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

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Fourth Quarterly Report to FDACS-AES
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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.

Fourth quarter state-level highlights – Thomas Obreza

Tomato (north, central, and south Florida): Controlled-release N fertilizer was evaluated for north Florida tomatoes. Harvest was completed but yield data are not yet available. Phosphorus management trials at central and south Florida commercial farms were harvested and fruits were graded. Plant, soil, and water sampling was completed. Research revealed a positive tomato yield response to P fertilizer on fields where soil tested high in P. Initial analysis showed that the P_2O_5 rate required to avoid yield loss at most sites (M3-P value greater than 45 ppm, or "high") varied between 50 and 100 lbs/acre, with most sites showing no yield response above 50 lbs/acre. Some sites showed a significant effect of soil moisture on yield. A statewide stakeholder meeting was held on Zoom to share results with producers and their organizations. Preliminary analyses of drone work showed that images can help improve the analyses of yield data by incorporating the effects of spatial variability on soil properties, especially at seepage irrigated sites. Investigators met with producers to plan fall field trials. We are likely heading towards a new P fertilizer management recommendation for tomato in central and south Florida.

Potato (northeast, central, and south Florida): Phosphorus management trials at commercial and UF research farms were harvested and potato tubers were graded. In northeast Florida, potato yield responded to P fertilizer regardless of the amount of P in the soil as measured by a standard soil test. As such, evidence is lacking to propose limiting fertilizer P application based solely on a pre-season soil test for P due to the inability of the Mehlich 3 soil test to correlate with plant-available soil P. In central and south Florida, some evidence for positive yield response to P fertilizer was observed at most sites where M3-P was greater than 45 ppm

("high" rating). Most south Florida sites showed a significant yield response to P_2O_5 fertilizer rates between 92 and 137 lbs/acre. There was no clear evidence of a significant yield response to P fertilizer at central Florida sites. However, increasing P rates showed a reduction in "hollow heart" disease at the chipping potato site. A statewide stakeholder meeting was held on Zoom to share results with producers and their organizations.

Citrus (statewide): Fertilizer was applied at established research orchard sites from the panhandle to south Florida. Leaf and soil analysis plus fruit yield and juice quality were evaluated. Production costs and economic parameters were measured. Since citrus is a perennial crop, several years of research will be required to arrive at improved nutrient management recommendations. A producer-focused webinar described optimal fertilization and irrigation management information, including: 1) a lag time is required for nutrient applications to affect yield, canopy and trunk size; 2) use of bi-weekly fertigation kept soil nitrate in the top 6-inches of soil; 3) growers should aim to keep leaf macronutrients and micronutrients within optimum to high ranges; and 4) growers should consider using a combination of improved fertilizer blends and crop protection products to improve juice quality and root density. Micronutrient management was discussed in a Citrus Industry Magazine article: https://citrusindustry.net/2023/06/27/managing-micronutrients-in-hlb-affected-trees/

Corn (Western Panhandle and Suwannee Valley): Various spring field trials were planted across north Florida to evaluate N fertilizer management. Newly-acquired equipment was used to apply fertilizer and to measure plant response. Data collection was in progress. No results to report, as the corn has not been harvested yet. Preliminary observations suggested that enhanced efficiency fertilizer performed better than conventional fertilizer, and that banding fertilizer was better than broadcasting. The use of drones to estimate crop yield was investigated. Progress is being made that will lead to improved N fertilizer BMPs for corn. Field days were held at Live Oak and Jay to share research information with producers.

Snap Bean (statewide): Field trials focused on N and P fertilizer response were harvested from Live Oak in the north to Homestead in the south. Live Oak research evaluated controlled release N and banding vs. broadcasting fertilizer. Response data were under analysis. In central and southwest Florida, two of three sites showed some evidence for a statistically significant positive yield response to added P fertilizer even though pre-plant soil test M3-P was greater than the current critical ("high") value of 45 ppm. At one south Florida bean site, yield from grower standard fertilization (liquid + dry) was greater compared with solely dry fertilizer applied at the same rate of 80 lbs P_2O_5/ac, indicating fertilizer source may need to be considered when updating bean fertilizer recommendations. The effect of soil moisture on yield (ditch effect) was also observed at one of the three bean sites. At Homestead, bean yield increased with P application rate at the UF/IFAS research farm, where 160 lbs P_2O_5/acre produced the highest yield. This rate is much greater than the rate snap bean growers use in the Hastings and Homestead areas. In contrast, on a commercial farm in Homestead with high background soil test P (240 ppm P on average), P application beyond 50 lbs P_2O_5/acre did not increase yield. Stakeholder meetings were held to share results with producers and other interested parties.

Cotton (Western Panhandle): Spring cotton trials were planted at West Florida REC in Jay to evaluate N fertilizer management. Data collection was in progress. No results to report, as the cotton has not been harvested yet. Progress is being made that will lead to improved N fertilizer BMPs for cotton. Work was summarized in a blog post found at https://nwdistrict.ifas.ufl.edu/phag/2023/07/21/cotton-nitrogen-fertilization-rate-study-2023-mid-season-update/

Watermelon (Suwannee Valley): A "Veris" rig was used to measure soil variability in row crop grower fields. Soil moisture probes were installed to help growers manage irrigation. On-farm demonstrations evaluated N rates, sources, and water management. A watermelon field day was held at a commercial farm to compare management practices used at different farms to keep N fertilizer in the root zone. Controlled release fertilizer was a successful alternative to water-soluble N fertilizer in producing typical commercial yields while minimizing N leaching.

Limpograss (central Florida): Data were compiled and summarized from the 2022 growing season, and the 2023 season trial was started. Preliminary data indicated that although Gibtuck limpograss has greater forage accumulation and nutrient uptake, the current P recommendation may supply sufficient P to optimize forage growth and persistence. Tissue P concentration will be an important tool to include in the P fertilization recommendations for limpograss. There was no effect of P fertilizer rate on the concentration of P in shallow groundwater beneath the plots. Findings from this project were presented to approximately 120 producers during the 2023 Range Cattle Research and Education Center Field Day.

Peaches (central Florida): Peaches were harvested, and yield, fruit size, and single fruit weight were measured. Soil and leaves were analyzed for mineral content. N-P-K fertilizer was applied to the trees at three rates. Trees receiving three applications of 3 lbs of 15-5-10 (N-P_2O_5-K_2O) fertilizer per year (total of 1.35, 0.45, and 0.90 lbs of N-P_2O_5-K_2O per tree per year) produced the highest single fruit weight and overall yield among the fertilizer treatments. Individual fruit weight did not significantly differ between NPK fertilizer treatments of 2 and 3 lbs/tree per application. Since 8-year-old mature peach trees are being used for this experiment, it is too early to draw conclusions from the fertilizer treatments. A draft of an extension publication on nutrient management in peaches under a subtropical climate is being developed.

Hemp (statewide): Nutrient management research on hemp continues at WFREC-Jay, PSREU-Citra, and TREC-Homestead. Efforts are centered on work that will help develop nutrient rate recommendations. Studies at PSREU are investigating fertilizer rate and timing in conventional systems for fiber, seed, and flower production. At TREC, nutrient management equipment has been deployed to establish and terminate cover crops ahead of an organic hemp and vegetable planting. The research is deploying multiple sources of organic, controlled release, and liquid fertilizers for experiment and demonstration. Field plantings have been established for nutrient management studies investigating rate, timing, and source in conventional systems for seed and flower production. Nutrient analysis of soil and plant tissue is ongoing at the EREC-Belle Glade Lab. A provisional nutrient recommendation for hemp has been drafted from cumulative literature review, quantitative research, and practical experience.

Soil Testing (statewide): Many hundreds of soil samples analyzed showed 0.90 or better correlation between Mehlich 3 P analysis run at commercial labs vs. the IFAS Soil Testing Lab. Soil sample storage did not significantly affect soil test P values. Scooping soil samples in the IFAS Lab resulted in 28% higher M3-P values compared with weighing samples. Lab accuracy of M3-P determination is of fundamental importance before any recommendations can be made for crop fertilization. Suggestions based on findings so far: 1) Use the same lab for soil analysis to ensure comparison of M3-P during any cropping cycle, and for subsequent cropping cycles; 2) Suggest including soils with known M3-P values with each batch to ensure that analytical techniques are consistent irrespective of the technical staff assigned to the analyses; 3) Identify procedure adopted – scoop vs. weighing of soils when reporting data.

Site-Specific Management and Artificial Intelligence (statewide): Calibration of the DSSAT (Decision Support System for Agrotechnology Transfer) model continued. Data generated using the DSSAT model was used to train a machine learning (ML) model based a long short-term memory (LSTM) model to understand the relationship of daily fluctuation of soil N concentration with changing weather conditions and fertilizer application rates/timings. Later, the soil N observations (4 times replicated in 6 sampling timings per season) were used to optimize the parameters of the LSTM model to improve the DSSAT simulated soil N estimates between the sampling dates in the potato fields. The hybrid-LSTM successfully improved the soil N estimates (less noise) simulated by the DSSAT model between sampling dates. To improve the ML modeling, we will continue exploring better features and approaches that could improve crop nutrient recommendations for Florida agriculture while considering site-specific variations for individual growers.

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:

- Cotton and industrial hemp trials were planted at West Florida Research and Education Center, Jay.
- All trials received fertilizer applications. The newly purchased band applicator was used to apply fertilizers in the placement treatments.
- A Rapidscan C-45 was ordered from Holland Scientific that will be used to collect NDVI/ NDRE vegetation indexes.
- Research data collection is in progress.
- A graduate student submitted a proposal to his supervisory committee and his first committee meeting was held where research progress was discussed.
- The investigator and his graduate students met weekly to discuss progress on the research trials and data collection.

Significant findings and/or events occurring during the quarter:

- None observed yet, as we are in middle of the season for all row crops in the field.
- On July 24th we held a "Corn and Soybean Field Day" where we demonstrated and discussed our nutrient management corn trials with producers and shared some preliminary results:
    - The corn produced using enhanced efficiency fertilizer (UMAXX, including both nitrification inhibitor and urease inhibitor) appeared to be performing more efficiently (greater plant uptake vs. amount applied) compared with conventional urea-N (more likely to be lost to the environment).
    - Observations of in-season crop data and visual corn growth suggested that band application of N fertilizer increased crop use efficiency, which would in turn lead to decreased fertilizer rates (lower cost, less environmental loss).

Activities planned for the subsequent quarter:

- Begin year 2 of this project.
- Harvest corn.
- Data analysis including crop response variables (e.g., grain yield), plant growth characteristics, soil testing, ammonia volatilization.
- Communication with stakeholders to describe the first year of the project.

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 were established. Sites for the cotton and industrial hemp trials were selected.
- 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.

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:

- We have established six experimental sites for this research project: Four sites in Quincy (Gadsden County), one is in Monticello (Jefferson County), and one is in Mariana (Jackson County).
- Spring fertilizer applications were made.

- Leaf greenness was measured with a SPAD meter.
- We pruned trees to remove dead and dried branches due to late freeze.

Significant findings and/or events occurring during the quarter:

- Acquired baseline (pre-treatment) soil and plant tissue samples from each site.

Activities planned for the subsequent quarter:

- Apply additional N fertilizer through the summer according to the treatment plan described in the FY 2023-24 (year 2) plan of work.

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.

Identified obstacles or challenges:

- December and March freezes caused severe damage to both young and established groves, resulting in 60 to 70% yield loss. Plants are recovering well but there will likely be a fruit crop yield reduction of 80 to 90% at fall harvest time.

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

Activities and accomplishments:

- Equipment acquisition and use.
    - Progress on equipment purchases.
        - Purchased and received: One-row OxBo/Pixall snap bean harvester; Veris MSP3 soil mapping rig; small plot fertilizer applicator; soil moisture probes; center pivot Irrigation variable rate upgrades; and fertigation equipment.
        - Purchase orders in place, awaiting delivery: Ford F-350 pick-up truck; Ford F-150 pick-up truck; field plot ATV buggies; John Deere 6R 120 tractor.
    - The new Veris rig has been used at six fields managed by four row crop growers and one high tunnel vegetable farm in Hamilton and Suwannee counties in addition to several fields at NFREC-SV to support ongoing research and extension activities.
    - Soil moisture probes were used at 12 farm demonstrations evaluating controlled release fertilizer on watermelons, grain corn, and sweet corn in Gilchrist, Levy,

and Alachua counties. Soil moisture probes are also being used in other demonstration projects evaluating on-farm corn N rates and sources, e.g., comparing "Everlizer" poultry manure with controlled release fertilizer in Madison and Dixie counties.
    - We used the fertigation equipment this spring to implement a watermelon BMP study on N fertilization.
- The NFREC-SV, Live Oak team completed two snap bean fertilizer trials.
    - These trials were planned with the advice of key north Florida snap bean farmers and industry representatives. They are following up previous work conducted with various rates of conventional and controlled release N fertilizers applied using different methods.
    - Snap bean N treatments included controlled-release fertilizer (CRF) broadcasted pre-plant and CRF applied in a 15-inch band over the row. This trial was harvested with the new harvester and yield and quality data were collected.
    - Our snap bean team, including a grad student, has been summarizing all N rate and source research that has been conducted at NFREC-SV in the past 3 years.
- Our NFREC-SV team has continued discussions with the leadership group from FDACS-Office of Ag Water Policy, FDACS-Division of Agricultural Environmental Services, and Suwannee River Water Management District. These discussions have led to the planning of a large regional cost-share project proposal for the Suwannee Valley.
- We hosted Commissioner Wilton Simpson for a day-long tour of IFAS-led BMP projects on farms and at NFREC-SV. The tour 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 farms in the region have been held to communicate activities led by UF/IFAS county and state faculty to further the progress of BMP adoption in this region. Examples of these meetings, projects, and tours have included:
    - Discussions among the Suwannee River Partnership steering committee.
    - Implementing 12 large scale on-farm demonstrations for controlled release fertilizers and soil moisture sensors in watermelon, grain corn, and sweet corn.
    - Hosting the UF/IFAS Youth Institute twice at NFREC-SV, corn field day, watermelon field day on a collaborating farm, and a follow-up meeting of county extension faculty, FDACS staff, and Conservation District field staff to discuss ways to collectively document BMP adoption in the region.

Significant findings and/or events occurring during the quarter:

- Faculty and staff are summarizing previous N rate and source studies in snap beans conducted in North Florida during the past 3 years. This summary will help identify gaps in N fertilizer research for the area's sandy soils and will guide research plans for next spring's snap bean trials.
- Data for the recently completed fall snap bean trial are being analyzed and will be added to the snap bean N research database being compiled and summarized as part of this project.

- Controlled release fertilizer demonstrations have been successfully implemented on 7 watermelon and 3 corn farms. In addition, several other on-farm BMP demonstrations have been implemented. This project has led to further discussions between UF/IFAS, FDACS Office of Ag Water Policy, and Florida DEP to develop and potentially fund a large regional BMP project in the Suwannee Basin in the upcoming year.

Activities planned for the subsequent quarter:

- Hire a communicator who will:
    - Demonstrate and evaluate the 5Rs concept of nutrient management on various crops that will lead to updated IFAS recommendations and grower adoption of same.
    - Summarize the ongoing research and extension activities being conducted in the Suwannee Valley, both at NFREC-SV and on cooperating farms.
    - Document progress toward adoption of BMPs and N load reductions on farms in the region.
    - Provide regional level activity coordination and communications between BMP project leaders and stakeholders in the Suwannee Valley

Progress made towards overall project objectives:

- The 4th quarter of this project was focused on continuing to build capacity through equipment purchases and completion of spring snap bean research trials. Great progress has been made on identifying sources of the equipment and following purchasing protocols.
- The snap bean project will help fill 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 acquisition has increased the capacity to do further nutrient management research and extension activities in this region, both at the Live Oak Center and on farms. Target crops in addition to snap beans for which BMP related activities continue include corn, cotton, watermelon, carrot and potato.

Identified obstacles or challenges:

- The main challenge in equipment purchases has been the ever-increasing costs of equipment, above the estimates given back in the early spring of 2022 when the proposal was developed.
- There have also been supply chain issues delaying delivery times.
- Otherwise, this project has proceeded well.

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:

- Corn planted during the 3rd quarter was up and growing well.
- Before being used in the field, the recently obtained equipment (a LI-COR, spectrometer, and plant canopy imager) was checked and calibrated to ensure it would perform as expected. The data are now through the processing phase of the procedure.
- After the plants had developed to the V4 stage, soil and biomass samples were taken at regular intervals of 21 days. The ARL laboratory is in the process of analyzing these samples.
- Every 2 weeks, or until the lysimeters exceeded their capacity (whichever occurred first), leachate samples were collected from lysimeter-equipped plots. No leaching took place at the beginning of the season due to dry weather.
- NDVI sensors were put in place and the basic data analysis was carried out.

Significant findings and/or events occurring during the quarter:

- Fig. 1 shows the strong relationship between N rates and NDVI across distinct development phases from V4 to R1. We observed minimum variation in NDVI readings when comparing Site 1 N rate treatments. However, at Site 2 highest NDVI values were observed at V12 and R1 growth stages where the N application rate was 280 lbs/acre.

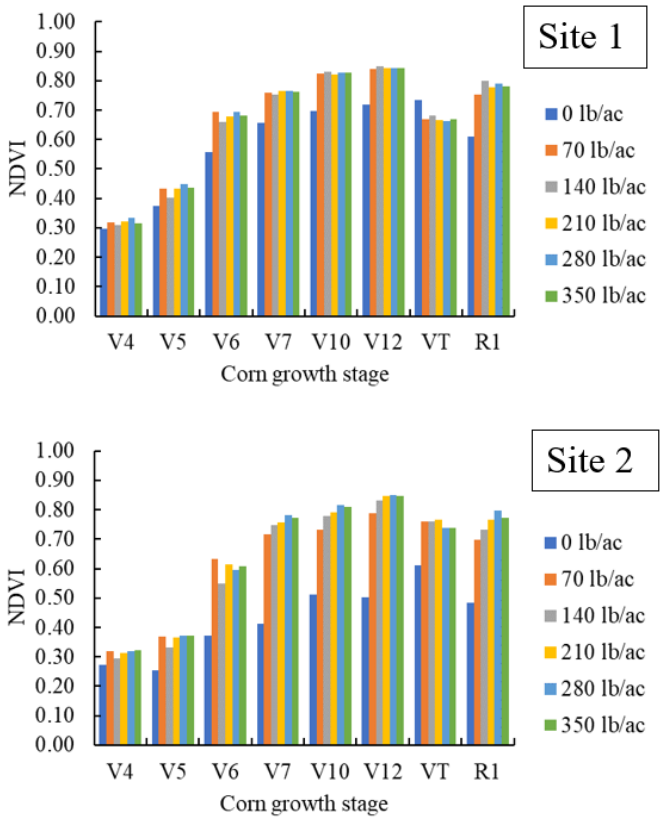

Fig 1. The relationship between N rates and NDVI across distinct development phases (V4 to R1.)

- A Corn Field Day was held to present findings to growers and other interested clientele. It was a well-attended event and the audience provided positive feedback about the research.
- A research article about yield prediction through active sensor readings article was submitted, accepted, and published:
    - Leitão, D. K., S. S. S. Sidhu, W. D. Griffin, U. Ahmad, and L. K. Sharma**.** 2023. Irrigated corn grain yield prediction in Florida using active sensors and plant height. Smart Agricultural Technology, Volume 5: 100276. https://doi.org/10.1016/j.atech.2023.100276.
- Currently working on a second research paper (crop-height model). The paper includes the ability of drones to estimate the crop yield, which could serve as an independent variable to improve the yield prediction early in the season.

Activities planned for the subsequent quarter:

- This research will continue for a 2nd year. We will determine phenotypic parameters to detect N and P stress from rate studies to develop BMPs to reduce the N and P loss.

Progress made towards overall project objectives:

- No yield data or results to share because the corn crop has not yet been harvested.

Identified obstacles or challenges:

- We observed N deficiency in some plots at V10. We rapidly corrected that issue, and the corn plants recovered.

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

Activities and accomplishments:

- We prepared and submitted all soil and tissue samples from P rate field trials.
- All data have been collected regarding tuber yield and quality characteristics. Compilation, quality check, and analysis for both seasons (2022 and 2023) have started with the data we have available.
- Three critical pieces of equipment (Kerian grading table, four-row vacuum cup potato planter, and 1.25-ton 4x4 truck) supported by this project funding have been acquired and used to support the scope of work.

Significant findings and/or events occurring during the quarter:

- First, a historical perspective from 2022: Mehlich 1 and Mehlich 3 extractable soil P for initial soil samples prior to fertilizer applications (initial samples) were correlated with total tuber yield to generate a calibration of soil sample results prior to fertilizer application. Mean initial sample M1 and M3 corresponding soil test P indexes of very

low, low, medium, high, and very high for M1 and low, medium, and high categories for M3 are shown in Table 1.

Table 1. 2022 season soil extractable P for M1 and M3, significance of total yield and estimated total yield at zero P rate for each of six sites in northeast Florida.

Site	Crop	[1]Beginning M1-P	[2]Beginning M1-P index	[3]Beginning M3-P	[4]Beginning M3-P index	[5]Total yield significance	[6]Total yield at zero P_2O_5 rate (CWT/acre)
NE P01	Potato	167 ± 29	Very High	314 ± 57	High	***	387.7
NE P02	Potato	69 ± 9	Very High	198 ± 18	High	***	344.2
NE P03	Potato	30 ± 10	Medium	67 ± 14	High	***	277.2
NE P04	Potato	140 ± 28	Very High	281 ± 58	High	NS	234.4
NE P05	Potato	**Study ended because of errant fertilizer application**					**N/A**
NE P06	Potato	186 ± 27	Very High	330 ± 47	High	**	408.2

[1]Mean extractable soil M1 concentration ± one standard deviation: [2]Mehlich 1 Extractable soil P index; [3]Mean extractable soil M3 concentration ± one standard deviation: [4]Mehlich 3 extractable soil P index; [5]NS = not significant (no response to P), **moderate significance (p = 0.01 to 0.05), ***highly significant (p = <0.01).; [6]Fertilizer application rate of 0 lbs/ac P_2O_5 as estimated by the zero intercept of the regression equation.

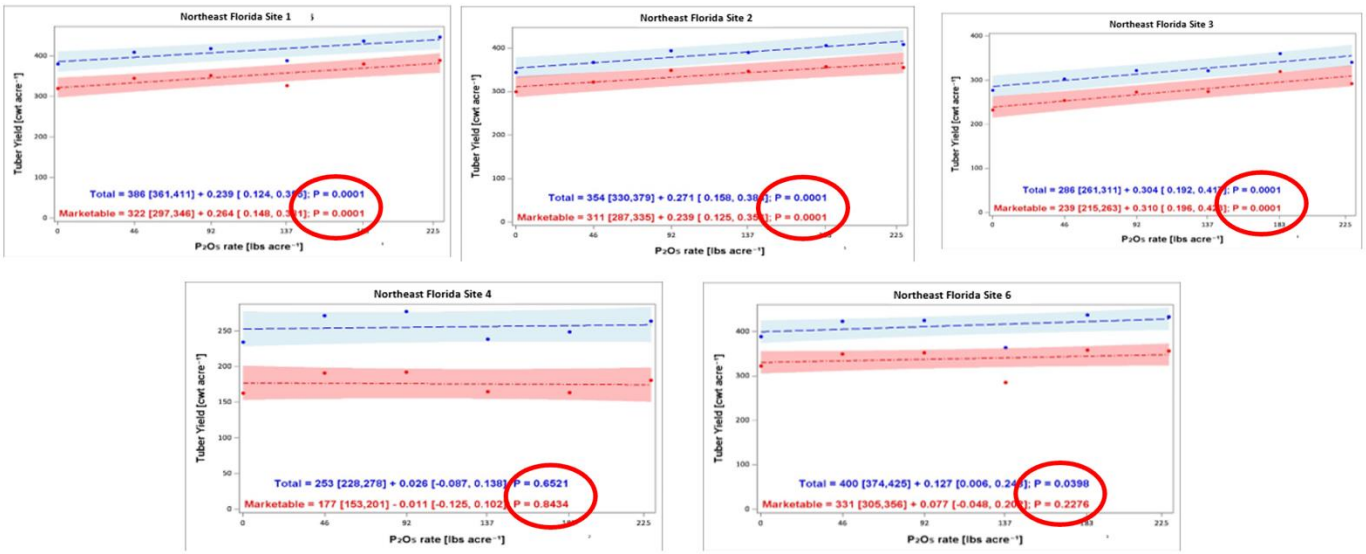

Figure 1. 2022 Season Linear Regression models of total and marketable tuber yield responses to phosphate fertilizer rate applications ranging from 0 to 229 lbs/acre.

- Focusing on potato research conducted specifically within the Northeast Florida region, 2022 investigations revealed notable patterns in yield response in relation to increased

application of P fertilizer. Only one site (NEFla4) yielded a non-significant regression between total yield and initial soil extractable P, with levels reaching up to 186 mg/kg for M1-P and up to 330 mg/kg for M3-P (Fig. 1). Results suggest that for soils with M3-P less than 330 mg/kg, it may necessitate fertilizer P rates up to 225 lbs/Ac of P_2O_5, the highest P rate examined in our studies. Additionally, tuber yield did not increase with increased initial soil extractable P or plots with 0 kg/ha P_2O_5 fertilizer application, either for M1-P or M3-P. As such, there remains insufficient evidence to propose the limitation of fertilizer P applications based solely on extractable soil P prior to application due to the inability of M3 to correlate with plant-available soil P.

- Preliminary results from the 2023 season offered congruent insights, suggesting similar responses of marketable potato yield to increasing P fertilizer application across three of the five sites tested in the previous year (NE P02, NE P03, NE P04; Fig. 2). However, it should be noted that the data for 2023 is still provisional, as we are continuing to receive updated data for lab analysis. Furthermore, the 2023 season was affected by a significant hailstorm event on April 27th at three out of the six testing sites (specifically plots located at the HAEC). The event's potential impact on our findings is currently under careful investigation.

Preliminary 2023 Season Total and Marketable Yield Responses to Phosphate Fertilizer Application

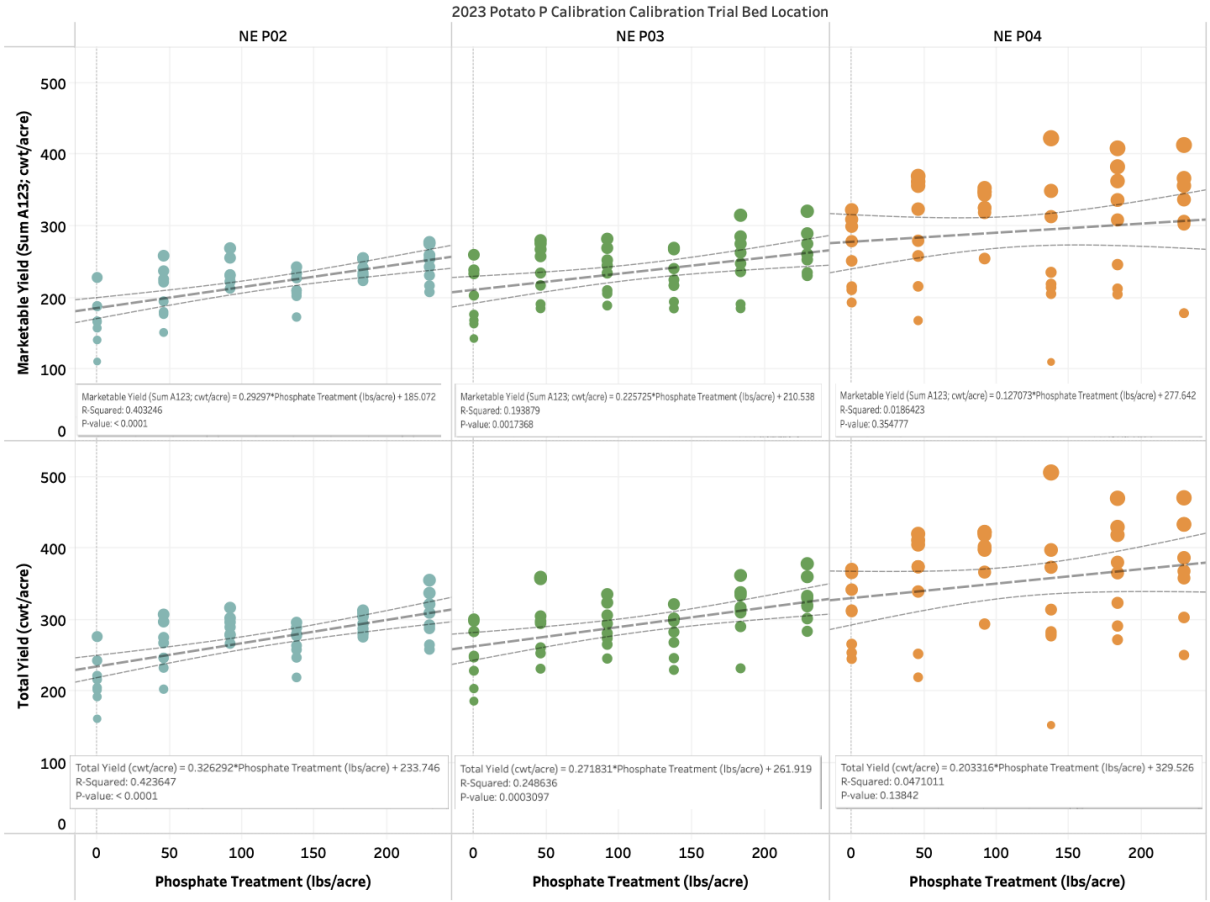

Figure 2. 2023 season linear regression models of marketable tuber yield responses to P fertilizer rate applications ranging from 0 to 229 lbs/ac for NE P02, NE P03, and NE P04.

- Finally, we advocate that future studies should continue to investigate the potential for yield improvements from increased fertilizer P use efficiency, specifically through the adoption of 4R practices such as split P applications during the season, use of fertigation, and use of amendments. The findings from this study will be supported by results from efforts from the UF/IFAS research team investigating alternative soil P extractants. The combined efforts will help establish reliable calibration curves for soil test results in potato farming and other commodities.

Activities planned for the subsequent quarter:

- The NE Florida potato team will shift their research from studying P fertilizer rates towards studies evaluating P fertilizer placement and timing in an effort to increase P fertilizer use-efficiency.

Progress made towards overall project objectives:

- With the support of UF/IFAS statisticians, statistical models will be used to fit total and marketable yield response to additional P from the combined 2022 and 2023 production seasons. Yield response will be contrasted with soil available P using M1 and M3, total biomass, and P uptake. P nutrient balance and efficiency of P fertilizer use will be estimated. The results from this comprehensive study will support revising the IFAS P fertilizer management recommendations for potatoes.
- In the current reporting period, the research team has sampled, prepped, and submitted all soil and petiole samples, respectively. Excluding a more in-depth analysis of all concurrent years of research data and writing of the peer-review scientific manuscripts, nearly allz100% of the proposed scope of work is completed to date.
- The HAEC team is confident that 2022 and 2023 season data combined provides robust evidence to support UF/IFAS's provisional recommendation of 120 lbs P_2O_5/acre, with an additional 25 lbs/acre for cold soil conditions in northeast Florida. The group is optimistic that the P rate developed via supporting evidence from this working group will be sustainable, promoting both environmental stewardship and farmer viability in the northeast region.

Identified obstacles or challenges:

- Efforts to hire additional staff proved to be challenging. Ultimately, the Hastings Agricultural Extension Center (HAEC) team, in addition to hired temporary labor, rose to the occasion providing remarkable support for the timely completion of research objectives.

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

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 experiments (conducted from 2011-2012 in four commercial farms and from 2013-2014 in two farms) reported by Zotarelli and other researchers.
- The additional data generated using the DSSAT model was used to train the ML based a long short-term memory (LSTM) model to understand the relationship of daily fluctuation of soil N concentration with changing weather conditions and fertilizer application rates/timings. Later, the soil N observations (4 times replicated in 6 sampling timings per season) were used to optimize the parameters of the LSTM model to improve the DSSAT simulated soil N estimates between the sampling dates in the potato fields. The combination of DSSAT and LSTM models was referred to as the hybrid-LSTM model.
- Daily weather data- rainfall, air temperatures (mean, min, max), daily soil temperatures (mean, min, max), applied N fertilizer rates-timings, soil N observations, growing degree days, and antecedent moisture condition were used to develop the hybrid-LSTM model.
- Earlier, several sharp peaks and valleys in the hybrid-LSTM estimate soil N curve were observed. These irregularities were induced due to huge variation in the soil N replicates and the treatments with partially similar N fertilizer applications. We were able to reduce the noise in soil N estimations by averaging the soil N observations in the treatments with partially similar N fertilizer applications.
- Given a huge variability in the soil N among the replicates, estimating a precise soil N line curve became a formidable challenge. Hence, we planned to estimate the daily area curve of soil N to capture its variability observed in the fields. We trained the hybrid-LSTM around 20 times (assumed) to generate 20 different soil N values for each day. Later, the standard deviation of these 20 values for each day was used to estimate the area curve of soil N. The mean of these 20 values was used to estimate the line curve of soil N.
- Since there were limited observations per potato season to evaluate the daily soil N estimates simulated by the hybrid-LSTM or the DSSAT model, we developed our own metric to evaluate these model estimates. The ratio of the number of times the soil N area/line curve estimated by the hybrid-LSTM/DSSAT model passing through or partially touching the replicant bounds and the total number of soil N sampling stages was used as a metric to evaluate these models. This metric was referred to as passing ratio (PR). [PR=1 means line passed through all the replicant bounds and PR=0 means line curve did not pass through any replicant bounds.]
- The hybrid-LSTM model was successfully developed combining the DSSAT model and ML based LSTM model to provide the soil N estimates between the sampling dates from potato fields. The hybrid-LSTM soil N model would eventually be used as foundation for developing a similar hybrid ML model for the potato growth that will in the future provide support to the nutrient recommendations for potato. Later, the methodology could be used to provide nutrient recommendations for other crops and other nutrients like P.

Significant findings and/or events occurring during the quarter:

- We observed that the hybrid-LSTM successfully improved the soil N estimates (less noise) simulated by the DSSAT model between the sampling dates.
- The overall Passing Ratio (PR) was 0.56 and 0.36 respectively, for the hybrid-LSTM and the DSSAT model area/line curve of soil N, while training the hybrid-LSTM model. PR was 0.53 and 0.27 respectively, for the hybrid-LSTM and the DSSAT model area/line curve of soil N, while testing the hybrid-LSTM model.
- The hybrid-LSTM model performed well in 2011 and 2012 [PR=0.59 (training)/0.75 (testing)] compared with 2013 and 2014 [PR=0.47 (training)/0.43 (testing)]. The possible reason could be more data available in 2011 and 2012 (4 farms of observations per year), compared with 2013 and 2014 (2 farms of observations per year).
- Moreover, due to limited data available for training the hybrid-LSTM model in 2013 and 2014, the LSTM was not able to develop a relationship between the fertilizer applied rate-timing and soil mineral N. That is why the hybrid-LSTM model missed the spike in the soil mineral N due to N fertilizer application.

Activities planned for the subsequent quarter:

- Continue year 2 of this project by organizing more datasets from experiments already conducted in Florida. We will calibrate DSSAT using observations from other farms and crops. Later, calibrated DSSAT results will be used to improve our current ML model developed to estimate soil mineral N and use the ML estimate soil N for plant growth and development.
- To improve the ML modeling, we will continue exploring better features and approaches that could improve crop nutrient recommendations for Florida agriculture while considering site-specific variations for individual growers.

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 ML model that could estimate daily soil N between the sampling dates.
- Our next step is to develop this hybrid model as foundation for developing another model to estimate the response of weather conditions and soil N on the plant growth and development. 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 P.

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 Dept., Gainesville

Activities and accomplishments:

- Mehlich 3-Phosphorus (M3-P) analyses of 400 soil samples [200 from the recently completed FDACS (USDA) project and 200 composited soil samples collected during the first year of this project] from four commercial labs [UF Extension Lab, Central Florida Soil Lab (CFSL), Waters Agricultural laboratories, and Waypoint] were analyzed statistically to determine accuracy and reliability of the results among labs.
- We also completed statistical data analyses of 200 USDA samples for water-soluble P (WSP) compared with the same analyses done previously (~6 years ago) to investigate the effect of soil storage on WSP. Both sets were analyzed in our laboratory (Figs. 1 & 2).
- Evaluated M3-P results for 400 soil samples analyzed at IFAS Analytical Research Lab (ARL) and UF Extension Lab to compare weighing vs. scooping soil samples (Figs. 3 & 4).
- About 600 new samples (received from different locations of Florida: Citrus group-Lake Alfred, vegetable group-Immokalee, Gulf Coast, Hastings; Fig 5) have been analyzed in-house for WSP.
- More than 300 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 (Fig. 5).

Significant findings and/or events occurring during the quarter:

- The table below shows the Pearson Correlation between M3-P analysis by four commercial labs. Replicate analysis at each of the labs are within QA/QC requirements. These results are based on 400 soil samples. All labs used the "scoop" procedure.

	Waters[1]	Waypoint	CFSL	UF Extension
Waters	1.00			
Waypoint	0.97	1.00		
CFSL	0.93	0.90	1.00	
UF Extension	0.95	0.95	0.91	1.00

[1]100 samples analyzed by Waters gave values which were double the expected M3-P values. The Lab was contacted, and they indicated that it was their problem. It was a unit issue that has been taken care of in this table.

- Water Soluble P of samples from the Beef Research Unit (BRU), Citra and Marianna, analyzed after 6-years.
    - Data show no significant differences (R^2=0.93) (Fig. 1) during soil sample storage.
    - Minor decreases in WSP with time depended on the location of soil sampling (Fig. 2).

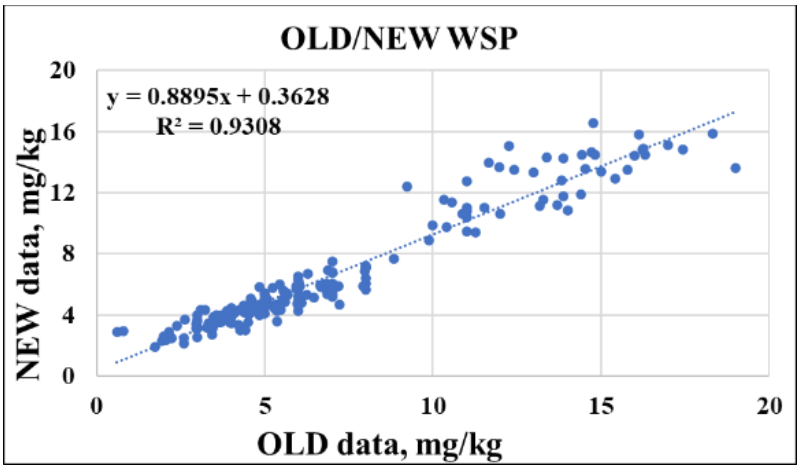

Fig. 1. Relationships between old (~6 years ago) and recently analyzed WSP concentrations (mg/kg) (200 soil samples from USDA); both sets analyzed in our lab.

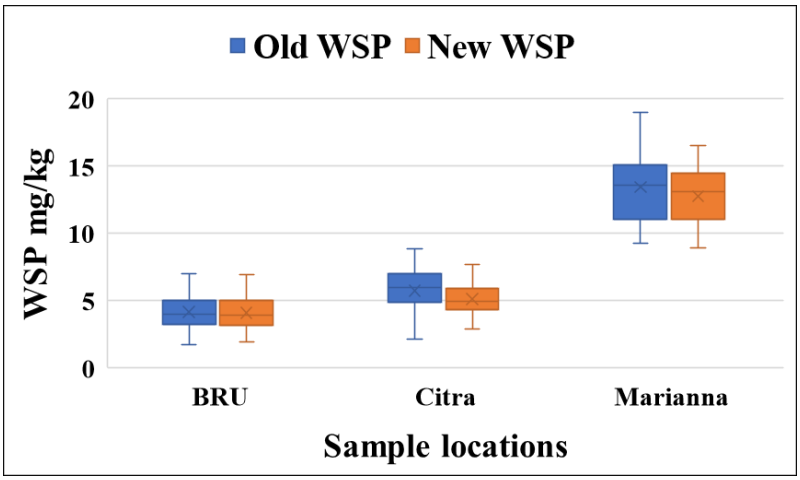

Fig. 2. Old and new WSP results from three locations. P concentration in BRU samples remained constant, while values from Citra and Marianna decreased slightly, averaging -4.1%.

- Mehlich 3-P comparison using weight (ARL) and scoop (UF Extension) procedures.
  - 28% increase at UF Extension Lab vs. ARL (Figs. 3 and 4). Note: Most recommendations are made based on analyses from ARL, while clientele use the Extension Soil Testing Lab to obtain analysis and recommendations.

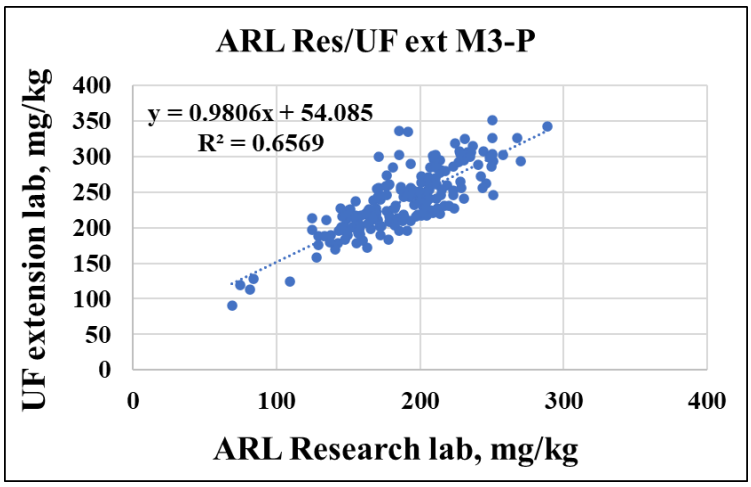

Fig. 3. Relationships between M3-P concentrations from ARL and UF Extension lab (200 soil samples from USDA).

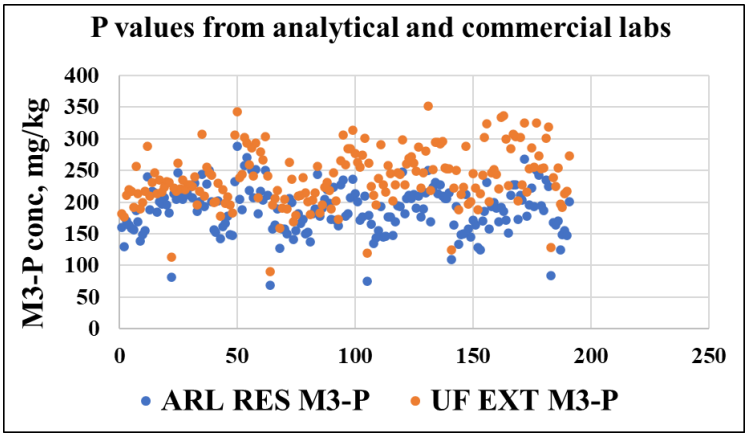

Fig 4. Comparison of M3-P values from ARL Research Lab (weigh samples) and UF Extension Lab (scoop samples). Statistical analyses show 28% M3-P increases in UF Extension data.

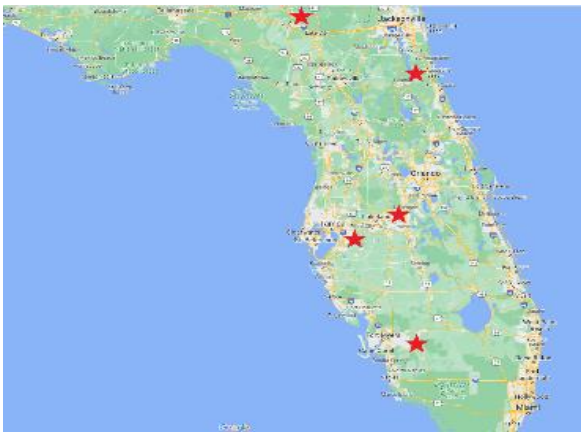

Fig. 5. Sample locations for the new samples we received in 2023 (Gulf Coast Research and Education Center-Wimauma, Southwest Florida Research and Education Center-Immokalee, Citrus Research and Education Center-Lake Alfred, Hastings Agricultural Extension Center-St. Johns, North Florida Research and Education Center- Suwannee). Various analyses in progress with 300 samples analyzed for FeO-P.

Activities planned for the subsequent quarter:

- Begin year 3 of this work to:
    - Develop and refine M3-P recommendations across all locations in Florida.
    - Identify additional site-specific components for locations that do not follow the expected trend.

Progress made towards overall project objectives:

- Lab accuracy of M3-P determination is of fundamental importance before any recommendations can be made for crop fertilization. Suggestions based on findings so far:
    - Use the same lab for soil analysis to ensure comparison of M3-P during any cropping cycle, and for subsequent cropping cycles.
    - Ensure units provided to clients are checked prior to reporting.
    - Suggest including soils with known M3-P values with each batch to ensure that analytical techniques are consistent irrespective of the technical staff assigned to the analyses.
    - Identify procedure adopted – scoop vs. weighing of soils when reporting data.

Identified obstacles or challenges:

- Delays in obtaining field soil samples.
- Year-to-year funding makes it difficult to recruit trained personnel.
- Lack of timely reporting of lab results by analytical and commercial labs.

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

Activities and accomplishments:

- Two Spectro ICP-OES instruments were installed in the lab.
- Two Deena II Automated Sample Prep and Digestion Systems were installed.
- Received the following instruments, awaiting installation:
    - AS3020D pH/EC Analyzer
    - A conversion kit to convert existing pH/EC system to dual
    - Agilent Bio-Tek Epoch 2 Microplate Spectrophotometer
- A Thermo Fisher ICP-IR-MS instrument was ordered.

Significant findings and/or events occurring during the quarter:

- The Spectro ICP instruments are functioning, analyzing samples.
- Progress made with field research on controlled-release fertilizer (CRF) as a BMP for vegetable production:
    - Tomato harvesting completed.

    - The study demonstrated that there were seasonal differences in yields between the conventional and compact bed geometries in north Florida. Under warm-season production, due to higher volume in compact beds, increased water and nutrient contact with the root system may have benefited yields.
    - Higher beds may not be suitable under low temperatures due to increased exposure to ambient weather conditions.
- Field research on Soil Health Index for Florida agricultural fields in on-going at north and south FL locations:
    - Ongoing tissue and soil sampling, along with analyses are in process for both north and south Florida projects. Data in south Florida is being collected from two different grower sites, who are incorporating cover crops in their vegetable production fields.
    - Data including yield, dry biomass, and soil health indicators are being compiled for all studies.
    - Potential soil health indicators we are evaluating include pH, organic matter, water-holding capacity, Mehlich 3 extractable P and K, total P and K, total Kjeldahl N, cation exchange capacity, bulk density, saturated hydraulic conductivity, active carbon, soil protein, soil enzyme-activities, and gene amplicon sequencing for biomass.

Activities planned for the subsequent quarter:

- Install new lab equipment and put the instruments to use.
- Compile and analyze data from field experiments.

Progress made towards overall project objectives:

- Thousands of samples from various nutrient management research projects are being analyzed using some of the new equipment and some existing equipment.
- Due to similarities in tomato yields, early findings indicate that use of CRF is a sustainable alternative N source for tomato production, even under suboptimal growing conditions.
- The economic benefit of applying CRF one time at preplant could be beneficial in terms of saving time, energy, and labor when compared with multiple fertigation applications of soluble N sources.
- Updated Nutrient Management/BMP website: bmp.ifas.ufl.edu

Identified obstacles or challenges:

- Long time lag between ordering, receiving, and installing new instruments.

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:

- Peach fruit was harvested four times. Yield, fruit size, and single fruit weight were measured for each treatment.
- After the fruit was harvested, soil samples were taken across the research plot at depths of 0-30, 30-60, and 60-90 cm.
- Leaf samples and harvested fruit samples were collected for analysis of mineral content.
- The third and final NPK fertilizer application treatments for the growing season were made during the second week of May.

Significant findings and/or events occurring during the quarter:

- Trees receiving three applications of 3 lbs of 15-5-10 N-P_2O_5-K_2O fertilizer per year (total of 1.35, 0.45, and 0.90 lbs of N-P_2O_5-K_2O per tree per year) had the highest single fruit weight and overall yield among the fertilizer treatments.
- Individual fruit weight did not significantly differ between NPK fertilizer treatments of 2 and 3 lbs/tree per application.
- There was no significant fruit yield difference between NPK treatments of 1 and 2 lbs/tree per application.
- A draft of an extension publication on nutrient management in peaches under a subtropical climate is being developed.

Activities planned for the subsequent quarter:

- Continue the project as described in the 2023-24 plan of work:
    - Determine the influence of NPK application rates on fruit yield and quality.
    - Determine the fate of NPK applied at different rates, as fertilizer application is split to coincide with four different phenological stages.
    - Provide extension resources for grower training and education and develop a statewide roadshow to extend project lessons to growers.

Progress made towards overall project objectives:

- Since 8-year-old mature peach trees are being used for this experiment, it is too early to reflect the results as affected by treatments.

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:

- Fertilizer application and data collection on tree growth, leaf and nutrient concentration, fruit yield and juice quality, production costs, and economic parameters.
- Field visits to project sites in the Florida panhandle.

Significant findings and/or events occurring during the quarter:

- Investigator Dr. Kadyampakeni delivered a webinar titled “Using optimal fertilization and frequent irrigation for managing HLB-affected trees.” About 36 growers attended the event. Main takeaways include:
    - Research suggests the need to update secondary, macronutrient, and micronutrient guidelines for HLB-affected trees for improved yield, canopy size, and juice quality.
    - A lag time is required for nutrient applications to affect yield, canopy and trunk size.
    - Use of bi-weekly fertigation kept soil nitrate in the top 6-inches of soil.
    - Growers should aim to keep leaf macronutrients and micronutrients within optimum to high ranges.
    - Growers should consider using a combination of improved fertilizer blends and crop protection products to improve juice quality and root density.
- Dr. Kadyampakeni published the tip of the week on “Managing Micronutrients in HLB-Affected Trees” (available at: https://citrusindustry.net/2023/06/27/managing-micronutrients-in-hlb-affected-trees/).
- Co-investigators Drs. Wright, Rossi, Ritenour, and Kadyampakeni presented a poster at the Florida Citrus Show describing their “Citrus Nutrient Management Project at UF/IFAS Indian River REC.”
- Project postdoc Dr. Ali Atta presented highlights of this project at the Florida State Horticultural Society annual meeting: “Effect of nitrogen and phosphorus rates on the citrus leaf, soil nutrient concentrations, fruit yield, and postharvest quality of HLB-affected sweet orange**.”** Main takeaways include:
    - The citrus trees used for this study in central and south Florida had deficient leaf N, K, and Ca concentrations.
    - Leaf P concentration was within the optimum range across all grove sites.
    - Trunk cross-sectional area and canopy volume were similar at all sites, indicating good uniform tree condition as this study commences.

Activities planned for the subsequent quarter:

- Continue the project as described in the 2023-24 plan of work.
    - Evaluate the impact of N and P fertilizer on yield, juice quality, fruit shelf-life, tree growth, physiology, and environmental quality.
    - Determine the optimal N and P rate for young and mature citrus trees based on growing zone and soil characteristics.
    - Assess nitrate and orthophosphate leaching following fertilizer application.
    - Collect data to support updated nutrient management recommendations that will result in optimal horticultural response and citrus tree performance.
    - Conduct a production-based economic analysis of nutrient use.

Progress made towards overall project objectives:

- Investigators are making progress on the project, but only 1 year of work on a perennial crop has been completed. We require 2 more years to validate current trends and observations. At that point we will be able to propose solid recommendations on novel BMPs focused on N and P.

Identified obstacles or challenges:

- Some difficulty was encountered navigating the UF Integrated Research Support Tool. Improvements will be made in the next fiscal year.

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

Activities and accomplishments:

- Water P concentration and microbiome samples were analyzed, completing the dataset for all response variables.
- A new master's degree-seeking graduate student joined the program and will work on the project.
- The 2023 experimental period has started. Fertilizer treatments have been applied and two harvests and sample collections have been concluded.

Significant findings and/or events occurring during the quarter:

- There was no effect of P fertilizer rate on water P concentration. However, there was a variation in water P concentration from May to September that followed the rainfall and water table pattern.
- There was no effect of P fertilizer rate on soil microbiome abundance.
- Findings from this project were presented to approximately 120 producers during the 2023 Range Cattle Research and Education Center Field Day held on April 20th.
- A grad student submitted an abstract to the ASA-CSSA-SSSA International Meeting this fall.

Activities planned for the subsequent quarter:

- Continue the project as described in the 2023-24 plan of work. The field study will be repeated for another year.
- An in-service training for county extension agents has been planned for September 2023. The date and agenda will be finalized in August.
- The abstract mentioned above will be presented by the grad student in the student competition.

Progress made towards overall project objectives:

- Preliminary data indicate that although Gibtuck limpograss has greater forage accumulation and nutrient uptake, the current P recommendation may supply sufficient P to optimize forage growth and persistence.

- Tissue P concentration will be an important tool to include in the P fertilization recommendations for limpograss in Florida.

Identified obstacles or challenges:

- There were no obstacles or challenges in this quarter.
- The investigator is contacting a soil microbiologist to help to expand the analyze of the microbiome data.

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:

- One tomato and three potato experiments in central and south Florida were harvested.
- Plant, soil, and water sampling was completed. Samples were processed and shipped to analytical laboratories.
- Results obtained from the labs were processed, consolidated, and standardized in database files for the three crops.
- Preliminary analyses of all available data including yield and soil P were completed for presentation to stakeholders.
- A statewide stakeholder meeting was organized in June 2023 to communicate results to statewide bean, potato, and tomato growers and leaders of specialty crop industries (Florida Farm Bureau, Florida Fruit and Vegetable Association, and Florida Tomato Committee). Results from all IFAS projects on bean, potato and tomato were presented. Feedback provided by the attendees was positive. The next stakeholder meeting will occur in November or December.
- A presentation to the IFAS Plant and Nutrient Oversight Committee (PNOC) was made in June 2023 to update the members on project goals, accomplishments, and plans.
- Hydrologic data collected at sites has been processed.
- Hydrologic modeling for one potato and one bean site was initiated.
- Orthomosaic images were developed from drone RGB images for sites and segmented by experimental units for analyses. Plant-area and yield covariates have been analyzed for correlations at two tomato sites.
- A meeting with two south Florida bean grower-cooperators was organized to present 2023 results.
- A field trip was conducted with a tomato grower-cooperator to select a tomato site for a 2023-2024 experiment.

Significant findings and/or events occurring during the quarter:

- Preliminary analyses of available data for 2021-2023 for the experiments showed:
    - Tomato

        - A statistically significant positive yield response was observed at majority of the sites despite the pre-plant M3-P levels being higher than the current threshold level of 45 ppm that indicates no fertilizer P is required per current IFAS recommendations.
        - Initial analyses showed that the P_2O_5 rate required to avoid yield loss at most sites (M3-P value > 45 ppm) varied between 50 and 100 lbs/acre, with most sites showing no yield response above 50 lbs/acre.
        - Some sites showed a significant effect of soil moisture on yield, confirming an earlier observation in a compact bed geometry project.
    - Potato
        - At least some evidence for positive yield response to P fertilizer was observed for most sites with M3-P > 45 ppm (high).
        - Most south Florida sites showed a significant yield response to P_2O_5 fertilizer rates between 92 and 137 lbs/acre.
        - There was a lack of clear evidence for a significant yield response to P fertilizer at central Florida sites. However, increasing P rates showed reductions in hollow heart disease at the chip potato site.
        - Regardless of the extraction method, soil test P generally increased in response to P-fertilization. Soil test P remained relatively consistent throughout the growing season.
    - Bean
        - Two out of three sites showed some evidence for statistically significant positive yield response to added P fertilizer even though pre-plant soil test M3-P was higher than the current critical value of 45 ppm.
        - At one south Florida bean site, yield from grower standard fertilization (liquid + dry) was greater compared with solely dry fertilizer applied at the same rate of 80 lbs P_2O_5/ac. Fertilizer source may need to be considered when updating bean fertilizer recommendations.
        - The effect of soil moisture on yield (ditch effect) was also observed at one of the three bean sites. Fertilizer source and soil moisture effects should be included in the next set of experiments. If confirmed, these factors may be useful in developing site-specific recommendations.
- Moisture content in ditch rows was generally higher than that in non-ditch-rows for tomato, potato, and bean sites.
- Preliminary analyses of drone images showed that images can help improve the analyses of yield data by incorporating the effects of spatial variability on soil properties, especially at seepage irrigated sites. Data from one south Florida tomato site showed significant correlation with yield.
- There was no clear effect of P rate on soil nematodes at the tomato sites in central and south Florida.
- P rate had no effect on bacterial spot severity at the central Florida tomato site. No appreciable disease was observed at the snap bean sites. However, P rate appeared to affect the severity of Alternaria brown spot in the two central Florida potato field trials. At two of the four south Florida sites, field variability was evident that likely affected

plant vigor and/or disease severity. This information will be used to refine future scouting and disease assessments.

- Dissemination/Extension Activities:
    - Three presentations of project results and plans were made to industry and other stakeholders at: i) Statewide Project Industry Stakeholder Group (June 2023); ii) Citrus Show (Vegetable Section) at Ft Pierce (May 2023); iii) bean grower-cooperators of South FL.
    - Yield data from all sites were shared and discussed when needed with grower-cooperators as soon as data was compiled.
    - The project team continued to discuss the goals and plans for the experiments, consulting with grower-cooperators to receive feedback in designing and implementing experiments.

Activities planned for the subsequent quarter:

- Continue compiling laboratory plant and soil data.
- Continue QA/QC of all plant and soil data including that from 2021-2022.
- Continue data processing and analysis, including identifying the relationship(s) among parameters like moisture content, soil nutrients, and plant factors (plant area, biomass, and yield) for tomato, potato, and bean. We will initiate detailed statistical analyses and explore advanced statistical methods.
- Aerial images will be processed further to improve correlation analyses for all sites and to explore its use in separating the effects of soil-hydrologic factors.
- Hydrologic modeling will continue for one potato, one tomato, and one bean site.
- Improve database functionality for storing soil and plant data.
- Depending on the data received from the lab, especially the baseline and at-planting M3-P, available data will be analyzed for a presentation to the Plant and Nutrient Oversight Committee (PNOC) in September 2023.
- Efforts to hire technical project staff, including filling positions (post-docs, technicians, field staff, engineer) that became vacant plus an administrative staff, will continue.
- Communication with grower-cooperators to get commitments for 2023-2024 experiments in central and south Florida.
- Work with grower-cooperators to identify sites and implement experiments at two tomato sites. Begin data collection as needed.

Progress made towards overall project objectives:

- Considering the continuing effects of delayed due to hurricanes Ian and Nicole on experiments with overlapping harvests combined with shortage of personnel and delays in getting lab results, the project progress is better than expected.
- We expect first round of analyses of M3-P and yield data to be completed by September 2023 and presented to PNOC.
- We are likely heading towards new P fertilizer management recommendations for tomato, potato, and bean in central and south Florida.

Identified obstacles or challenges:

- Return of laboratory analysis data from Waters Lab has been much slower than anticipated. The project staff has had several meetings with Waters to expedite the analyses and communicate the results to us. There is backlog of 3 to 6 months for plant and soil samples depending on the sites.
- Crop performance was affected by soil moisture variability, resulting in high variance in data and P (statistical) values – particularly for some potato and bean sites.
- Recording yield data for multiple tuber sizes and culls and collecting tuber samples simultaneously from commercial packinghouse is labor intensive, requiring long hours for project staff as well as the grower-cooperator's harvesting and packing house crew. It has been challenging to manage a team of 20 IFAS project staff to handle harvest and processing of samples on the same day. Similar challenges exist for bean sites in south Florida given the size of the experimental field (45 ac) and transporting the beans in multiple trucks to a packinghouse located 40 minutes from the field. Bean and potato harvesting and collecting final yield data by categories requires 12-16 hours of work for each harvest with some harvests only occurring on weekends to have access to the packinghouse. The benefit of collecting this level of industry-relevant, scalable, and high-quality data is a more robust, real-world dataset for developing recommendations.
- The project continues to suffer from the lack of qualified personnel mainly due to the nature of the short-term (1-year) project. 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. To assure the success of the project, it is important that funds are provided for more than 1 year to allow sufficient time to select sites, hire and retain personnel, and collect and analyze data to better cope up with delays.
- The ripple effect of extreme weather events can complicate timing of simultaneous planting and/or harvest for several sites.

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

Activities and accomplishments:

- Field experiment at TREC-Homestead:
    - Final bean harvest on May 1.
    - Soil, plant, and soil porewater sampling continued until harvest.
    - Samples were sent to the IFAS Analytical Research Lab for analysis.
    - Data analysis of previous growing season was completed.
    - Manuscript development started.
    - Result from grower-cooperator trial were communicated to the grower.
- Field experiment PSREU-Citra:
    - The experiment was planted on March 28, but seed germination was poor.
    - The experiment was re-planted with a modified irrigation rate on April 11.

- Plants were fertigated twice a week with 0-54-0 using a dosatron from April 3 thru May 20.
- Beans were harvested on June 6 and 7.

Significant findings and/or events occurring during the quarter:

- Bean yield increased with P application rate at UF/IFAS research farms, where 160 lbs P_2O_5/acre produced the most yield. This rate is much greater than the rate snap bean growers use in the Hastings and Homestead areas.
- In contrast, on a commercial farm in Homestead with high background soil test P (240 mg/kg P on average), P application beyond 50 lbs P_2O_5/acre reduced yield.
- Plant emergence was significantly greater where fertigation was used compared with dry granular fertilization.
- At 80 lbs P_2O_5/acre, bean yield was significantly greater when fertigated compared with dry granular fertilization, but at the other rates there was no significant difference.
- Due to drip irrigation failures, no P application rate except for 80 lbs P_2O_5/acre applied as liquid fertilizer increased pod yield above the zero rate. This trial must be repeated next spring.
- Abstracts and presentations.
  - Team members presented “Optimizing Irrigation and Phosphorus Management for Snap Bean Production on Calcareous Soils of South Florida: Best Management Practices and Lessons Learned” at the Florida Section of the American Society of Agricultural and Biological Engineers Annual Meeting. (1st place winner).
  - A grad student team member presented “Irrigation and Phosphorus Best Management Practices for Snap Bean Production on Calcareous Soils of South Florida” in the South Florida Graduate Student Organization Flash Talk Competition. (3rd place winner).
- A field demonstration for stakeholders was held at HAEC in Hastings.
- A field demonstration for stakeholders was held at PSREU in Citra.
- The team met with the commercial grower-cooperator to discuss spring field trial results. The grower agreed to continue his cooperative work on multiple farms during the 2023-24 crop season.

Activities planned for the subsequent quarter:

- Soil and plant tissue samples will be analyzed and the data will be processed.
- This study will be repeated in the fall. We may need to add higher P rate treatments to find the point at which bean yield response to fertilizer P goes to zero.

Progress made towards overall project objectives:

- Additional data collected from this project will be used for crop modeling and machine-learning work.
- We are on track to develop P fertilizer BMPs for Krome soil in the Homestead area following research completed during the 2023-24 crop season.

- Results from HAEC and PSREU bean research will be combined with results from other investigators to update P fertilizer recommendations for beans grown on sandy soils.

Identified obstacles or challenges:

- High soil test P at the grower-cooperator's farm.
- Poor seed emergence from most of the high P treatments at the 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.
- Both hurricanes Ian and Nicole affected the results of the Hastings trial. Heavy rain from Hurricane Ian destroyed some rows of the trial. Hurricane Nicole delayed the harvest.
- Drip line failures on weekends flooded the trial twice in Citra. These failures significantly affected the results of the trial. For example, the plot area was very uneven. Some affected plots in the low-lying area had extremely low pod yield of 85 lbs/acre. The unaffected plots yielded more than 6,000 lbs/acre.

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

Activities and accomplishments:

- All equipment has been delivered and deployed across sites.
- Hemp nutrient management field research is ongoing at PSREU (Fig. 1).
- Hemp and cover crop nutrient management field research is ongoing at TREC (Fig 2).
- Soil analysis at the EREC Soil Testing Laboratory (Fig. 3).
- Hemp is in mid-way program development with established research protocols, data templates, and an analytical framework. We are generating publishable results that appropriately contribute to nutrient rate recommendations. We continue to coordinate across nutrient rate research aiming at science-based recommendations and site-specific nutrient management for the diversity of crops and environments in Florida.

Fig. 1. PSREU liquid and granular fertilizer spreaders.


Fig. 2. TREC cover crop termination with sickle bar mower, flail mower, and rolling crimper.

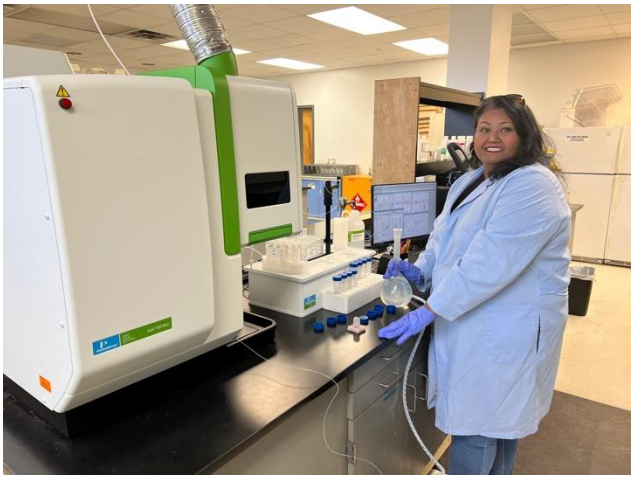
Fig. 3. - EREC analytical equipment

Significant findings and/or events occurring during the quarter:

- The equipment and effort funded by this LBR has accelerated the development of research infrastructure and operations for hemp nutrient management at UF across Florida.
- A provisional nutrient recommendation for hemp was prepared for internal and FDACS review.
- PSREU installed hemp nutrient rate and lysimeter experiments for the 2023 growing season.
- TREC installed hemp nutrient rate, timing, and source experiments for the 2023 growing season.
- TREC installed a cover crop rotation study with organic hemp and vegetable production.
- The Perkin Elmer Avio 550 ICP (K, Ca, Mg, and Si analysis) and the Seal AQ400 Discrete Analyzer (P analysis) are working well and are a critical component of this research.

Activities planned for the subsequent quarter:

- Continue work to evaluate N and P fertilizer rates, N timing, and potential nutrient losses to the environment. Drone-based aerial imaging technology will be deployed to further develop site-specific nutrient management. Field trials will focus on plant development, crop production, and environmental impacts.

Progress made towards overall project objectives:

- PSREU: Nutrient management studies have been initiated to investigate fertilizer rate and timing in conventional systems for fiber, seed, and flower production. Existing lysimeter infrastructure along with sensor- and sample- based analytics are used to establish a recommendation for hemp with methods consistent with other crops and nutrient rate studies.
- TREC: Nutrient management equipment has been deployed to establish and terminate cover crops ahead of an organic hemp and vegetable planting. We are deploying multiple sources of organic, controlled release, and liquid fertilizers for experiment and demonstration. Field plantings have been established for nutrient management studies investigating rate, timing, and source in conventional systems for seed and flower production.
- EREC: We are performing nutrient analysis of soil samples for grower and research applications. Equipment is used for all client soil analysis and fertilizer recommendations. We assist in recommendation development for nutrient management of hemp production.
- A provisional nutrient recommendation for hemp has been drafted from cumulative literature review, quantitative research, and practical experience.
- Research findings are being prepared for publication in support of new recommendations.
- Several areas of research are ongoing with consistent methods and sustained effort to develop recommendations for hemp.

Identified obstacles or challenges:

- Coordinating nutrient rate application and experimental design statewide is challenging.