UF/IFAS Fertilizer Rate and Nutrient Management Studies
Addressing HB 5001 (SA 1480A) and SB 1000, FY 2022-23

Thomas A. Obreza
Professor of Soil, Water, and Ecosystem Sciences
Director, UF/IFAS Nutrient Management Program

FDACS Contract #28897
Third Quarterly Report to FDACS-AES
Period covered: January 1 to March 31, 2023
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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.

Third quarter state-level overview – Thomas Obreza

Activities and accomplishments:

- Equipment was received and used in nutrient management projects.
- Field research activity accelerated in north Florida as we entered the spring planting season for **cotton**, **corn**, **snap bean**, **watermelon**, and industrial **hemp**. Cold-hardy **citrus** work resumed following the winter dormant period. Field work was planned or initiated at research centers in **Jay**, **Quincy**, **Live Oak**, and **Hastings** plus various grower-cooperator farms.
- Research activity continued with winter-planted **tomato**, **potato**, and **snap bean** on grower-cooperator farms in **central and south Florida** plus the **Homestead** research center. Work on **citrus** and **peaches** resumed following the winter dormant period. Another season of **limpograss** forage and industrial **hemp** research was planned.
- Soil moisture monitoring equipment was installed in citrus, watermelon, grain corn, sweet corn, and potato research fields.
- A plethora of soil, plant tissue, and water samples were analyzed for nutrient content.
- Tomato, potato, snap bean, and citrus crops were harvested for total yield and graded for marketable quality.
- Soil sample analytical results were compared between the IFAS lab and three commercial labs.
- Hydrologic modeling in south Florida and DSSAT (Decision Support System for Agrotechnology Transfer) model calibration continued.
- We are analyzing the economics of citrus and vegetable nutrient management systems.

Significant findings and/or events occurring during the quarter:

- Project goals, activities, and preliminary results were shared with growers and other stakeholders at events across the state, including county extension meetings, commodity meetings, field days, workshops, in-service training for Extension Agents, farm tours, and the Citrus Show.
- We observed yield response to P fertilizer with tomato and bean crops even if soil test P is in the "High" range. For tomato, evidence is building that the 45 mg/kg Mehlich 3 P threshold that triggers zero P fertilizer application is too low. For potato, the interim P recommendation adopted last fall appears to be supported in winter/spring trials.
- Uptake of P by limpograss appeared to be much higher compared with bahiagrass.
- DSSAT simulations are improving.
- We are learning that P fertilizer source (liquid vs. dry) makes a difference in bean fertilizer response.
- Correlation of soil test values between public and private labs was not as high as expected, which is a concern considering that fertilizer recommendations are based on soil test results.
- Variation in soil moisture across a field based on row distance from the irrigation ditch affected tomato response to P fertilizer.

Activities planned for the subsequent quarter:

- Continue acquiring and installing equipment that will enhance our capacity for BMP research.
- Caretake field experiments.
- Collect a wide variety of field and lab data, including soil and plant testing, crop yield, and marketable yield.
- Harvest beans, potato, tomato, watermelon, and peaches for yield and quality.
- Continue working to improve DSSAT for site-specific recommendations.
- Continue comparing lab soil test results and evaluate different tests for their ability to estimate available soil P for site-specific recommendations.
- Continue economic analysis.
- Hold field days and other extension activities to share what we are learning.
- Present south Florida vegetable research results to a meeting of growers and related industry, and possibly the IFAS Plant Nutrient Oversight Committee depending on results.
- Begin planning research and extension activities for fiscal year 2023-24. While continuing with our current crops, if new funding allows, we intend to add blueberry, lettuce, and sod production to our suite of crops for possible fertilizer recommendation changes.

Progress made toward overall project objectives:

- Progress continued on foundational work needed to evaluate N and P fertilizer management for a variety of crops that will lead to improved BMPs.

- We are building a new knowledge base about nutrition of cold-hardy citrus trees, peach trees, and limpograss forage.
- We suspect that 240 lbs N/acre (the highest IFAS grain corn N recommendation) may not be enough for maximum yield.
- The provisional P fertilizer recommendation for potato appears to be supported in current trials.
- Incremental improvement in DSSAT aims to bring an AI component to nutrient management.
- It is likely we will accumulate enough science-based evidence to change IFAS N recommendations for corn and P recommendations for tomato, potato, and snap bean.

Identified obstacles or challenges:

- Finding and hiring the right people has been a challenge. Year to year funding makes long-term employment planning difficult. Some personnel budget was changed to equipment or operating because it was not being spent on people. Equipment is a good investment because it will be used in subsequent years for various nutrient management studies.
- Equipment costs have increased and supply chain continues to be an issue regarding delivery. Purchasing UAVs for field imaging remains challenging.
- Installation of new analytical instruments in the IFAS Soil Testing Lab has been delayed as building improvements must occur first.
- Field difficulties: soil variability, logistics needed to complete competing tasks, high initial soil test P, poor seed emergence in one bean trial, cold weather in March affected a central Florida trial.

Individual investigator quarterly reports (from north to south)

Optimizing Nitrogen Management by Improved Fertilizer Placement and Utilizing Enhanced Efficiency Fertilizers – Hardeep Singh – WFREC-Jay

Activities and accomplishments:

- Band fertilizer applicator was received; it will be used in corn fertilizer management research.
- Formulated, ordered, and/or received fertilizer blends for upcoming research on corn, cotton, and hemp production.
- Corn research trials were planted, and N source and fertilizer placement treatments were applied.
- Pickup truck was received.
- Investigator and graduate students met weekly to discuss the progress on the trials and data collection.
- Selected sites to conduct cotton and industrial hemp trials at WFREC.

Significant findings and/or events occurring during the quarter:

- No findings yet, as the field work just started in the 3rd quarter.
- Investigator presented the scope of the project and described 2023 planned trials at extension meetings in Santa Rosa, Escambia, and Okaloosa counties.

Activities planned for the subsequent quarter:

- Pre-plant soil sampling, flagging of research plots, fertilizer application, planting of cotton and industrial hemp trials.
- Collect plant tissue and soil samples in corn trials and send for lab analysis.

Progress made towards overall project objectives:

- Progress was made 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 were established and sites for cotton and industrial hemp trials were identified.
- 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.
- Scope of work is **50% complete**.

Identified obstacles or challenges:

- None.

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:

- Fertilizers were applied to citrus research plots.
- Soil and citrus leaves were sampled for nutrient analysis.
- Probes to monitor soil moisture were installed at two experimental sites.
- Trunk-based moisture sensors were installed.
- Citrus trees were pruned to remove dead and dried branches due to the December 2022 freeze.

Significant findings and/or events occurring during the quarter:

- Cold-hardy citrus nutrient management research was shared with stakeholders at:
    - Field day at NFREC, Quincy on February 23.
    - Citrus Nutrient Management workshop at CREC, Lake Alfred on March 15.
    - In-service training for extension agents at NFREC, Quincy on March 23.

Activities planned for the subsequent quarter:

- Pruning and training to remove damaged wood due to a late freeze on March 20.
- Application of fertilizer at all experimental sites.
- SPAD readings to measure leaf greenness.
- Soil and leaf sampling at all sites.
- Data collection on physiological attributes of citrus trees.
- Presentation of findings at Florida State Horticultural Society annual meeting in June.

Progress made towards overall project objectives:

- Documentation of soil and leaf nutrient analysis is providing a measure of tree nutrition that could lead to adjustments in fertilizer recommendations for north Florida citrus production.
- No core findings to report at this point that would suggest a change in IFAS recommendations because citrus is a perennial crop that will require several years of yield and fruit quality measurements.
- **Scope of work is 65% complete**.

Identified obstacles or challenges:

- December and March freezes caused severe damage to both young and established groves, resulting in a 60 to 70% yield loss.

Precision Ag Research to Fill Knowledge Gaps in North Florida Nutrient Management – Robert Hochmuth – NFREC-Suwannee Valley at Live Oak

Activities and accomplishments:

- Equipment:
    - Acquired a snap bean harvester, Veris MSP3 soil mapping rig, small plot fertilizer applicator, soil moisture probes, center pivot irrigation variable rate upgrades, and fertigation equipment.
    - Waiting on two pick-up trucks, field transport buggies, and a tractor.
- Two snap bean fertilizer trials, following up from previous N rate/source experiments, were planted based on input from snap bean farmers and industry representatives.
- The snap bean team has been summarizing all N-rate and source research that has been conducted at NFREC-SV in the past 3 years.
- The new Veris rig has been used on six farms managed by four growers in Hamilton and Suwannee counties in addition to several fields at NFREC-SV.
- Soil moisture probes are incorporated into an on-farm demonstration at 12 farms for controlled release N on watermelons, grain corn, and sweet corn in Gilchrist, Levy, and Alachua counties.
- Moisture probes are also used in other demonstration projects such as on-farm corn N rate studies and comparing “Everlizer” poultry manure and controlled release N in Madison and Dixie counties.

Significant findings and/or events occurring during the quarter:

- Summarizing previous N rate and source research has revealed gaps in to fill in north Florida that are guiding research for spring snap bean trials.
- Data analysis for the recently completed fall snap bean trial was added to the snap bean N research database as part of this project.
- The NFREC-SV team hosted a meeting and tour for leadership groups from FDACS-OAWP, FDACS-AES, and the Suwannee River Water Management District. We discussed this project and plans for spring work. It also included discussion of the vision forward of UF/IFAS to meet the requirements of the Suwannee BMAP.
- Numerous other tours and meetings at NFREC-SV and at regional farms have been held to discuss activities led by UF/IFAS county and state faculty to further the progress of BMP adoption in this region:
    - Suwannee River Partnership steering committee.
    - 12 large scale on-farm demonstrations for controlled release N and soil moisture sensors in watermelon, grain corn, and sweet corn.
    - Hosting the Natural Resources Leadership Institute class twice.
    - A planning meeting of county extension faculty, FDACS staff, and Conservation District field staff to plan collective documentation of BMP adoption in the region.

Activities planned for the subsequent quarter:

- Continue acquiring equipment that will enhance our capacity to conduct BMP research on targeted crops (initially, corn and snap beans).
- Snap bean trials will finish in the field in the next quarter, harvested by our new machine.
- Additional fertigation equipment will be identified and purchased.

Progress made towards overall project objectives:

- We continued to build our research capacity at NFREC-SV with equipment purchases that will support BMP research for years to come.
- Results from the completed fall snap bean research trial is advancing our understanding of the “5Rs” of nutrient management that will lead to improved fertilizer and water management recommendations.
- **Scope of work is 75% complete**.

Identified obstacles or challenges:

- The ever-increasing costs of equipment, above the estimates given back in the early spring of 2022 when the proposal for this work was developed.
- Supply chain issues have delayed delivery times.

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

Activities and accomplishments:

- Field equipment for nutrient management studies (plant canopy imager, photosynthesis system, leaf spectrometer, and truck) was received.
- Two soil augers were ordered, due to arrive in the Quarter 4.
- Corn was planted in March at NFREC-Suwannee Valley and at two on-farm sites to start the new season. Fertilizer was applied on the day of planting.

Significant findings and/or events occurring during the quarter:

- An extension activity for growers and industry was held in January to share findings from previous years' nutrient management work.

Activities planned for the subsequent quarter:

- Fertilizer will be applied at each corn growth stage starting with V4.
- Soil and biomass sampling will begin in Quarter 4. Sensor data collection will be synchronized with sampling dates.
- By late April we expect the corn to be ready for sensor readings from LICOR, spectrometer, and canopy sensor.

Progress made towards overall project objectives:

- A new corn research season will add more production data to the nutrient management database we will use to refine IFAS corn fertilizer recommendations.
- The equipment procured through this project will provide new data we have not previously had access to will be used to refine recommendations.
- Last year's results suggest that the IFAS corn recommendation of 240 lbs N/acre might not be sufficient for maximum yield.
- Keeping in mind that the major activity related to the funding provided by this project was to acquire equipment, we are **80% complete**. From a field research perspective, we have completed **10%** of the project.

Identified obstacles or challenges:

- Dealing with delays in receiving equipment. We had hoped to all of it by January 1, but we did not receive the photosynthesis system until the end of March.

2022-23 LBR Phosphorus Rate Study – Northeast FL - Potato - Spring 2023 – Christian Christensen – Hastings Agricultural and Extension Center (HAEC), Hastings

Activities and accomplishments:

- Preparation for soil and plant tissue sampling.

- Established production timelines and prepared digital resources for data acquisition and storage.
- The Kerian grading table, four-row vacuum cup potato planter, and pickup truck have been acquired and have been used to support the scope of work.
- Efforts to hire additional personnel continued.

Significant findings and/or events occurring during the quarter:

- Two-thirds and one-half of soil and petiole samples, respectively, were collected, prepped, and submitted to Waters Analytical Lab for analysis.
- Environmental sensors (weather stations with accompanying soil moisture probes) were deployed and began collecting data at 15-minute intervals.

Activities planned for the subsequent quarter:

- We will be refining and executing our harvest schedule for six production sites (Table 1). Data collection includes, but is not limited to, total yield, marketable yield, percentage culls (categorized and aggregated), specific gravity, internal quality ratings, chip fry quality ratings, soil, petiole, and tissue nutrient analysis.

Table 1. Locations of six production sites in the scope of work.

Production Site	General location within St. Johns County (SJC), FL
NEFla-1	HAEC: Bed 101 and 105; Southwest SJC
NEFla-2	HAEC: Bed 202; Southwest SJC
NEFla-3	HAEC: Bed 303; Southwest SJC
NEFla-4	Wells; Northwest SJC
NEFla-5	Parker; West-central SJC
NEFla-6	Smith; Southwest SJC

Progress made towards overall project objectives:

- Linear regression models were fitted to the total and marketable yield response from the 2022 production season. These results helped IFAS create a provisional change to the potato phosphorus fertilizer recommendation. Experimental design and rates have been kept consistent in the 2023 season to compare with 2022 findings.
- Soil and potato petiole analysis values are contributing to the database that will lead to improved IFAS recommendations for potato. **The scope of work is approximately 50% complete.**
- The TCAA HAEC team is confident that the ongoing research will provide robust evidence to support UF/IFAS's provisional recommendation of 120 lbs P_2O_5/acre, with an additional 25 lbs/acre for cold soils in northeast Florida. The group is optimistic that the P rate developed from this research will be sustainable, promoting both environmental stewardship and farmer viability in the TCAA region.

Identified obstacles or challenges:

- Hiring additional staff has proven to be challenging. Localized cost of living coupled with available salary dollars has limited the ability to hire quality staff. We defaulted to hiring temporary labor and reallocating project duties to salaried HAEC staff to ensure timely completion of the scope of work.

Using Artificial Intelligence for Improved Crop Nutrient Management – Lincoln Zotarelli – Horticultural Sciences Dept., Gainesville

Activities and accomplishments:

- We calibrated a process-based crop model (DSSAT) to generate additional simulated data for experiments (2011-2014 AS farm, 2011-2014 JR farm, 2011-2012 MJ farm, and 2011-2012 PP farm).
- We framed a method to develop a hybrid model combining the DSSAT and machine learning-based long short-term memory (LSTM) models.
- Since plant nitrogen (N) uptake and soil N depend on each other, growing degree days (GDD) was added as a new feature to help the LSTM model track plant growth.
- Antecedent Moisture Condition (AMC) was added as new feature to support the LSTM model predictions of soil N at different soil moisture conditions. Although most of the datasets have no irrigation record, AMC could be useful to track irrigation requirements in dry weather.
- We proposed a strategy to improve the prediction of daily soil N by training the LSTM model with DSSAT simulated/generated data to fine-tune the soil N daily estimates with experimental soil N data. This strategy was evaluated on different sub-datasets divided by farms, years, and treatments to show the prediction accuracy in different situations.
- Regularization methods were used to smooth the prediction curve during the growing period.

Significant findings and/or events occurring during the quarter:

- The calibration of DSSAT soil parameters has resulted in a better match between simulated and experimental soil data. This improvement in data accuracy and reliability can have a significant positive impact on the training of the LSTM model, leading to more effective soil N predictions and insights.
- The LSTM model predictions for the soil N are based on the DSSAT simulated soil N. If the DSSAT simulations could successfully capture the overall trend of soil N with time, the LSTM would also be able to predict the daily soil N more precisely after fine-tuning. However, the current version of DSSAT does not account for seepage irrigation, and poor prediction of soil mineral N during dry conditions is occurring. Therefore, AMC was introduced as a proxy feature in the LSTM model to improve soil mineral N estimation.
- We observed that some features were different for various farms and years. For example, the rainfall in 2010 was different from that in 2013. The treatments in 2011-2012 AS were different from 2013-2014 AS. Such differences in the intrinsic characteristics of the experimentals used in training and testing data considerably

affected the prediction accuracy. Therefore, we are developing a robust strategy to divide the datasets by training and testing in such a way that the LSTM model learns all possible differences to improve its performance.

- We also noticed that the LSTM model is generating a great degree of noise (sharp peaks and valleys) in soil N estimation due to different soil N observations for the treatments with partially similar N fertilizer applications. Since measured soil N values already have a huge amount of noise, the LSTM model fine-tuned on that noise created even greater noise in its prediction. Due to the volatile nature of soil N, it would be challenging to predict its exact value. Therefore, we introduced a new concept to predict an areal soil N curve (with a certain degree of confidence level) instead of a line curve.

Activities planned for the subsequent quarter:

- Continue to generate and calibrate the DSSAT soil data for other farms and years. We expect to train the time-series model using data from all the farms and years.
- Study how the DSSAT simulated data affect the performance of the proposed model. We will manually select the 1st group of farms and years that DSSAT simulated data was good, and the 2nd group of farms and years that DSSAT simulated data was poor. Then, the proposed LSTM model will be trained on each group to compare the prediction accuracy.
- The proposed model would also minimize the noise generated from different observations for partially similar N treatments.
- Try different constraints and regularizers during the fine-tuning process to smooth the prediction curve by decreasing the noise and removing the unexplainable peaks.

Progress made towards overall project objectives:

- Our earlier experiments showed that soil N had a major impact on plant yield. However, the observed experimental soil N data were limited and could not be used to train any machine learning model directly to predict the extremely volatile soil mineral N. To tackle this issue, we developed a highly robust model capable of predicting daily soil N concentration by training the LSTM model on DSSAT simulated data and fine-tuned on the observed experimental data.
- With the proposed methods, we will continue working on models to anticipate when nutrient deficiencies are likely to occur and determine the need of additional nutrients to maintain crop yield. In the future, these models associated with monitoring soil nutrient levels in real-time will enable us to make informed decisions about fertilization and optimize crop yields.
- **Scope of work is 75% complete**.

Identified obstacles or challenges:

- None.

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

Activities and accomplishments:

- We submitted 400 soil samples (200 from a recently completed FDACS/USDA project and 200 composited soil samples collected during the current project) to four analytical labs: UF Extension Soil Testing Lab, Central Florida Soil Lab (CFSL), Waters Agricultural laboratories, and Waypoint.
- Results of Mehlich-3-P analyses from the commercial labs are being statistically analyzed to determine accuracy and reliability of the results among labs.
- We completed the analyses of the 200 USDA samples for water soluble phosphorus (WSP) in our laboratory and we are now comparing the results with the same analyses done about 5 years ago to see the effect of soil storage on WSP.

Significant findings and/or events occurring during the quarter:

- Preliminary data of the samples analyzed show the following Pearson Correlation between four analytical labs. Replicate analysis at each of the labs are within QA/QC requirements.

	Waters	**Waypoint**	**CFSL**	**UF Extension**
Waters	1.00			
Waypoint	0.89	1.00		
CFSL	0.62	0.58	1.00	
UF Extension	0.81	0.77	0.47	1.00

- The above results are based on the 200 soil samples from the USDA project. Results from the 200 samples collected during the first year of the current project will be available in the final (4^{th} quarter) report.
- We also collected Mehlich 3-P sample-processing details from all the labs for comparison:

Lab	**Sample weight requested (g)**	**Cost**	**Spectro/ICP**	**Soil: solution ratio**	**Scoop vs. exact weight**	**Response time**
UF Extension†	10	$10	ICP‡	1:10	scoop	4-5 days
Waypoint Analytical	4	$3	ICP	1:10	scoop	4-5 days
Waters	10	$3	ICP	1:8	scoop	3 days
Central Florida Soil	10	$5	ICP	1:5	scoop	7 days

† Costs for Mehlich 3-P analysis at the UF Lab are for several elements including P; the lab does not provide results for only Mehlich 3-P unlike the other labs, and no information is available for the cost of only Mehlich 3-P analysis at the UF Lab. Elements provided by UF Extension Lab for $10 include P, K, Mg, Ca, S, Cu, Mn, and Zn, pH and lime requirement.
‡ ICP = Inductively Coupled Plasma

Activities planned for the subsequent quarter:

- Comparisons of Mehlich 3-P analysis for fresh vs. 5-year-old soil samples will be made when results become available from the UF Analytical Research Lab (ARL).
- Run statistical analyses for Mehlich 3-P from the commercial labs to determine accuracy and reliability of the results among labs.
- Soil sample analyses for iron-oxide-impregnated strip-P (FeO-P), WSP-P and Haney H3A-P (H3A-P) for samples recently received from the citrus group, vegetable group, and other locations.
- Begin evaluating the influence of site-specific soil characteristics on plant available P and its relationship to yield using FeO-P and H3A-P analysis. The proportion of bioavailable P in M3-P will be evaluated across all sites and by location, before and after the soil P saturation point.
- Evaluate the relationship between FeO-P analyzed in the lab and those embedded in the field (not part of the original work plan).
- Compare Mehlich 3-P analysis at ARL and at the UF extension lab to identify discrepancies, if any, due to methodological differences (actual weight vs. scoop)
- Compare Mehlich 3-P as determined colorimetrically in our lab and ICP from other labs to provide a conversion factor if users are provided with colorimetric analytical data instead of ICP. The differences will likely be site-specific as ICP extracts all P in a Mehlich 3 solution that will vary by location after the “change point.”

Progress made towards overall project objectives:

- Understanding how soil extractants work to measure soil P, the relationship of Mehlich 3 P to plant-available P, and the variation in results between labs will be a giant step forward in our ability to use soil testing as a guide to fertilizer requirements.
- **Scope of work is 50% complete**.

Identified obstacles or challenges:

- Delays in obtaining field soil samples from other co-PIs due to problems associated with hurricanes.
- Timely recruitment of staff remains a problem.
- Year-to-year funding makes it difficult to recruit trained personnel.

Capacity Building at the IFAS Analytical Services Laboratories to Support Nutrient Management Research Work in Florida – Rao Mylavarapu – Soil, Water, and Ecosystem Sciences Dept., Gainesville

Activities and accomplishments:

- Several meetings with equipment manufacturers were scheduled and completed. The equipment vendors and models were selected reflecting researcher needs, efficiency, serviceability, and cost.
- Except for ICP-IRMS, orders were placed for all equipment or requisitions were forwarded to UF Procurement office for approval.

Significant findings and/or events occurring during the quarter:

- Two ICP-OES instruments were received in the lab.

Activities planned for the subsequent quarter:

- The two ICPs will be installed and commissioned as soon as UF Facilities installs appropriate gas connections and required exhaust systems. Manufacturers will be on-site to install and provide technical training as a part of instrument purchase.
- Place orders for the remainder of the equipment and successfully complete the acquisitions.

Progress made towards overall project objectives:

- Progress is being made as planned.
- **Scope of work is 50% complete**.

Identified obstacles or challenges:

- Cost of the equipment pieces has gone up in certain cases significantly in the recent months and for others is constantly rising.

Developing a Guideline on NPK Application Rates and Timing for Low-Chill Peaches Grown in Florida – Ali Sarkhosh, Horticultural Sciences Dept., Gainesville

Activities and accomplishments:

- Soil was sampled (three depths down to 90 cm) in the 1st week of January.
- Fruit was thinned from trees in the 3rd week of February.
- The first 2023 NPK fertilizer application treatments were made in the 2nd week of January.
- The second soil sampling and first leaf sampling occurred in the 2nd week of March.
- Lab work and data analysis.

Significant findings and/or events occurring during the quarter:

- Based on leaf analysis data, we found no significant differences among fertilizer treatments. Lower fertilizer rates did not negatively affect tree nutrition as measured by leaf nutrient status.
- Based on soil analysis, we found no significant differences among treatments at each depth increment, but significant differences were observed between depths.

Activities planned for the subsequent quarter:

- Fruit harvesting and fruit quality measurement will be completed by the end of April.
- After-harvest soil and leaf sampling in May.
- Last NPK fertilizer application for the season in June.

Progress made towards overall project objectives:

- Nutrient management for Florida peaches has not been intensively studied. We are building a database that has not previously existed. These data will allow us to create science-based fertilizer recommendations for commercial peach production.
- In this quarter we completed most of the initial work for the project, corresponding about **65%** of the project goals.

Identified obstacles or challenges:

- None.

Developing Site-Specific N and P Rates for Young and Mature Sweet Oranges, Grapefruits, and Mandarins in Florida – Davie Kadyampakeni – CREC, Lake Alfred

Activities and accomplishments:

- Fertilized citrus trees, measured canopy volume and other horticultural aspects, sampled soil and leaves, and performed laboratory analysis.
- Harvested fruit and measured fruit quality for late-maturing Valencia oranges.
- Researched commercial production costs and market price data trends.
- Conducted a Strengths/Weaknesses/Opportunities/Threats analysis of the supply chain for citrus.
- Designed a flow chart-based online decision tool to capture marginal costs and benefits of varying fertilizer application rates.
- Conducted a literature review on environmental costs associated with water and fertilizer management practices.

Significant findings and/or events occurring during the quarter:

- Shared project information at:
    - A field day and project meeting at Citrus REC on February 15.
    - An in-service training for IFAS Extension Agents on March 15.

- Graduate students and post-docs presented project results at the Soil, Water, and Ecosystem Sciences Research Forum on February 6 and at the Citrus REC Symposium on March 24.

Activities planned for the subsequent quarter:

- Present project highlights at the Florida Citrus Show, Ft. Pierce in April.
- Install soil moisture sensors in all sites to track soil moisture storage.
- Fertilize citrus trees at all sites.
- Present project results at the Florida State Horticultural Society in June.
- Draft reports and an extension document to include break-even and sensitivity economic analysis.
- Begin evaluating the economic viability of the fertilizer rates we are testing.

Progress made towards overall project objectives:

- We acquired baseline data describing fruit yield, fruit quality, soil/leaf nutrient content, and other horticultural variables in the research groves. Future yield and fruit quality responses will be compared with baseline values to measure fertilizer rate effects that will lead to improved recommendations.
- **Scope of work is 65% complete.**

Identified obstacles or challenges:

- One of our grower-cooperators in Lake Wales abandoned the grove and designated the land for a future housing development. We had two sites in the Lake Wales area; we will continue the project with one site there.

Refining P Fertilization Recommendations for Limpograss in South Florida – Joao Vendramini – RCREC, Ona

Activities and accomplishments:

- Forage and soil sample analyses were completed.
- Analysis of water P concentration is in progress.
- The graduate student withdrew from the program. Recruitment is underway for a new student.
- The experimental area was prepared for 2023 research. Fences were repaired, gates replaced, and water monitoring equipment was tested, repaired, or replaced.
- The new experimental period started in March, when plots were staged and fertilizer treatments were applied.

Significant findings and/or events occurring during the quarter:

- The minimum limpograss tissue P concentration measured in this trial was 0.26%, which is greater than minimum tissue P concentrations previously observed for bahiagrass (0.15%). The 2nd year of the study will be crucial to improve the accuracy of the model

and determine the critical tissue P concentration that could be incorporated in a modernized nutrient management recommendation for P.

Activities planned for the subsequent quarter:

- Soil microbiome analysis will be completed in May.
- Once we receive soil P concentration results, we will determine the correlation between tissue P and soil P.
- Purchase fertilizer for the new experiment.
- Process and analyze soil samples.
- Educate approximately 150 Florida forage and beef cattle producers about the project at the April 20th UF/IFAS Range Cattle REC field day.

Progress made towards overall project objectives:

- Gibtuck limpograss has greater forage accumulation and P extraction from the soil compared with other forage grasses. However, P residing in deeper soil layers may be sufficient to provide the necessary P for limpograss.
- Limpograss tissue P concentration can be incorporated into fertilizer recommendations as a tool to monitor plant P status and potential need for nutrient addition.
- **Scope of work is 75% complete**.

Identified obstacles or challenges:

- The main obstacle has been the difficulty recruiting a graduate student suitable to work on this project. We hired an hourly worker for sample collection, preparation, and analysis but a graduate student will be vital for data analysis and presentation.

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:

- The research team met with bean and potato growers and packing house managers to plan and develop protocols for snap bean harvesting, transport, and grading.
- Harvests (one tomato, one potato, one bean) and grading operations were conducted at three south Florida field sites.
- Preliminary analyses of yield data were completed for some sites. Statistical methods of data analysis were explored.
- Two experiments (one tomato and one potato) were started in south Florida and one experiment (potato) was started in central Florida.
- Plant and soil sample collection, processing, and shipping to a commercial lab for nutrient analysis continued for all the ongoing experiments.
- Soils are being analyzed for iron oxide phosphorus (FeO-P) to understand the P chemical status in south Florida sandy soils.

- Rain gauges, groundwater level recorders, and soil moisture probes were installed in all new experiments, while data QA/QC continued for new and existing sites.
- Soil, plant, hydrologic and weather data processing needed to develop a hydrologic model was initiated at one potato experiment site to evaluate relationship between water and P dynamics.
- Scouting for plant diseases continued at two tomato, two bean, and one potato experiment. Presence of pathogens was confirmed, and relative disease severity was assessed between the treatments. Foliar ratings for early blight were collected from potato experiments.
- Nematode soil and root samples collected from the two tomato sites were analyzed.
- Drone-based aerial imagery of the experimental sites was captured. Image processing was initiated to identify spatial variations in soil moisture, plant growth, and disease and relate it to observed differences in yield. Spatial patterns were used to develop plans for harvesting and soil and plant sampling, where appropriate, to evaluate abiotic and biotic factors and explain variability in soil characteristics and yield.
- Economic analyses, collection of external data on production costs and market price trends, and literature review continued.
- Extension activities and communication:
    - Preliminary yield data from all sites were shared and discussed with the grower-cooperators as soon as they were compiled to ensure transparency.
    - The project team continued discussing the goals and plans for the experiments and consult with the grower-cooperators to receive their feedback in designing and implementing experiments.

Significant findings and/or events occurring during the quarter:

- Preliminary analyses of harvest from the completed experiments showed that yield from the 0 lbs P_2O_5/acre fertilizer rate was numerically lower than all the other treatments where P fertilizer was applied.
- In some experiments, the maximum numerical yield was achieved for an intermediate fertilizer rate, but for other experiments, maximum yield was achieved for the maximum fertilizer rate.
- Early observations from comparison of numeric yield data suggests that the current recommendation of 0 lbs P_2O_5 fertilizer application rate, when initial Mehlich-3 P value is above 45 ppm (the point at which the soil test interpretation changes from “Medium” to “High”), may be insufficient for tomato, potato, and green bean crops under central and south Florida production conditions.
- Preliminary statistical analyses suggest that at all six completed experiments (central - one bean, one tomato; south – one bean, one potato, and two tomato sites) conducted since July 2022, there is likely to be a significant yield response to P fertilizer addition despite all sites having the Mehlich-3 P concentrations above the current threshold value of 45 ppm.
- Preliminary results from the bean experiment provided a unique insight into the effects of fertilizer formulation (liquid vs. dry P applied at 80 lbs P_2O_5/acre) on bean yield.

Growers in south Florida use both dry and liquid forms of P (grower standard is 80 lbs P_2O_5/acre). The grower standard was included in the experiment as a fifth treatment along with four other dry fertilizer treatments (0, 40, 80, and 120 lbs P_2O_5/acre). Comparison of numerical yield data showed yield from grower standard (liquid + dry) was greater than the solid fertilizer at the same rate of 80 lbs/acre. If additional analyses confirm that the grower standard treatment yielded statistically higher than a similar or higher P input (80 and 120 lbs/acre), we must consider a combination of dry and liquid P fertilizer formulations in future experiments to inform future changes in recommendations.

- Variation of soil P with P fertilizer application rate in central Florida depended on baseline (before experiment) P availability. We saw a positive correlation when initial P was low, but no correlation was detected when initial P was high.
- Preliminary analyses of soil moisture data showed no significant difference between P fertilizer treatments. However, a root zone moisture content trend by row position was observed related to distance from the irrigation/drainage furrows. Rows closer to a furrow were wetter than rows further away. This effect combined with earlier observations of yield differences in a separate tomato study tomato (and observed visually in central and south Florida bean and potato experiments) provides an opportunity to modify recommendations by including soil moisture effects.
- Spatial differences and relationships between soil moisture and plant growth were detected within the same treatments at some south Florida sites.
- Due to spring drought conditions, disease pressure was low to very low in tomato, one bean, and potato field. At two of the four sites, field variability was evident that likely affected plant vigor and/or disease severity.
- Nematodes were mostly bacterivores and fungivores; plant parasitic nematodes were mostly stubby root nematodes, with some root knot nematodes.

Activities planned for the subsequent quarter:

- The remaining ongoing experiments [three potato (two table stock, one chip), one tomato, and one bean] will be harvested.
- Plant and soil sampling, processing, and analyses will continue at all active sites.
- Hydrologic monitoring will continue at all active sites.
- Hydrologic modeling will be completed for one potato, one tomato, and one bean site.
- QA/QC for plant, soil, and water data will continue.
- Disease and nematode (tomato) monitoring will continue.
- Economic analyses will be completed. Costs and benefits of various P inputs will be evaluated.
- A soil and plant database will be developed and detailed statistical analyses will be initiated. Advanced methods for statistical analyses will be explored where needed especially where water is a co-factor influencing soil P concentrations and yields.
- Soil sample FeO-P analyses will continue.
- Scouting and disease assessment will be refined based on recent history.

- A presentation describing the project will occur at the 2023 Citrus Show's vegetable production session on April 13.
- Preliminary results will be presented to IFAS Nutrient Management Project Stakeholder Meeting that includes growers and commodity leaders from north, central, and south Florida including Florida Farm Bureau, Florida Tomato Committee, Potato Grower Association, and FFVA.
- Depending on data analyses, a project summary will be presented to the Plant Nutrient Oversight Committee (PNOC).
- Continue efforts to hire technical project staff, including recently vacated positions and administrative staff.

Progress made towards overall project objectives:

- Considering the effects of hurricanes Ian and Nicole on the project, progress is better than expected. The hurricanes affected experiments where harvests overlapped combined with a personnel shortage and delays in instrument and equipment acquisition. Thus, accomplishing all original project objectives will be delayed into the next fiscal year.
- Preliminary assessment of completed work suggests that the team will be able to complete 60 to 80% of the planned experiments and data collection by summer. We estimate that 50 to 75% of collected data will be analyzed by July. We expect analyses of yield data to be completed and presented to PNOC in July.
- If the observations of tomato, potato, and bean response to P fertilizer are consistent and statistically significant, IFAS recommendations for soil test interpretation and P fertilizer application will change.

Identified obstacles or challenges:

- Logistics of completing required tasks has been a major challenge. Factors include the large geographical area of the first bean trial; close harvesting intervals between experiments; planning for the soil, tissue, and biomass sampling events; commercial harvesting and grading; travel and accommodation of the project staff; long distances from and between field sites and packinghouses; 15- or 16-hour workdays in some instances; harvesting and grading on weekends.
- In some cases, cold weather events impacted experiments in central Florida.
- The bean experiment in Hendry County experienced large variability in soil moisture within experimental blocks, which is likely to significantly affect treatment effects within blocks.
- Application of liquid nitrogen fertilizer (ammonium nitrate) on four treatments in the Hendry County bean experiment was challenging and may have affected the uniform application of N fertilizer to the four treatments that received solid P fertilizer. Application rates were also at the low range of grower-cooperator's equipment settings.
- The ability to hire qualified personnel suffered due to the short-term (1-year) nature of the project. For continued success, the ideal situation would be to provide funds for more than 1 year to allow sufficient time to select sites, hire personnel, and collect and

analyze data and better cope up with time lost due to extreme weather events such as hurricanes that occur during the planting (August-October) of fall season crops.

Optimizing Phosphorus Management for Snap Bean Production on Mineral and Calcareous Soils of Florida – Haimanote Bayabil, TREC, Homestead

Activities and accomplishments:

- Experimental activities on a commercial farm
    - 40 soil samples were collected and baseline soil-P status was assessed.
    - In-season soil and plant tissue were sampled three times.
    - Snap beans were planted in January and harvested in March.
    - Data processing commenced.
- Experimental activities at TREC
    - Snap bean was planted to 40 plots in February.
    - Lysimeter and soil moisture sensors were installed.
    - Porewater samples were collected.
    - In-season soil and plant tissue were sampled every 14 days.
    - Plant height, canopy cover, above-ground biomass, stomatal conductance, SPAD reading, and leaf water potential data were collected.
- Field demonstration at TREC
    - TREC hosted a field demonstration for 39 growers and other interested parties in late March to discuss research findings.
- Experimental activities at PSREU-Citra
    - Selected a site at PSREU for a fertigation trial in early March.
    - Collected soil samples before planting.
    - Prepared P fertilizer for the trial. As our previous trial in Hastings showed greatest pod yield at 160 lbs P_2O_5/acre, this fertigation trial has added a higher P rate of 200 lbs P_2O_5/acre.
    - Planted snap bean seeds in late March for the fertigation trial.
    - Applied N, P, and K fertilizer according to a prescribed schedule.

Significant findings and/or events occurring during the quarter:

- Baseline soil test P was very high on a commercial field in Homestead (average extractable soil P was 240 ppm). Preliminary results showed that high P fertilizer rates reduced germination and snap bean yield. The team suggests conducting multiple commercial field trials next year.
- Bean yield increased with P application rate. The 160 lbs P_2O_5/acre rate resulted in the greatest yield.

Activities planned for the subsequent quarter:

- At TREC
    - Continue sampling soil and plant tissue.

    - Measure plant height, canopy cover, above-ground biomass, stomatal conductance, SPAD reading, and leaf water potential.
    - Analyze data from the commercial farm research site and disseminate the results to growers.
    - Analyze plant and soil samples.
    - Harvest beans from experimental plots at TREC.
- At HAEC
    - Complete all sample collections and data analyses.
    - Host a field day for growers and other interested parties in April.
- At PSREU
    - Collect soil and plant tissue samples in April and May.
    - Pod harvest is expected in late May.
    - Host a field day for growers and other interested parties in May.

Progress made towards overall project objectives:

- If the observations of bean response to P fertilizer are consistent and statistically significant, IFAS recommendations for soil test interpretation and P fertilizer application will change.
- We have finished about **60%** of the planned work at TREC for 2022-2023 and we are currently on track to accomplish **100%** of all planned activities.
- We are collecting additional crop and soil data that we did not plan so it can be used for crop modeling and machine-learning activities.
- At HAEC, we found the highest P rate resulted in the greatest bean yield. We plan to repeat this study this spring and may need to add another higher P rate to find the inflection point of green bean yield.
- We have finished **50%** of the work at HAEC.

Identified obstacles or challenges:

- High soil test P in most soil samples at the commercial farm in Homestead.
- Poor seed emergence from most of the high P treatments on a commercial farm. Similarly, poor seed emergence was observed at TREC but was observed across all treatments. These issues could bias the results, so repeating the study is critical.
- Unexpected bad weather (hurricanes) and pest damage could influence the results.

Accelerating Collaborative Hemp Fertilizer Research to BMP Development of Rate, Timing, Source, and Site-Specific Management – Zachary Brym, TREC, Homestead

Activities and accomplishments:

- TREC equipment has been delivered except the flail mower and tractor (expected Q4).
- TREC remote sensing device received (second expected Q4).
- TREC UAV purchase reallocated to seed thresher (PO executed).
- EREC Perkin Elmer ICP delivered with Seal AQ400 discrete analyzer expected Q4.

- PSREU liquid applicator received.
- Hemp nutrient research studies prepared for May planting.

Significant findings and/or events occurring during the quarter:

- Overall hemp nutrient management research is at the peer-reviewed publication phase from which findings can be translated into a recommendation. A publication on the topic has been accepted for publication at Agronomy Journal titled, “Nitrogen fertilization impact on hemp (Cannabis sativa L.) crop production: a review.”
- The equipment and effort funded by the legislative budget request (LBR) has accelerated the development of the research infrastructure and operations for hemp nutrient management at UF across Florida.
- There are currently five UF locations prepared for planting nutrient management studies in 2023 broadly related to the LBR with complementary support from FDACS Office of Agricultural Water Policy. Nitrogen rate, timing, and source are targets for the 2023 season.

Activities planned for the subsequent quarter:

- Finalize and receive equipment orders.
- Initiate “gap year” hemp nutrient trials to connect funds from phase 1 & 2 OAWP projects.
- Complete installation of fertigation system at TREC.
- Prepare cumulative reporting of hemp nutrient management trials for peer-review.

Progress made towards overall project objectives:

- TREC: Nutrient management equipment has been deployed to establish cover crops ahead of an organic hemp planting. Identifying multiple sources of organic, controlled release, and liquid fertilizers for experiment and demonstration this season. Land preparation and field design has been established for nutrient management studies this season investigating rate, timing, and source in conventional systems for fiber, seed, and flower production.
- EREC: Performing nutrient analysis of soil samples in support of this project to assist in development of BMP recommendations for nutrient management of hemp production. The new equipment is on track to replace the old instruments in the Everglades Soil Testing Laboratory for nutrient analysis.
- PSREU: Nutrient management studies have been initiated to investigate rate and timing in conventional systems for fiber, seed, and flower production. Existing lysimeter infrastructure along with sensor- and sample-based analytics has been used to establish a recommendation for hemp with methods consistent with other crops and nutrient rate studies.
- There are currently no IFAS recommendations for hemp. Research efforts are nearing a publication milestone for preparation of recommendations. Several areas of research are ongoing with consistent methods and sustained effort to achieve this milestone.
- Completion

- TREC: **65%**.
- EREC: **75%**.
- PSREU: **100%**.
- Research studies: **25%**. (Primarily a Q3-Q4 activity.)

Identified obstacles or challenges:

- UAV purchase is not possible with current Florida restrictions and there does not seem to be an indication that will change with the legislative session. The cost for drone has been reallocated to a seed thresher.
- FDACS-OAWP does not sufficiently cover travel or publication costs to complete project outputs and outreach from which LBR support could assist in overcoming the obstacle.
- The challenge of complex and site-specific nutrient management decisions has been appreciated in detail through ongoing efforts by the hemp nutrient management team. Experiments investigating the interactions of nutrient rate, timing, and source rapidly become complicated and large, and represent an opportunity for growth. The research team has identified manageable targets for the 2023 season for actionable progress. The group has identified areas to consider additional studies that would benefit from FY 2023-2024 and sustained funding support.