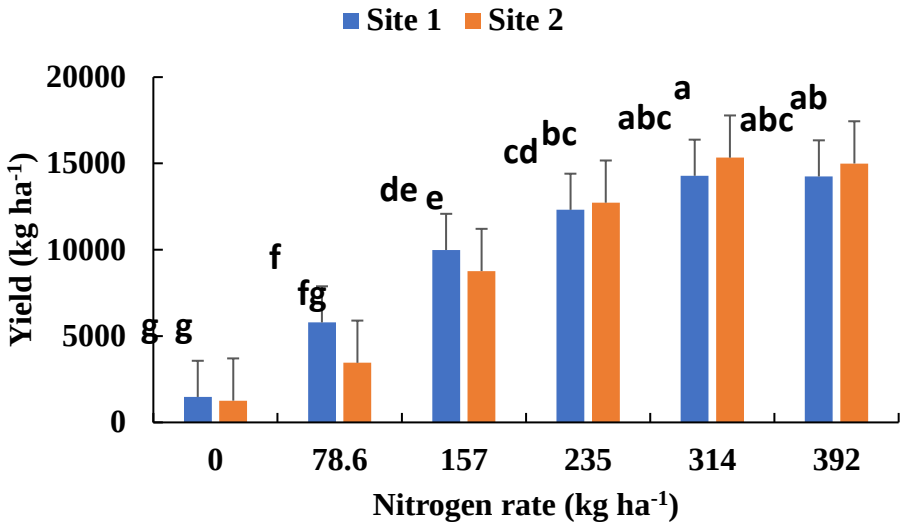
- A "BMP Summit" was held on August 10 and 11 at the Plant Science Research and Education Unit in Citra to present the progress of the N rate study among other research trials from our BMP group. It was a mixed event (online and in-person attendance), with more than 50 participants.
- A second manuscript entitled "Yield and plant height predictions of irrigated maize through remote sensing in North Florida" was submitted to Computers & Electronics in Agriculture. Authors: Diego Arruda Huggins de Sá Leitão, Ayush Sharma, Aditya Singh, and Lakesh Sharma. We are waiting on the journal editor's decision.

Activities planned for the subsequent quarter

- Write a nitrogen budget paper including data from both sites and both years.
- Write a review paper on N management for corn in Florida.
- Sample biomass at 30-day intervals in the cover crop trial.
- Monthly collection of leachate samples from the lysimeter plots.
- LICOR LI-600 will be purchased to measure stomatal conductance and chlorophyll fluorescence.

Progress made towards overall project objectives

- The following figure shows the relationship between nitrogen (N) rates and corn yield for Site 1 and Site 2 in 2023. Analysis of variance results showed that the interaction between location (Site 1 and Site 2) and N rates (0, 70, 140, 210, 280, and 350 lbs N/acre) was significant. Tukey's test was performed to compare yield means across rates x sites. The highest average yield was observed in Site 2 at 280 lbs N/acre, while lowest average yields were observed where no N was applied regardless of location.



- We noticed that the yields at the two highest N rates were lower compared with the previous year, likely due to the N deficiency observed at V10 in the plots this year.
- We still did not receive the complete dataset results for soil and plant data (soil nitrate-N and N uptake). Therefore, we were not able to analyze the data statistically. As soon as we receive the remaining results, we will analyze the complete data set, including both sites and both years.
- The FY 2023-24 plan of work is **15% complete**.

Identified obstacles or challenges

- None.

5. Optimizing Phosphorus Management for Snap Bean Production in North Florida – Guodong (David) Liu – Horticultural Sciences, GNV

Activities and accomplishments

During this quarter, the key activities and accomplishments were:

- August 9: Snap bean, 'Caprice' seeds were purchased.
- August 22: Land was prepared and Telone II was applied to fumigate the soil in Bed 316 at HAEC.
- August 18: Fertilizers were applied (10-0-10 and 0-46-0 separately).
- August 18: 'Caprice' snap bean seeds were planted.

Significant findings and/or events occurring during the quarter

- Initiation of fall field work.

Activities planned for the subsequent quarter

For the next quarter, the following activities are planned:

- Data collection: Plant growth, soil nutrient concentrations, SPAD and petiole sap readings.
- Fertilizer application: The remaining (60%) N and K derived from 8-0-8 liquid fertilizer will be applied on October 16.
- Snap bean pods will be harvested by November 3.
- Data Analysis: Soil P, pod yield, and nutrient uptake.

Progress made towards overall project objectives

- Last year, we highest bean yield occurred at a P fertilizer rate of 160 lbs P_2O_5/acre. This year, two P rates of 200 and 240 lbs P_2O_5/acre were added.
- In spring 2024, we will start a new trial in Citra. After this year's project is completed, we will get much closer to the overall objective of the project.
- Our project is on the right track. We are optimistic about achieving our objectives for optimizing P fertilizer rates and improving nutrient management for snap bean production in Florida.
- The FY 2023-24 plan of work is **10% complete**.

Identified obstacles or challenges

- None.

6. Phosphorus Fertilizer Application Timing and Source Study for Potato in NE Florida – Christian Christensen – Hastings Agricultural and Extension Center (HAEC), Hastings

Activities and accomplishments

- Prepared production sites, equipment, and all associated farm-level resources for research farming activities directly related to the scope of work.
- Conversations with Co-PIs Drs. Lincoln Zotarelli, Lakesh Sharma, and grad student Ester Ricken are ongoing to formalize field-level production timelines for the 2024 spring potato production season. The research team visited three sites to determine the location of the field experiments at HAEC. The team prepared a plan of work, experimental design (including soil, petiole, and biomass sampling schedule), and the distribution of treatments across the research area.

Significant findings and/or events occurring during the quarter

- None yet. Efforts are ongoing to review the results from the Spring 2022-2023 production season to identify opportunities for improved research outcomes during the spring 2024 potato production season and trial.

Activities planned for the subsequent quarter

- The three production sites at HAEC will be identified and flagged for the first pre-season soil sampling event (October) and the second event (early January 2024, 30 days prior to planting in early February).

- Co-investigators will formalize spring 2024 potato production timelines and vendors from whom we will be sourcing our inputs (fertilizer, seed, chemistry, etc.).
- Commercial-grade fertilizers (10-0-10 w/sulfur, 0-46-0, 8-0-8, and 11-37-0) will be ordered in preparation of the spring 2024 production season.

Progress made towards overall project objectives

- In the past two growing seasons, we generated data evaluating potato response to P fertilizer rates and the critical value of soil test P. These data will contribute to the fertilizer rate component of 5Rs nutrient management recommendations for potato.
- In the current year we will be studying the fertilizer source and placement components of 5Rs management.
- The FY 2023-24 plan of work is **25% complete**.

Identified obstacles or challenges

- HAEC is having difficulty receiving critical equipment back from certified mechanics conducting repairs. This is extending the timeline for preparing soil beds to be ready for research projects ahead of fumigation.

7. **Benchmarking Site-Specific Nutrient Management Practices in Florida Cropping Systems** – Emma Matcham – Agronomy, GNV

Activities and accomplishments

- An employee, Ms. Rachel Stormant, has been hired and onboarded at the PIE Center, and has started working with the project team.
- Survey development has started, including identifying knowledge and demographic questions that are appropriate for our target audience.
- A position description for a post doc was posted on the UF Careers website. The position has been advertised via LinkedIn and X (formerly Twitter), and there are multiple applicants at this time. The application pool will close on October 13th, and Drs. Morgan and Matcham will begin interviewing candidates later in the month.
- The project team met monthly to discuss project timelines and tasks.
- Team members have been attending calls related to the current FDACS minimum data set project, led by Ms. Kathryn Holland. This furthers our progress towards Objective B in our plan of work, and will also be beneficial during glossary development.

Significant findings and/or events occurring during the quarter

- None yet.

Activities planned for the subsequent quarter

- A project team meeting set for October 13th will focus on post doc hiring and identifying important stakeholders to generate a glossary of site-specific nutrient management terms.

- The project team will focus efforts on finalizing and distributing the survey, which is essential for all project objectives.
- The team will also begin drafting the glossary and will schedule interviews and meetings with stakeholders to review definitions and find consensus.
- We plan to hire and onboard the post doc who will be working primarily on Objective D in our plan of work, to develop a prototype decision tool.

Progress made towards overall project objectives

- The survey we are developing will help us understand current recommendation practices that agronomists are using for precision nutrient management across Florida. Understanding current practices and will allow us to identify future site-specific nutrient management strategies that are well-suited to the needs of farmers and consulting agronomists.
- The FY 2023-24 plan of work is **5% complete**.

Identified obstacles or challenges

- None.

8. **Using Artificial Intelligence for Improved Crop Nutrient Management** – Lincoln Zotarelli – Horticultural Sciences, GNV

Activities and accomplishments

- Amid limited field sampled observations for the developing machine learning (ML) model, a process-based crop model (SUBSTOR-Potato model of DSSAT) was used to generate additional simulated data for the potato field trials [conducted from 2011-2012 (four farms), 2013-2014 (two farms), and 2015-16 (one farm)] from data reported by Zotarelli et al. (2014), Rens et al. (2015, 2016, and 2018), and da Silva et al. (2023).
- The additional data generated using the DSSAT model was used to train a ML model called long short-term memory (LSTM) to understand nexus of the soil mineral nitrogen (SMN) with changing weather conditions and fertilizer application rates and timings. Subsequently, the SMN observations were used to fine-tune the LSTM model's parameters, improving its accuracy in estimating soil N levels between sampling dates. The combination of the crop model (DSSAT) and LSTM model was referred to as the hybrid-LSTM model, allowing for more accurate predictions in potato fields.
- The hybrid-LSTM model is now developed and is continuously being improved to get better results.
- Some of the features such as average air and soil temperatures possessed seasonal variability that was observed to impact the model accuracy. These seasonal fluctuations in the data could mislead the model's (hybrid-LSTM) learning in capturing the complex relationships among the features. Hence, the features were normalized by apply regression to remove the seasonal variability.

- Moreover, we performed grid-search to find the best hyperparameters for the hybrid-LSTM model including learning rate, number of hidden units, and farms and years combinations for training/testing the hybrid-LSTM model.
- DSSAT and hybrid-LSTM model performance is assessed and compared using the normalized Root Mean Squared Error (nRMSE), which calculates errors through two approaches. In the first approach, we employed nRMSE comparing predictions to the mean values of the replicant bounds at different sampling stages. In the second approach, we employed a new metric called Passing Error (PE) to calculate nRMSE if the prediction falls outside the replicant bounds, whereas if predictions lie within the replicant bound the nRMSE is equal to 0. PE reflects the extent to which the prediction deviates from the nearest bound.

Significant findings and/or events occurring during the quarter

- We noticed that the hybrid-LSTM effectively enhanced the accuracy of SMN estimates generated by the DSSAT model, resulting in reduced variability in the estimates between the sampling dates.
- The hybrid-LSTM model estimated the SMN with 26.1/32.5% (nRMSE/PE) and 18.3/21.8% improvement in training and testing farms-years, respectively.
- Overall, the hybrid modeling approach could produce more reliable SMN time series. However, there were a few farms and years where the hybrid-LSTM could not outperform the DSSAT model. The possible reasons could be the limited experimental observations, incorporating a generalized modeling approach for the farms with slightly different textures, or inconsistencies in the DSSAT simulated SMN on which the hybrid model was initially trained.

Activities planned for the subsequent quarter

- The developed hybrid-LSTM model for estimating the SMN would eventually be used as foundation for developing similar ML models for the potato growth and N leaching to provide the nutrient recommendations for potato.
- Our next goal is to develop several ML models by training on the DSSAT simulated data from various hypothetical scenarios to simulate various components of potato cropping system, for instance, plant biomass/N uptake, tuber yield/N uptake, SMN, and N leaching.
- The hypothetical scenarios include varying planting dates, irrigation depths, N fertilizer application rates and timings, and multi-year weather uncertainty. The main aim here is to reduce our dependency on DSSAT, as it requires a lot of data and time to calibrate.
- Moreover, we also plan to explore the hyperspectral/multispectral data from aerial images in our current model in approach. Our overarching objective is to combine drone imageries with DSSAT expertise to enhance the accuracy and informativeness of our predictions.

Progress made towards overall project objectives

- Our earlier analysis showed that soil N had a major impact on plant yield. However, the observed soil N data was limited and could not be used directly to train any ML model to estimate daily soil N. Hence, we developed a hybrid-LSTM model that could estimate daily soil N between the sampling dates.
- Our next step is to develop several ML models to estimate the influence of weather conditions and soil N on plant growth and development and N leaching using multispectral data and DSSAT simulated data on various realistic hypothetical scenarios. The combined approach would be used to provide crop nutrient recommendations under different rainfall conditions. The methodology developed would extensively be used for other crops and nutrients like phosphorus, potassium.
- The FY 2023-24 plan of work is **20% complete**.

Identified obstacles or challenges

- None.

9. Evaluation of Site-Specific Plant P Bioavailability and Lab Accuracy on Mehlich-3 P Fertilizer Recommendations – Vimala Nair – Soil, Water, and Ecosystem Sciences, GNV

Activities and accomplishments

- Recruited three full-time OPS personnel to assist with numerous lab analysis and one part-time OPS student to assist with statistical analyses.
- Accuracy and reliability of the Mehlich-3 phosphorus results among one state university lab and three commercial labs (UF Extension Lab, Central Florida Soil Lab (CFSL), Waters Agricultural Laboratories, and Waypoint) have been determined on 400 selected samples (200 in addition to soils reported in earlier report) representative of different locations in Florida (Table 1).
- The 400 samples have been analyzed for M3-P in our laboratory (colorimetrically) and in UF Analytical Research Laboratory (by ICP). This was performed to evaluate the difference of the data resulting from different methods for the same parameter (Figs. 1 and 2).
- The 400 soil samples have been analyzed for water soluble phosphorus (WSP), Haney H3A-P (with solutions sent to ARL for additional analyses), M3-P, and FeO-P in our laboratory. Data analyses are in progress.
- Another 95 soil samples, received from Dr. Shukla's group (from Gulf Coast REC and SW Florida REC), have been analyzed for FeO-P. Results and related QA/QC have been reported.
- All 800 new samples (Citrus group-Lake Alfred, vegetable group-Immokalee, Gulf Coast, Hastings) have been analyzed in-house for WSP.
- 400 selected soil samples from different parts of Florida have been analyzed for FeO-P to evaluate the availability of P to plants, P desorption kinetics and P dynamics in the field.

Significant findings and/or events occurring during the quarter.

- Table 1: Data analyses for M3-P show the following correlation (Pearson Correlation) between 4 commercial labs. Replicate analysis at each of the labs are within QA/QC requirements. These results are based on 400 soil samples (including the previously reported 200 soils). All labs used the "scoop" procedure.

	Waters	*Waypoint*	*CFSL*	*UF ext*
Waters	1			
Waypoint	0.97	1		
CFSL	0.93	0.90	1	
UF ext	0.97	0.95	0.92	1

- Figures 1 and 2: Mehlich 3-P comparison using weight (ARL) and scoop (UF Extension) procedures.

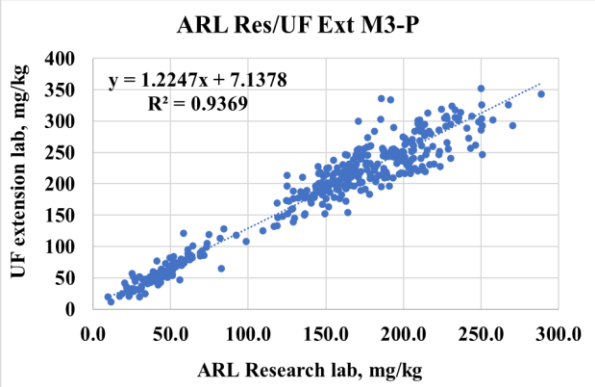


Fig. 1. Relationships between M3-P concentrations from ARL Research & UF Extension labs (400 soil samples).

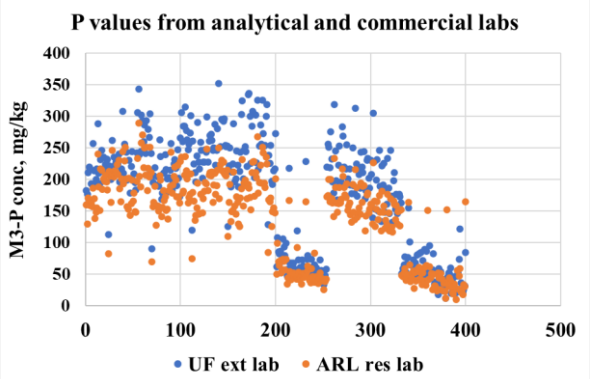


Fig. 2. M3-P values from ARL Research & UF extension labs (400 soil samples).

Statistical analyses show 22% M3-P increases in UF Extension data (Figs. 1 and 2). Note: Most M3-P recommendations are made based on analyses from ARL, while clientele use Extension Labs (UF or others) for obtaining soil test data.

Activities planned for the subsequent quarter.

- In-house M3-P colorimetrical analyses for all the 800 new samples (received in 2023 from different locations of Florida: Citrus group-Lake Alfred, vegetable group-Immokalee, Gulf Coast, Hastings). We will also perform M3-TP analyses using the same extractant, digesting it with acid and analyzing for TP (all done in-house,

colorimetrically). A subsample of the M3-P extracted solution will be sent to ARL for TP analyses by ICP.
- We will identify P in the solid state via X-ray diffraction on representative soil samples, especially when there is underlying calcareous material below a thin surface soil layer.
- Obtain the relationship of M3-P with other soil components (particularly Ca and Mg) to address variability in bioavailable P under site-specific conditions.

Progress made towards overall project objectives.

- Satisfactory progress has been made toward overall project objectives as reported above.
- The FY 2023-24 plan of work is **20% complete**.

Identified obstacles or challenges.

- Delays in obtaining field soil samples, and year-to-year funding making it difficult to recruit trained personnel.
- Lack of timely report of lab results by analytical and commercial labs.
- We have obtained new lab facilities which has resulted in additional time devoted to cleaning and rearrangement of lab space.

10. Developing Optimal Nitrogen Fertilizer Recommendations for Sod Producers in Florida – A.J. Lindsey – Environmental Horticulture, GNV

Activities and accomplishments

- Coordinated on-site field locations for the project at four sod farms.
- Prepared for trial initiation at the field sites (e.g., purchased fertilizer, organized soil/tissue testing supplies, etc.).
- Planned and scheduled trial initiation at the four sod locations for the week of October 9th.
- Checked and confirmed that all lysimeters were operational for the nutrient leaching portion of the project.
- Treatment plans, application frequency, and applications timings were established for each location.

Significant findings and/or events occurring during the quarter

- Finalized treatment plans for each location to ensure fertilizer applications followed normal practices in each region.

Activities planned for the subsequent quarter

- Establish plots and treatment applications.
- Collect field soil and tissue samples for each of the locations and grasses and send for analysis.

Progress made towards overall project objectives

- Created treatment plans for each trial location to ensure that fertilizer is applied when the grass is actively growing, which will optimize the harvest cycle and minimize potential nitrogen losses to the environment.
- The FY 2023-24 plan of work is **10% complete**.

Identified obstacles or challenges

- Finding farm locations for the different regions that would give us enough space to complete the study. A few locations only wanted to give us a small area and we are trying to have larger plot sizes.
- Coordinating when fields are harvested and trial initiation with the cooperating farms.

11. Developing a Guideline on Nitrogen-Phosphorus-Potassium Application Rates and Timing for Low-Chill Peaches Grown in Florida – Ali Sarkhosh – Horticultural Sciences, GNV

Activities and accomplishments

- Data collected on peach fruit were analyzed.
- Soil was sampled across the research plots at three depths (0-30, 30-60, 60-90 cm) and were analyzed for nutrients.
- Leaf and soil samples were collected for analysis of mineral content.

Significant findings and/or events occurring during the quarter

- Highest peach fruit quality was observed where either 2 or 3 lbs of 15-5-10 N-P_2O_5-K_2O fertilizer was applied three times per year. (The 3-lb rate totaled 1.35, 0.45, and 0.90 lbs of N-P_2O_5-K_2O per tree per year). There was no significant quality difference between the two rates.
- Weight of single fruits did not differ significantly between NPK treatments of 2 and 3 lbs per tree.
- Highest nitrate-N and ammonium-N concentrations were observed at a soil depth of 60-90 cm in the 3 lbs NPK treatment.
- The highest phosphorus concentration was found in the 3 lbs NPK treatment at the 0-30 cm soil depth.

Activities planned for the subsequent quarter

- Planning 2024 project activities.
- Managing research plots and winter pruning of trees.
- Collecting leaf and soil samples prior to the first fertilizer application in 2024.
- Apply fertilizers.

Progress made towards overall project objectives

- No statistical difference has been observed so far between treatments receiving 2 lbs or 3 lbs NPK per tree per year when evaluating peach fruit quality, yield, and general tree

nutritional status. This finding suggests an opportunity to minimize nutrient applications to peach trees, leading to reduced environmental impact.

- The FY 2023-24 plan of work is **20% complete**.

Identified obstacles or challenges

- None.

12. Determining Nitrogen Fertilization Requirements for Commercial Blueberry Production in Florida – Jeff Williamson – Horticultural Sciences, GNV

Activities and accomplishments

- Two on-farm grower locations for the research were identified. Straughn Farms near Archer, FL (Alachua County), and Wild Goose Farm near Umatilla, FL (Lake County).
- Meetings with the grower-cooperators Kyle Straughn (Straughn Farms) and Chuck Allison (Wild Goose Farms) resulted in selection of cultivars used at each site and the specific locations of experiments on each farm. It was decided that 'Sentinel' will be used at Straughn Farms and 'Optimus' will be used at Wild Goose Farm.
- The experimental designs and randomizations were determined for both locations. Each field site was laid out as a randomized complete block design with 5 treatments and six replications. Each replicated plot consists of 14 plants at the Straughn location and 13 plants at the Wild Goose location. Individual plots were marked at the Straughn Farm site. Plots at Wild Goose Farm will be marked in October.
- Pine bark, soil and leaf samples were collected at the Straughn Farms for baseline analyses. The same type of samples will be collected from Wild Goose Farm in early October (2nd quarter).
- A leaf area meter has been purchased. Purchase orders for weather stations and a fruit firmness meter have been requested.
- A postdoctoral associate has been identified who will lead the project treatment application, and data collection and analyses. Interviews were conducted with perspective candidates. A letter of offer has been signed by the new researcher and she is scheduled to begin working on the project in January 2024.

Significant findings and/or events occurring during the quarter

- As the research is new, there are no significant findings to report.

Activities planned for the subsequent quarter

- Research plots at the Wild Goose Farm will be marked by treatment according to the randomized plot plan.
- Leaf, bark, and soil samples will be collected at the Wild Goose Farm like that described for Straughn Farms.
- Plants will be measured (manually) and leaf area will be measured with the purchased instrument.

- The postdoctoral associate who will handle the day-to-day project activities will begin working on the project in early January 2024.

Progress made towards overall project objectives

- We have accomplished foundational work to achieve the project objective:
    - Two research sites on commercial farms have been identified and the grower-cooperators are engaged.
    - Samples to document initial plant and soil (and bark) nutritional status have been collected.
    - The postdoctoral associate has been identified and is set to begin working on the project in early January 2024 after graduating (PhD) in December 2023.
- Due to the growth cycle of blueberry, the fertilization treatment applications and most data collection will occur in 2024 during flowering, fruiting, and the summer growing season. The FY 2023-24 plan of work is **10% complete**.

Identified obstacles or challenges

- None.

13. Developing Site-Specific Nitrogen and Phosphorus Rates for Young and Mature Sweet Oranges, Grapefruits, and Mandarins in Florida – Davie Kadyampakeni – CREC, Lake Alfred

Activities and accomplishments

- Data collection on tree canopy size.
- Collected leaf tissue and soil samples.
- Sample preparation in the laboratory.
- Developed a draft grower survey to gather economic data.
- Participated at the American Society of Horticultural Science Annual Meeting where data from the previous year were shared.
- Hired additional personnel to help coordinate project work.

Significant findings and/or events occurring during the quarter

- We participated at the Citrus Expo in Tampa, FL where new technology on citrus production was shared with stakeholders and other interested parties.

Activities planned for the subsequent quarter

- Final round of fertilizer applications for 2023.
- Educate growers at an October Cold Hardy Citrus Field Day, North Florida REC-Quincy.
- Share the results of the project at the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America Annual Meetings.
- Harvest fruit, measure yield, and determine juice quality for Hamlin oranges and Satsuma mandarins at all project sites.

Progress made towards overall project objectives

- As research with this perennial crop progresses, we continue to build progress towards achieving the objectives.
- Sample results are in for all soil and leaf samples collected in the 2022-23 growing season.
- Data collection for the 2023-24 season is underway.
- Coordination with our grower cooperators has been effective.
- The FY 2023-24 plan of work is **10% complete**.

Identified obstacles or challenges

- None.

14. Refining Phosphorus Fertilization Recommendations for Limpograss in South Florida – Joao Vendramini – RCREC, Ona

Activities and accomplishments

- The third harvest and evaluation of the growing season was completed. Plots were harvested and evaluated for light interception and forage height. Forage samples were processed and stored for subsequent tissue P analysis.
- Seven water samples were collected from April to July 2023. The water samples were processed and have been submitted to the lab.
- The second set of membranes were incubated in the experimental area and were submitted to the UF Lab for P analysis.

Significant findings and/or events occurring during the quarter

- The results from the first set of membranes were received and there was no difference in P concentration among treatments.
- We observed that N concentration was greater after fertilization and decreased linearly from 1 to 15 days.
- Based on the P membrane concentrations, it is expected that the IFAS recommendation for P fertilization would not impact soil and water P concentration due to fast plant uptake of the P fertilizer.

Activities planned for the subsequent quarter

- The fourth harvested will be conducted in October, followed by soil sampling for nutrient concentration and microbiome determination.

Progress made towards overall project objectives

- Our research supports the idea that the current IFAS recommendation for P fertilization in limpograss is likely sufficient to promote optimum growth with no impact on soil and water P concentrations.
- The FY 2023-24 plan of work is **30% complete**.

Identified obstacles or challenges

- None.

15. Agronomic P Recommendation for Bahiagrass Pastures Fertilized with Biosolids – Maria Silveira – RCREC, Ona

Activities and accomplishments

- The experimental area was established, initial soil samples were collected, and treatments were imposed. Treatments consisted of a factorial combination of two fertilizer sources (inorganic N and P fertilizer) applied at 40, 80, 160, or 320 lbs P_2O_5/acre. Treatment selection was based P recommendations imposed by new DEP biosolids regulations (P rates of 40 to 80 lbs P_2O_5/acre/year for grazed and hayed bahiagrass, respectively). Based on site characteristics, up to 160 lbs P_2O_5/acre/year could potentially be land applied. The highest rate (360 lbs P_2O_5/acre/year) is based on IFAS bahiagrass N requirement, but it exceeds FL DEP recommendations.
- Bahiagrass was harvested on August 22 and September 25. Forage and soil laboratory analyses are currently underway.
- Rainfall simulations were conducted in September. Leachate and runoff samples are currently being processed for laboratory analysis.

Significant findings and/or events occurring during the quarter

- A new PhD student (Nikitha Kovvuri) was recruited to work on this project.
- A peer-reviewed article was published (available online 27 July 2023) - https://doi.org/10.1002/saj2.20568.

Activities planned for the subsequent quarter

- An additional forage harvest is expected to occur in November.
- Additional rainfall simulations and a greenhouse study will be conducted later this year.
- We will continue to collect data (forage and soil responses) and finalize laboratory analysis.

Progress made towards overall project objectives

- Despite the numerous agronomic benefits, land application of biosolids presents some environmental risks if not managed properly. Many of these issues are minimized through the adoption of BMPs. Recent changes in biosolids regulations in Florida are expected to force a larger portion of Class B biosolids to be disposed of in landfills or converted to Class AA materials. Although the totality of impacts of the new regulations are still uncertain, from an agronomic standpoint, pasture productivity is expected to be detrimentally affected. In addition to the reduced biosolids rates, nutrients (including N and P) in biosolids are much less bioavailable than those present in inorganic fertilizer sources. That means that if applied at equivalent rates, biosolids is expected to be less

effective than inorganic fertilizer in improving forage productivity. Farmers who have historically relied on biosolids as the main source of fertilization for their pastures and hayfields will be forced to seek out other sources of nutrients to sustain forage yields. The unintended consequence is that by replacing biosolids with commercial fertilizer production costs will increase as will the likelihood of off-site nutrient transport.

- This long-term, instrumented field trial was designed to evaluate the risks and benefits of land application of biosolids to pastures in Florida. One of our hypotheses is that reduced biosolids application imposed by new regulations will detrimentally impact forage production, nutritive value, and crop N and P recovery, mainly due to limited N and P supply.
- The FY 2023-24 plan of work is **30% complete**.

Identified obstacles or challenges

- None.

16. Developing Phosphorus Recommendations and Site-Specific Management for Tomato, Potato, and Green Beans through Large-Scale Participatory Research with Stakeholders – Sanjay Shukla – SWFREC, Immokalee

Activities and accomplishments

- Plant tissue and soil results obtained from the labs for the previous seasons were processed, consolidated, and standardized in a master database.
- QA/QC is ongoing for all plant and soil data from 2021-22 and 2022-23.
- Preliminary analyses of available yield and partial soil phosphorus data were completed for presentation to the stakeholders.
- Hydrologic modeling for one potato and one bean site was started.
- Preliminary analyses of drone images have been completed and aerial image segmentation is ongoing for selected tomato sites. The aerial image analysis is used in canopy area calculation, a feature that alongside soil Mehlich-3 phosphorus (P) and P fertilizer input will be used to evaluate yield response.
- A series of meetings and subsequent field trips were conducted with two tomato grower cooperators in south and central Florida to select tomato sites for 2023-24 experiments. For this purpose, soil maps from Web Soil Survey and soil profile checks at multiple locations in several fields were used to assess spatial variability of soil horizons. Soil samples are taken to evaluate background soil Mehlich-3 P values. These analyses are combined with the annual soil test results from the grower-cooperator to select the appropriate sites.
- Four experiments (two tomato in south Florida plus one tomato and one bean experiment in central Florida) were started. Soil samples were collected and sent to the lab for nutrient analyses.
- Drone flights for aerial imagery of the tomato experiment started in central Florida.
- Hydrologic instruments were installed at the tomato sites.

- A post-doctoral associate was hired for the south Florida experiments.

Significant findings and/or events occurring during the quarter

- Four experiments (two tomato experiments in south Florida plus one tomato experiment and one bean experiment in central Florida) were planned and started.
- Given that we are early in the 2023-24 vegetable growing season, there are no significant findings to report.
- Three presentations on project results and plans were made to industry and stakeholders:
    - A presentation to the Florida Tomato Conference 2023 organized by UF/IFAS on September 13th. Attendees included tomato growers and allied industry, commodity leaders, local and state agencies, and attendees from universities.
    - A presentation to the UF/IFAS Plant and Nutrient Oversight Committee (PNOC) on September 13th was made by the team leader to provide an update on the project including preliminary analyses and upcoming plans for next year.
    - A team presentation was made at the Citrus & Specialty Crop Expo in Tampa to update the attendees on phosphorus projects across the state.
- A team of four post-doctoral associates on the project made four presentations in August at the 2023 ASHS Annual Conference in Orlando.
- The project team continued to disseminate results to individual growers through one-to-one meetings (onsite, telephone, virtual) to discuss the goals and plans for upcoming experiments and receive grower-cooperator feedback in improving design and implementation of experiments.

Activities planned for the subsequent quarter

- Continue to compile the plant and soil data from the analytical labs. Process and ship samples to the lab.
- Hold regular follow-up meetings with waters lab to avoid backlog.
- Continue QA/QC of all plant, soil, and hydrologic data.
- Meet with potential bean and potato grower-cooperators in central and south Florida to plan the 2023-24 experiments.
- Conduct site visits, preliminary soil assessment and background soil sampling to identify sites with grower cooperators. Work with Waters Lab to get soil analyses results (Mehlich-3, Ca, and pH) within 48-72 hours to be able to discuss with the grower cooperators and finalize site selection in time that meets the grower-cooperator's planting schedule.
- Conduct soil, leaf, and biomass samples.
- Collect hydrologic data and aerial imageries.
- Identify harvest data plots for tomato experiments.
- Continue hydrologic modeling at one potato, one tomato, and one bean site.
- Continue to maintain communication channels with grower-cooperators to discuss interim results, arrange field visits, get grower commitments, and identify sites for 2023-24 experimental sites.

- Install hydrologic instruments, including rain gauges, and plan drone missions for selected sites.

Progress made towards overall project objectives

- Given that the 2023-2024 season has recently started and the experiments are ongoing, no major progress has been made during the first quarter.
- Preliminary analyses of two-year (2021-2023) data indicates statistically significant positive yield response at most of the sites despite the pre-plant M3-P levels being higher than the current threshold level of 45 ppm, which requires no additional P as per the current recommendations. These results indicate that the current phosphorus recommendations for potato and tomato may need to be changed.
- The FY 2023-24 plan of work is **5% complete**.

Identified obstacles or challenges

- There have been up to 6-month delays in getting results from Waters Lab. Efforts will be made to reduce the backlog by regular meetings with the lab management. These delays combined with delays related to extreme weather events during the 2022-2023 experiments continue to affect the team's ability to complete the QA/QC and compilation of data for a comprehensive analysis.
- The project continues to suffer from the lack of qualified personnel. This poses a significant challenge with limited time to process and analyze data compounded by long turn-around times for laboratory analyses and administrative delays involved in setting up new contracts each year and making funds available for the project. The recruitment process is ongoing for biological scientists, post-doctoral associates, an engineer, and an administrative assistant. The annual funding cycle and contracts limits the ability to offer long-term employments to hire talent with graduate degrees.
- Selecting suitable experimental sites based on several background soil sampling events and analyses at commercial farms is time-consuming. Several meetings with the growers and analytical lab need to be held to ensure appropriate site selection, procuring the correct fertilizer, and calibrating commercial fertilizer spreaders. Experiments initiated in the fall season are especially challenging given frequent rainfall events causing flooding that makes site assessment and sampling challenging. Although time consuming, extensive background analyses and communication have resulted in improved experimental designs that are relevant for large-scale commercial farm settings and are likely to result in comprehensive evaluation of the current phosphorus recommendation.
- The large-scale nature of the project and need for quality control for over 10,000 samples has resulted in a large database and metadata. Compiling the data and managing the database has been challenging.

17. Phosphorus Recommendations for Lettuce Grown on Muck Soils – Germán Sandoya Miranda – EREC-Belle Glade

Activities and accomplishments

- This new project is just getting underway, so there are no activities to report currently.

Significant findings and/or events occurring during the quarter

- This new project is just getting underway, so there are no findings or events to report currently.

Activities planned for the subsequent quarter

- Hire a postdoctoral researcher to work on this project.
- Set the first experiment in the field.

Progress made towards overall project objectives

- This new project is just getting underway, so there is no progress to report currently.
- The FY 2023-24 plan of work is **1% complete**.

Identified obstacles or challenges

- Funding was available in a later date than planned in the proposal.
- The approval to hire a postdoctoral researcher is taking longer than expected.

18. Optimizing Phosphorus Management for Snap Bean Production on South Florida Calcareous Soils – Haimanote Bayabil – TREC, Homestead

Activities and accomplishments

- Snap beans were planted on a commercial field in September.
- The experiment involves seven P rates: 0, 25, 50, 75, 100, and 200 lbs P_2O_5/acre.
- Pre-plant soil samples were taken for lab analysis.
- Continuing data analysis from previous studies.
- Developing a draft manuscript based on results from two seasons at TREC.

Significant findings and/or events occurring during the quarter.

- No new findings during this quarter.

Activities planned for the subsequent quarter

- At the commercial farm:
    - Collect soil and tissue samples for P analysis.
    - Harvest beans at maturity.
- At TREC, Homestead:
    - Start an experiment using research plots.
    - Collect pre-experiment soil samples for background soil P testing.

- Collect soil, water, and tissue samples throughout the crop growth period.
- Install suction lysimeters and soil moisture sensors on selected plots.
- Collect plant height, canopy cover, above-ground biomass, stomatal conductance, SPAD reading, and leaf water potential.
- Harvest beans at maturity.
- Collect drone multispectral images weekly.

Progress made towards overall project objectives

- We have finished 100% of the planned work at TREC for 2022-2023.
- On track to develop P BMP for Krome soil in the Homestead area but need more data.
- The FY 2023-24 plan of work is **5% complete**.

Identified obstacles or challenges.

- Background P-level in most soil samples remains high.
- Limited study on commercial farms to capture field-to-field variability will challenge making P recommendations.

19. Visibility for Hemp Fertilizer Research and BMP Development – Zachary Brym – TREC, Homestead

Activities and accomplishments

- Equipment deployed across sites.
- Review and preliminary adoption of FDACS nutrients data template.
- Bi-weekly research team meetings.
- Harvest across three sites for 2023 season studies.
- Developing crop rotation study with cover crops and conservation tillage TREC + WFREC.

Significant findings and/or events occurring during the quarter

- Presentation of hemp provisional nutrient management recommendations to UF/IFAS Plant Nutrient Oversight Committee (currently public comment period).
- Extension field day at BMP Summit with tour of PSREU-Citra and presentations for each study site.

Activities planned for the subsequent quarter

- Travel and presentation by students at professional meeting (American Society of Agronomy, Crops Science Society of America).
- 2023 season sampling and analysis.
- Development of data templates.
- Preparing publications from 2020-2023 studies.

Progress made towards overall project objectives

- The target for hemp projects this year is primarily outreach. Related progress includes PNOC presentation for provision nutrient recommendation and field day tour and presentation at BMP Summit (PSREU-Citra).
- The FY 2023-24 plan of work is **25% complete**.

Identified obstacles or challenges

- None.