UF | IFAS
UNIVERSITY *of* FLORIDA

FNGLA Endowment 2022-2023 Funding Reports

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ABOUT THE FNGLA ENDOWMENT

The Florida Nursery, Growers and Landscape Association (FNGLA) created an endowment in 2005 to address problems and questions that are important to the Florida nursery industry.

The FNGLA Endowed Research Fund (#F003129/30) provides awards up to $5,000 each to supplement and extend existing research projects. The principal balance of the endowment is more than $1.45 million, and **9 projects** involving **15 faculty members** were funded for 2022-2023.

The following priorities were determined for the selection of the 2022 - 2023 projects:

1. Enhance Floridians' Quality of Life (no projects this year)
2. Improve Environmental and Resource Management
3. Improve Pest Management Practices and Strategies
4. Improve Production Systems Practices and Strategies (no projects this year)
5. Genetics and Breeding to Enhance Quantities and Diversity of Plant Material

The selection process included a review by the following FNGLA committee members:

- Ed Bravo
- Joe Cialone
- Van Donnan
- Sylvia Gordon
- Stefan Liopiros
- David Liu
- Mike Marshall
- David McDonald
- Nancy McDonald
- Linda Reindl

A MESSAGE OF THANKS

To the Florida Nursery, Growers and Landscape Association:

Thank you for your support. The funding your organization raised allows UF/IFAS researchers to continue their great work towards research and discovery both on campus and at our off-campus research centers (see map on the final page of this document).

We also want to thank the selection committee for the time they dedicated to this program. Your thorough review ensures the projects that receive funding are the best of the best.

We look forward to this continued collaboration and hope you find this document helpful.

Sincerely,

Robert Gilbert
UF/IFAS Dean for Research
Director of the Florida Agricultural Experiment Station (FAES)

Damian Adams
UF/IFAS Associate Dean for Research
Associate Director of the FAES

Jerry Fankhauser
Associate Director of the FAES

Genetics and Breeding to Enhance Quantities and Diversity of Plant Material

This priority area is defined as:

FNGLA supports research to improve the quality of plant material to improve ecological and social benefits.

FNGLA supported <u>two projects</u> under this priority area, and those summaries are on pages 5-13.

Developing Sterile, Non-invasive Porterweed for the Florida Nursery and Landscape Industry and its Consumers

PI: **Zhanao Deng, Environmental Horticulture | Gulf Coast REC**
Co-PIs: **Brooks Parrish, ENH | GCREC & Sandra Wilson, ENH**

ABSTRACT

Porterweed (*Stachytarpheta spp.*) is a garden favorite in Florida, attracting a variety of pollinators. However, one species, nettleleaf porterweed, is invasive and can hybridize with the native species, posing ecological risks. This study aimed to develop sterile porterweed hybrids that are both ecologically safe and horticulturally desirable. Three novel triploid lines (NRC-1, NRC-2, and NRC-3) were generated through manual pollinations and evaluated for growth habits, flower abundance, and sterility across multiple locations in Florida. The study found that these hybrids generally outperformed their parent plants in terms of plant ratings, bloom ratings, and spike count. Importantly, all three hybrids demonstrated sterility, as evidenced by the absence of seed germination, tetrazolium seed staining, and acetocarmine pollen staining. Among them, NRC-2 emerged as the most promising candidate for cultivar release due to its superior performance across multiple parameters. These findings represent a significant advancement in the development of non-invasive, sterile porterweed varieties that are both attractive and ecologically responsible. Future work will focus on preparing these hybrids for market release following UF/IFAS Assessment protocols.

OBJECTIVES AND METHODS

1. To produce more triploid lines, manual pollinations will be made between a tetraploid and a diploid porterweed. The progeny will be screened using flow cytometry to identify new triploids. Triploid lines will be maintained in the greenhouse as stock plants for cuttings.

2. To evaluate triploid lines in north central and central Florida, five replicates of each of the triploid lines will be planted in Gainesville and Balm, FL. Data on plant growth, performance, and flowers will be taken monthly.

3. To assess male and female sterility, seeds will be collected from each plant grown in Gainesville and Balm, and flowers will be collected to evaluate pollen viability. The top-ranking triploid lines based on plant and flower performance and sterility will be planted in the greenhouse for reciprocal hand pollinations with the native jamaican porterweed to verify that the lines do not hybridize with the native and pose no threat to the native species. The best triploid line with male and female sterility and inability to pollinate with the native species will be selected for releasing to the industry and consumers.

Methods

Manual pollinations were made between the invasive nettleleaf porterweed and cultivar 'Red Compact' in late summer of 2022. Seeds were subsequently collected and germinated. Seedlings were allowed to grow until flowering stage and hybrids were identified by a unique violet flower color (Fig. 1). Ploidy of identified hybrids was determined using flow cytometry. Seedlings were planted in raised beds in an open field in early fall of 2022. Plants were evaluated visually two months after planting for plant symmetry, flower abundance, and plant fullness. Breeding lines selected for trials were propagated via stem cuttings.

Cuttings from stock plants of nettleleaf, 'Red Compact', NRC-1, NRC-2, and NRC-3 were taken in January 2023 for plant performance trials. In March 2023, three separate trials were initiated, each with 4 replicates arranged in a RCBD. The trials took place in Gainesville, FL (container trial), Balm, FL (container trial), and Balm, FL (raised bed trial). The container trials were conducted using 2-gallon plastic containers filled with a commercial potting mix.

Plants were maintained in an open greenhouse for the first month of growth, then transferred to an open plot on black landscape fabric. In the Balm raised bed trial (location 3), rooted cuttings were transplanted directly into raised white plastic beds in an open field. All container plants were fertilized with 1 tablespoon of controlled-release fertilizer (Osmocote, 14N-14P-14K, 3-4 months release at 21°C; The Scotts Company, Marysville, OH).

Data were collected monthly for four months at each trial location. Metrics included plant height, width across two perpendicular axes, and the number of spikes. Plant ratings were taken on a scale of 1-5: 1 = Poor quality - severe leaf chlorosis, significant leaf spot/damage, not marketable; 2 = Below-average quality - some leaf chlorosis, some leaf spot/damage, leggy and unattractive growth habit; 3 = Average quality - moderate health, somewhat desirable growth habit; 4 = Above-average quality - good health, vigorous growth, desirable and symmetrical growth habit, full appearance; and 5 = Excellent quality - premium health, most desirable and symmetrical growth habit, peak plant fullness.

Bloom ratings were also taken on a scale of 1-5: 1 = No flowers or spikes present; 2 = Flower spikes visible, but no open flowers; 3 = One to several spikes with open flowers; 4 = Many spikes with open flowers with multiple flowers open per spike; and 5 = Abundant flowering, full plant coverage, numerous spikes, multiple flowers open per spike.

Over the third and fourth months, three mature spikes, characterized by a yellowing to brown coloration, were harvested from each plant, with seeds subsequently extracted and cleaned. These cleaned seeds were then quantified by weight, where 100 seeds weighed 10 mg. 500 seeds per genotype and location were then sowed atop potting mix within seedling trays, which were subsequently covered with clear plastic domes to ensure high humidity. Weekly over the subsequent three weeks, the number of germinated seeds was tallied, and germinated seeds were removed following each count.

In January 2023, cuttings were taken from the stock plants of Jamaican (Florida native porterweed), NRC-1, NRC-2, and NRC-3 for cross-compatibility evaluations within the controlled environment of a greenhouse at the UF/IFAS Gulf Coast Research and Education Center in Wimauma, FL. Three rooted cuttings from each triploid and six cuttings from Jamaican porterweed were transplanted into 1-gallon plastic containers filled with potting soil. The plants were maintained until each had at least two spikes with open flowers.

RESULTS

A total of 20 interspecific triploid hybrids were generated from hand pollinations conducted in the greenhouse. Field evaluations revealed very little differences between these hybrids, and thus only three were selected for replicated trials. The trials demonstrated variable performance among three plant hybrids (NRC-1, NRC-2, and NRC-3) across different parameters and locations. While plant ratings were largely consistent for locations 1 and 3, NRC-2 emerged as a standout in location 2 with a significantly higher average rating (Table 1). Regarding bloom ratings, all hybrids generally performed better than their parent plant 'Red Compact' across all locations and equal to or better than nettleleaf. Spikes showed a similar pattern, with NRC-2 consistently outperforming both parents at all sites (Fig. 2). In height and width comparisons, the hybrids usually fell between the two parent plants, being taller and wider than 'Red Compact' but not always significantly different from nettleleaf. Despite this, at some locations, specific hybrids did show statistically significant increases in dimensions compared to both parents.

Importantly, the hybrids demonstrated sterility, as evidenced by the absence of seed germination. Although nettleleaf exhibited strong germination rates and 'Red Compact' lagged behind, none of the seed from the triploid hybrids germinated. Moreover, hand-pollination experiments with the native species, jamaican porterweed, yielded seeds only from the hybrids. Further analysis via tetrazolium seed staining confirmed embryo abortion, supporting the lack of germination and thereby confirming sterility (Fig. 3).

Figure 1. Representative flowers of (left to right) nettleleaf, 'Red Compact', NRC-1, NRC-2, and NRC-3. Scale bar = 1 cm.

Table 1. Average plant and bloom ratings of three porterweed hybrids and two parents across three locations and 4 time points (April – July 2023).

Genotype	Location	Plant Rating (1-5)	Bloom Rating (1-5)
Nettleleaf	1	3.44 ± 0.63 a	3.75 ± 1.06 ab
Red Compact	1	3.44 ± 0.51 a	3.50 ± 1.10 b
NRC-1	1	3.94 ± 0.85 a	4.06 ± 1.06 a
NRC-2	1	3.88 ± 0.62 a	4.06 ± 1.06 a
NRC-3	1	3.44 ± 0.63 a	4.06 ± 0.93 a
Nettleleaf	2	3.25 ± 0.58 b	2.88 ± 0.50 bc
Red Compact	2	2.63 ± 0.81 c	2.56 ± 0.89 c
NRC-1	2	3.88 ± 0.81 a	3.13 ± 0.81 ab
NRC-2	2	3.63 ± 0.62 ab	3.44 ± 0.96 a
NRC-3	2	3.63 ± 0.50 ab	3.25 ± 0.86 ab
Nettleleaf	3	3.13 ± 0.99 a	3.07 ± 1.22 b
Red Compact	3	2.93 ± 1.39 a	3.07 ± 1.62 b
NRC-1	3	3.53 ± 0.83 a	3.93 ± 1.28 a
NRC-2	3	3.73 ± 0.96 a	3.60 ± 1.64 a
NRC-3	3	3.40 ± 0.83 a	3.87 ± 1.41 a

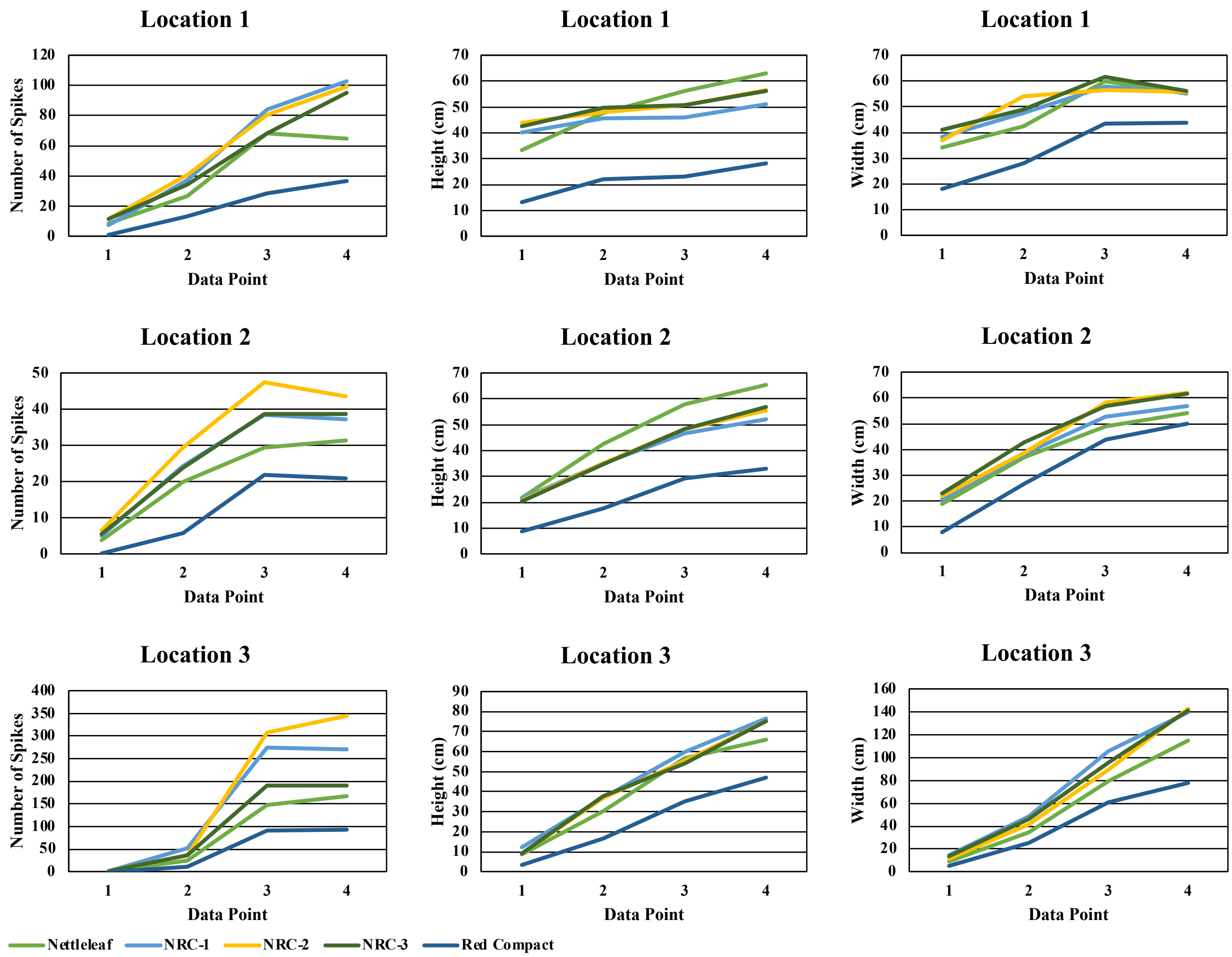


Figure 2. Average number of spikes, plant height, and plant width of three porterweed hybrids and two parents across three locations and 4 time points (April – July 2023).

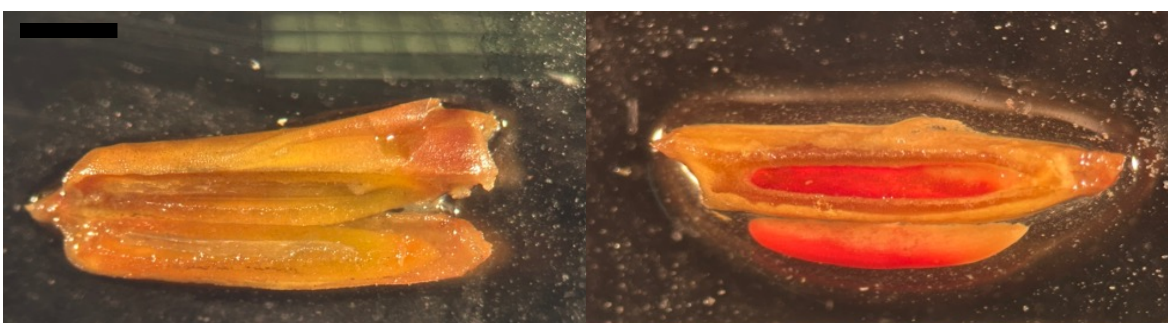


Figure 3. NRC-2 (left) and Jamaican (right) developing porterweed seeds 4 weeks after pollination with jamaican pollen and stained with 1.0% tetrazolium at 35°C for 18 hours. Red color indicates embryo viability in jamaican seed. No viable embryos are observed in NRC-2 seeds. Scale bar = 1 mm.

CONCLUSION AND NEXT STEPS

This study aimed to generate new triploids and evaluate the performance of three triploid hybrids (NRC-1, NRC-2, and NRC-3) across various morphological and reproductive metrics. The overarching objective was the development of sterile porterweed hybrids. The findings suggest that the hybrids generally outperformed both of the parent plants ('Red Compact' and nettleleaf) across multiple parameters such as plant ratings, bloom ratings, and spike count, depending on the location. These results offer valuable insights into the performance of plant hybrids, indicating that hybrid plants can manifest beneficial traits inherited from their parent plants while circumventing some of their drawbacks. Notably, NRC-2 performed significantly better than the parent plants in many parameters, thereby becoming the leading candidate for cultivar release. A critical accomplishment of this study is the confirmed sterility of the hybrids. The absence of seed germination in all three hybrid varieties is indicative of their sterility, which holds significant implications for environmental conservation and minimizes the risk of these hybrids becoming invasive species or contaminating the native gene pool. In conclusion, the study significantly advances the field by developing porterweed hybrids that not only exhibit desirable morphological characteristics but are also sterile. Future research should focus on conducting the infraspecific taxon protocol with IFAS assessment to prepare one of the hybrids for release to the market.

Detecting Genetic Variation of Sugarcane Mosaic Virus (SCMV) in St. Augustinegrass

PI: **Jianping Wang, Agronomy**
Co-PI: **Camila Sanchez, AGR**

ABSTRACT

Sugarcane Mosaic Virus (SCMV) is a Potyvirus, which causes Lethal Viral Necrosis (LVN) disease of Floratam St. Augustinegrass, the dominant St. Augustinegrass cultivar used in Florida landscapes. SCMV is highly variable, with several recombination hotspots along its genome. The goal of this project was to assess the genetic diversity of SCMV infecting St. Augustinegrass cultivars across Florida by using RT-PCR of CP of SCMV and Sanger sequencing. A total of 14 St. Augustinegrass samples infected by SCMV were sampled across the state where LVN is occurring. The leaf samples were subjected to RNA extraction and RT-PCR using the primers targeting the Coat Protein (CP). The successful and specific amplicons were sequenced and compared to assess the genetic diversity. The results showed that the viral CP sequences were varied among the samples with 74 to 93% sequence identity to the reference genome of SCMV. A total of 121 SNPs and 3 insertion/deletions were identified in 523nt aligned CP sequences suggesting a notable diversity of SCMV isolations in Augustinegrass cultivars across Florida. The cluster analysis showed that isolations from St. Lucie, Broward, and Martin counties are closer to each other and are similar to the maize SCMV. The isolations from Palm Beach and Collier close to each other but seemed evolved and diverged from the maize SCMV. Interestingly, the isolations from the same county had nearly identical sequences suggesting that the same strain may spreading out in the same county. This information would help us to understand the variations of the SCMV in the field and strategically design molecular tools to target the virus for effective control.

OBJECTIVES AND METHODS

The coat protein (CP) gene of the virus is located at the 3′ end of the genome, which is often used for diagnosis of Sugarcane Mosaic Virus SCMV and characterization of its genetic diversity. The goal of this project was to assess the genetic diversity of SCMV infecting St. Augustinegrass cultivars across Florida by using RT-PCR of CP of SCMV and Sanger sequencing.

Methods

Leaf samples of St. Augustinegrass suspected to be infected with SCMV based of symptom morphology of mosaic patterning on the blades of grass were collected from fields across the state of Florida, which were submitted to the UF Plant Diagnostic Center. The samples were received downstream processing was restricted to the living tissue of the grass blades. Dead (browning) tissue and root material were excluded from sample collection due to low viral RNA yield, determined previously in tissue comparison experiment. Tissue was collected in liquid nitrogen and processed immediately after by grinding with mortar and pestle. Finely crushed tissue was transferred to 1.5 mL tubes and stored in -80°C until further processing. Ground tissue material underwent RNA extraction using Direct-zol RNA Miniprep Plus Kit (Zymo) and further purification if necessary (Goal purity of samples was 260/280 ≥2.00 and 260/230 ≥1.8) with RNA Clean and Concentrator-5 kit (Zymo). cDNA synthesis was preformed using ProtoScript II Reverse Transcriptase (NEBiolabs).

The primers utilized for viral detection and sequencing was designed using NCBI's primer-BLAST tool according to a complete SCMV genome (NC_003398.1) in the database as reference. Primer criteria included specificity and exclusivity to the virus genome. A conserved CP region, of the SCMV genome was targeted for broader detection for downstream sequencing of the most amount of viral strains. Initially, three primers were designed as possible candidates (Primers: CP1, CP2, and CP3), however after PCR testing, one primer was selected for primary use in this project (primer CP1). Gel electrophoresis was utilized to assess success and quality of primer amplification as seen above (Fig. 1). Location of the selected primer CP1 amplicon in genome is visualized below (Fig. 2).

The primer was then used for PCR amplification of the CP region from the cDNA samples derived from all the collected turfgrass samples mentioned above. The procedure was progressively modified to optimize amplification success by titrating annealing temperatures and concentrations. Some samples required two PCR experiments to meet the criteria for sequencing.

Successful samples (examples can be seen in Fig. 1 where the wells encompassed in red boxes) were sent to be sequenced by both forward and reverse primers by Eurofins Genomics. The received forward and reverse sequences were aligned to create a consensus sequence, which was then utilized for sequence comparison by aligning to them to the reference genome and among themselves as well using Clustal alignment (https://www.ebi.ac.uk/Tools/msa/clustalo/) tool (Fig. 3).

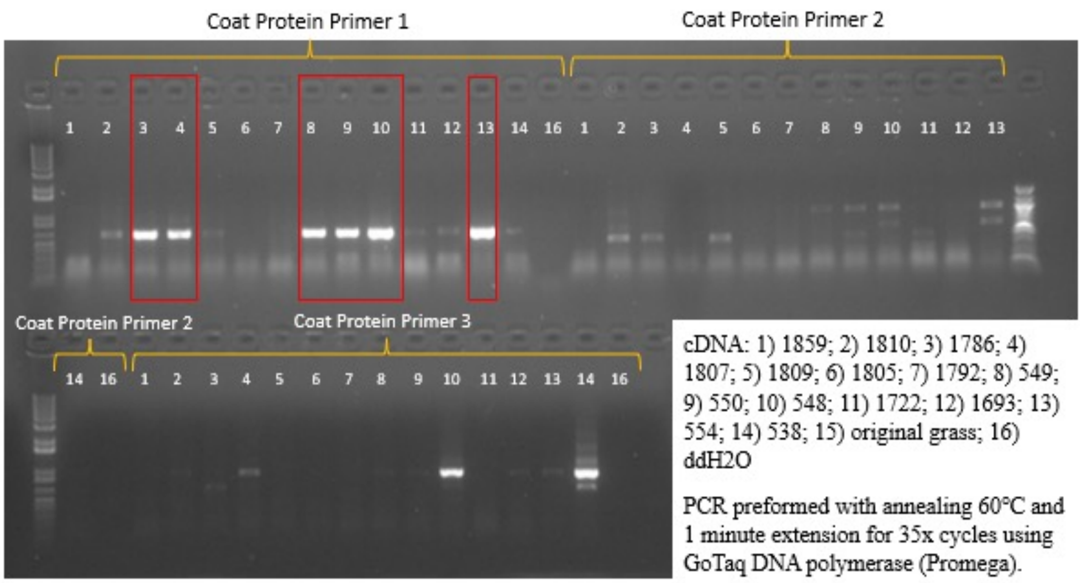


Figure 1. Gel image of three coat protein primers tested to amplify SCMV genetic material within turfgrass tissue cDNA

Note: Columns marked within red boxes indicates PCR products that were sent out for Sanger Sequencing. This is later discussed in detail.

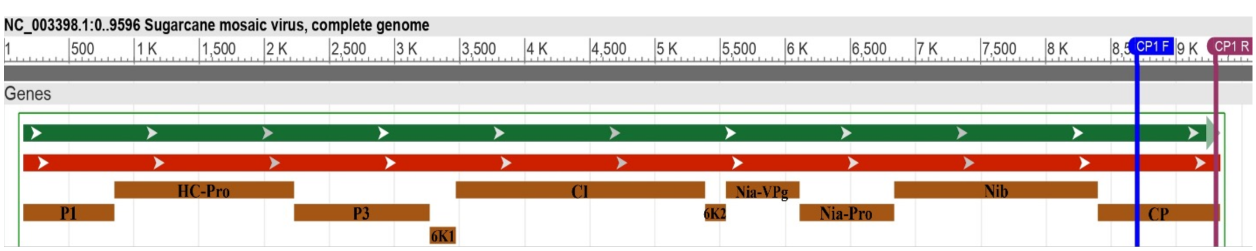


Figure 2. Complete SCMV genome with notable structures and primer location annotated at coat protein region.

Note: Coat protein (CP) 1 forward primer is demarked in blue and CP 1 reverse primer is in purple. Primer amplicon size is 625 bp. Primer sequence; forward: AGAAAATGCGCCTGCCAAAG; reverse: GAGTGCATGTTGCGACTAACG.

RESULTS

The 14 isolations showed different sequence identity to the reference genome of SCMV infecting maize (Chen et al., 2002). The sequence identity ranged from 74 to 93% (Table 1). A total of 121 single nucleotide variations (SNPs) and 3 insertion/deletions (indel) were identified within an aligned region of 523 nt.

The cluster analysis showed that isolations from St. Lucie, Broward, and Martin counties are closer to each other and are similar to the maize SCMV. The isolations from Palm Beach and Collier close to each other but seemed evolved and diverged from the maize SCMV.

Table 1. The pairwise alignment output values between the samples and the reference genome.

Sample	County	Score	Expected	Identities	Gaps
550	Palm Beach	777 bits(404)	0.0	516/572(90%)	0/572(0%)
549	Palm Beach	763 bits(397)	0.0	516/573(90%)	1/573(0%)
548	Palm beach	758 bits(394)	0.0	508/565(90%)	0/565(0%)
554	Palm beach	754 bits(392)	0.0	512/572(90%)	0/572(0%)
1788	Collier	717 bits(373)	0.0	489/547(89%)	0/547(0%)
590	Palm Beach	585 bits(304)	4e-170	474/554(86%)	2/554(0%)
1789	Collier	694 bits(361)	0.0	485/547(89%)	0/547(0%)
1810	St. Lucie	53.6 bits(58)	4e-10	46/56(82%)	1/56(1%)
1786	Broward	861 bits(466)	0.0	546/586(93%)	0/586(0%)
1807	St. Lucie	862 bits(448)	0.0	540/586(92%)	0/586(0%)
1791	Collier	698 bits(363)	0.0	490/551(89%)	1/551(0%)
1790 sym-	Collier	683 bits(355)	0.0	483/547(88%)	0/547(0%)
1875	Martin	719 bits(374)	0.0	471/517(91%)	1/517(0%)
1858	Martin	332 bits(367)	1e-93	382/514(74%)	3/514(0%)

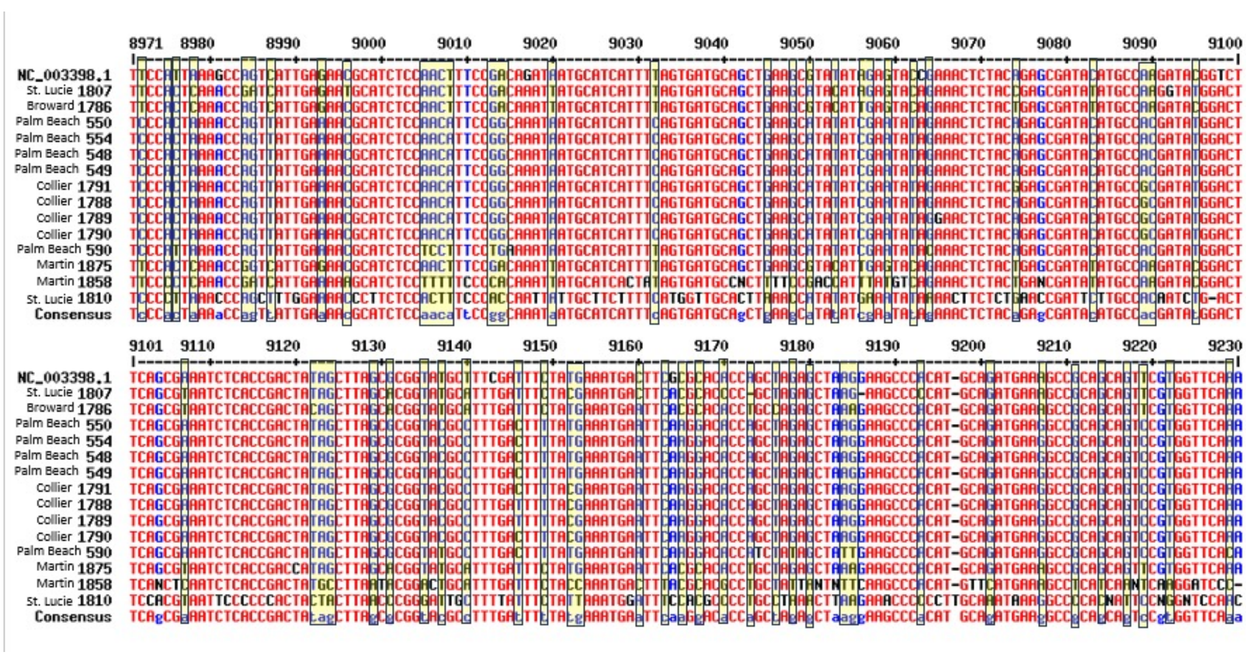


Figure 3. Part of sequencing alignment of sequences from SCMV infecting turfgrass samples and reference SCMV genome.

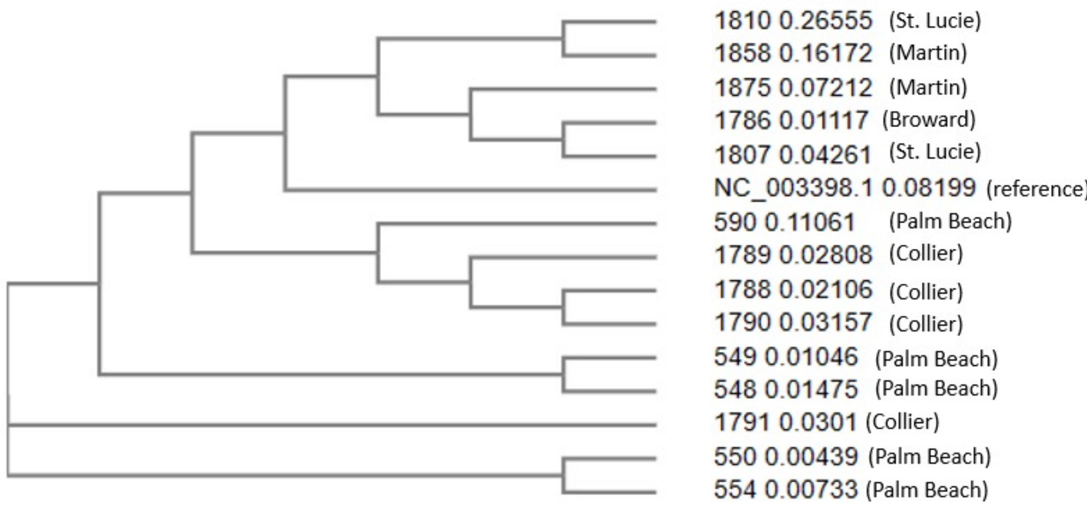


Figure 4. Clustal alignment showing phylogenetic relationships between turfgrass samples.

CONCLUSION AND NEXT STEPS

It is very important assess the genetic diversity of the SCMV infecting St. Augustinegrass cultivars across Florida and to identify the pathogenic strain, so we can develop molecular tools to target and control all the SCMV strains. Ultimately, the detection and identification of viral strains has many important applications, including correlation of symptoms variations/severity, geographic mapping of strain distribution, and phylogenetic analysis. Distinguishing between strains of SCMV in St. Augustinegrass may be a key aspect of identifying milder or more severe forms of the viral infection in a turfgrass which is susceptible to LVN at lower temperatures. So far, there is no cure for the LVN disease. Avoidance through sanitation practices, using resistant St. Augustinegrass cultivars or other species are the only options. With further sequencing and analysis of virus strains, a distinct symptom profile may be created for each strain. Furthermore, the identification of strains in conjunction with geographic distribution would allow for exploring epigenetic elements impacting disease presentation and severity, such as temperature which we know leads St. Augustinegrass to develop LVN. Outside of agricultural use, strain identification can be used for building better informed phylogenetic models. Identifying close relationships with other better studied viruses may lead to development of preventive treatments not yet implemented in SCMV treatment.

Improve Environmental and Resource Management

This priority area is defined as:

FNGLA encourages and supports research to maximize efficient water use and research designed to react to and identify exotic insects, diseases, and plants that can harm our industry and our environment. FNGLA supports research for control and prevention of such pest introductions.

FNGLA supported three projects under this priority area,
and those summaries are on pages 15-28.

Next Level Young Plant Environmental Control

PI: **Paul Fisher, Environmental Horticulture**

ABSTRACT

Matching mist irrigation to plant needs for cutting propagation is difficult in the hot, humid, and sunny Florida climate. Correct irrigation scheduling is important in order to reduce water use, avoid saturation of the root substrate which starves roots of air, and causes a delay in plant rooting, disease, and crop losses. The main objective was to install climate sensors in commercial and research greenhouses, combined with evapotranspiration (ET) models that predict the effect of weather on plant water loss, to improve mist irrigation control and propagation success. Sensors were installed in a UF greenhouse for cutting propagation, and we found that affordable infrared sensors were very effective at measuring cutting and soil temperature (an important parameter that affects water loss), and we could also use sensitive load cells (weight sensors) to measure water loss. Infrared cutting/soil temperature, light, air temperature, and relative humidity sensors were installed in two commercial greenhouses. We developed a draft dashboard to interpret key climate parameters for young plant growers to help check that climate control is on track, and a simple method to measure the applied mist volume. Based on results, one of the growers has changed their mist irrigation practices to reduce water applied per boom pass in order to avoid waterlogging of the soil. This project has provided pilot data for a larger USDA-ARS grant application we have submitted in collaboration with Purdue University, provided hands-on experience for three Agriculture and Biological Engineering (ABE) undergraduate students, and led to a student MS project for one of the ABE students in collaboration with Dr. Ying Zhang at UF.

OBJECTIVES

1. Install sensors into the University of Florida research greenhouse and gain experience in installation, testing and interpreting these sensors using unrooted cuttings and an existing ET model.

2. Use two Florida commercial young plant growers as case studies for interpreting climate parameters, sensor selection, setpoints and strategies.

3. Collect high quality environmental data from these commercial operations to analyze Florida propagation conditions and identify opportunities for improvements in mist control for Florida growers in general.

RESULTS

1) Sensors at University of Florida

Sensors were tested at UF that measure aspects of the greenhouse climate that affect water loss in propagation. These sensors included leaf and soil temperature, air temperature and relative humidity, air speed, and light sensors.

The infrared (IR) leaf temperature sensors (Figure 1a) were very reliable, cost around $250, can be connected to environmental control computers (we connected to Argus system at UF and a grower location), were practical and robust and provided temperature data similar to research grade sensors. The IR sensors are also much more accurate than “artificial leaf” temperature sensors (a painted thermistor exposed to the sun) that are currently used by industry. One outcome has been that two environmental control companies are considering providing these IR sensors to growers.

(2) Installations at Florida commercial young plant grower operations

Based on the data collected and past research, we developed a dashboard as a summary of data. Actual grower values are changed below for confidentiality. The dashboard will be designed to help growers focus on key aspects of their environmental data with a quick report. We plan on working with environmental control companies to automatically generate a report.

3) Identify opportunities for improvements in mist control for Florida growers

We developed a simple strategy to quantify water applied by young plant growers. Twelve collection trays were placed under the irrigation boom, and the boom was passed over the crop six times. The trays were then weighed (easy to calculate because 1 ml of water weighs 1 gram). If we knew how much water was applied with each pass, and how many boom passes occurred (from grower records or the environmental control system) we could calculate the amount of water applied during a day.

We also collected data from seven other growers in NH, NJ, and MI, and can identify around 5 ml per tray as an ideal light mist application, and 200 mL per tray per day in the winter for unrooted cuttings (a teaspoon per tray, and a cup a day). Based on the information we analyzed, the grower changed the boom speed and reduced the volume applied each day, and they reported improvements in plant rooting with less saturation of the substrate.

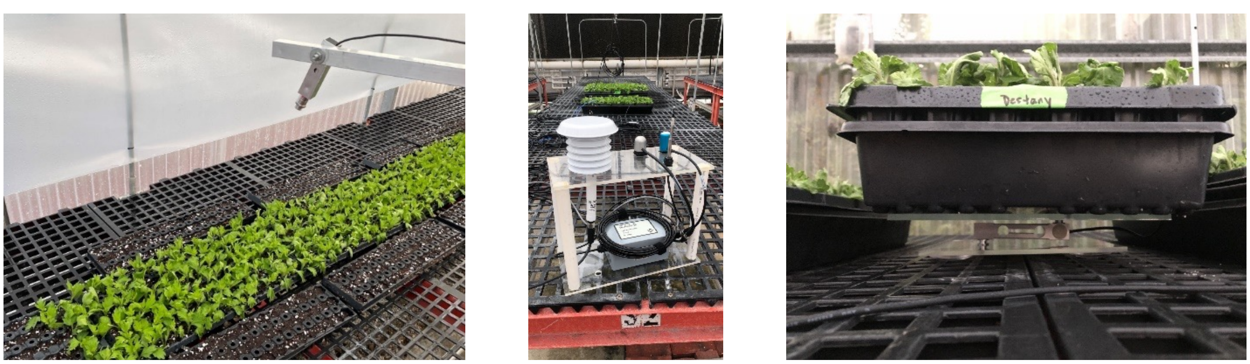


Figure 1. Infrared sensor measuring leaf/soil temperature (left), a group of sensors measuring greenhouse climate (center), and a load cell measuring the weight of propagation trays (right).

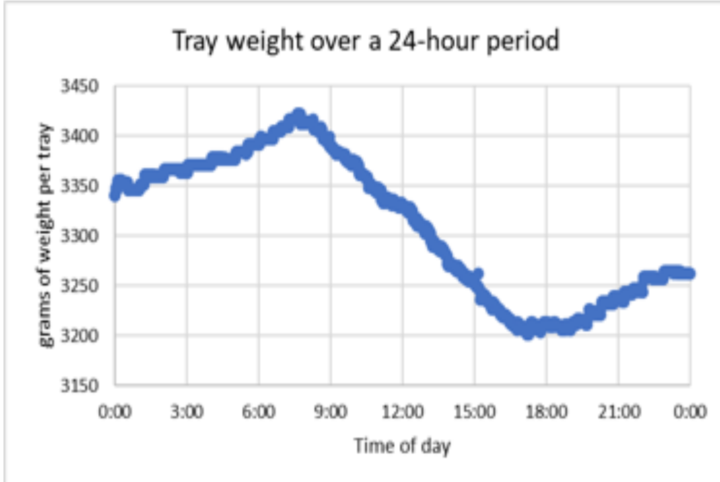


Figure 2. Load cell sensors tracked plant tray weight. Because most of the weight was from water, we could see exactly how much water was accumulating or being lost over days or even mist events. Tracking tray weight over the course of one example day in this graph at left shows that plants were being over-misted at night (weight was increasing because water was accumulating in the soil) and were under-misted during the day (tray weight was declining). This information allows us to fine-tune mist settings.

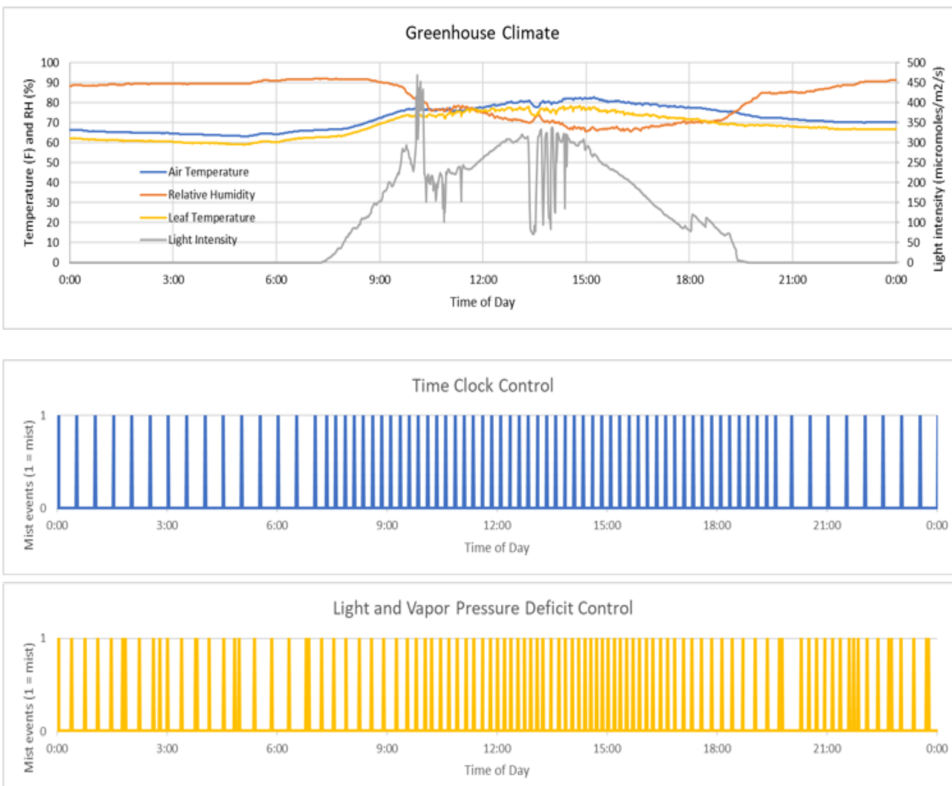


Figure 3. Greenhouse conditions of course vary a lot over time, as shown by the climate data in the graph (top). We tested different strategies to control mist irrigation.

Misting based on a time clock, which is the most common method (middle) is not as responsive as a climate-based approach to schedule when mist turned on in response to light, temperature and relative humidity (vapor pressure deficit, or VPD). We programmed an ET model into the Argus control system, and will be refining this model the future.

Figure 4. Sensors were installed in two commercial greenhouses by UF students Daniel Crawford, Mario Molina and Marcus Beck (above left) and the local facilities staff. In one case, this was a wifi enabled data logger that allowed climate reports on the iPhone (above right) and in the other case sensors were attached to the environmental control system. One outcome was therefore increased climate data available to the commercial growers to improve their crop management decisions.

Table 1. Grower dashboard example.

Dashboard	Value	Comments
Daily Light Integral (moles/m^2/day)	5	Low. Excess shade during morning or late afternoon?
Peak light intensity (micromoles/m^2/s)	450	High on a couple of days and could stress plants– adjust shade
Leaf temperature (F)	69	Good average, cooler than air because of evaporative cooling and no bottom heat
Air temperature average (F)	72	Good, but highly variable daily range
Air temperature minimum to max (F)	60 to 90	Low enough at night to slow rooting – adjust heating
Relative humidity average (%)	70	Good
Relative humidity minimum (%)	30	Low because of high temperature and need to vent
Air VPD (kPa)	0.8	Moderate
Air VPD maximum (kPa)	2.9	Very high, rapid drying
Mist volume per tray per pass (mL)	25	Higher than most other growers
Average boom passes	20	Lower than most other growers
Average water application (ml per day)	500	Higher than most other growers for this time of year. Reduce water volume per day (1/2 as much, twice as often is a good strategy)

Figure 5. Collection trays underneath irrigation booms can easily measure water applications per boom pass, which can help to tune irrigation scheduling.

CONCLUSION AND NEXT STEPS

Climate sensors were successfully deployed in commercial and research greenhouses. Infrared sensors were robust, affordable, accurate, and practical for measuring leaf and soil temperature in young plants. Load cell sensors allowed precise measuring of how much water was lost by cuttings through evapotranspiration. We modeled climate effects on water loss, and were able to program this into an environmental control system to schedule boom irrigation to match plant needs. We will continue to refine that model over time. The project provided hands-on experience to UF students, and has provided data for a new grant proposal and an MS project. We have developed a draft summary report (dashboard) to provide growers with feedback on climate. We are developing benchmarks on water volume applied by irrigation booms based on our research and testing at commercial growers. Results from this study led to improvements in water use and plant performance by a participating grower.

Developing Water-efficient Pollinator Plants for Florida

PI: **Rachel Mallinger, Entomology & Nematology**
Co-PI: **Xavier Martini, ENT**

ABSTRACT

Gardening for pollinators has become increasingly popular among land managers and the general public, with 50% of surveyed gardeners already consciously purchasing plants marketed as pollinator-friendly, and 78% of consumers reporting that they actively try to assist pollinators. However, gardeners also report that they are unsure what plants attract pollinators due to a lack of labeling and research-backed recommendations. The value of a plant for pollinators will depend on its floral density and phenology, and the quantity and quality of nectar and pollen it can provide to pollinators, which can be affected by inputs such as water and nutrition. Plants that require minimal irrigation but still produce abundant and resourceful plants for pollinators will serve multiple gardening and conservation goals. In this project, we assessed plant performance, including pollinator attraction and floral resources, under different irrigation treatments in the field and in a greenhouse, and compared native and non-native congeners. In the field, native plants were significantly larger than non-native congeners, had significantly more flowers, and attracted significantly more insects. Reduced irrigation in the field negatively affected plant size, but did not have a significant effect on floral display or insect visitation. In potted plants, drought stress reduced nectar volume and floral display significantly. Notable exceptions to these trends include the non-native *Salvia longispicata x farinacea*, which outperformed its native congener, and *Gaillardia pulchella*, which produced relatively similar amounts of nectar and flowers under full and partial irrigation. Our results highlight the value of native plants for pollinators, and suggest that *Gaillardia pulchella* may be a good option in water-limited environments.

METHODS

Overview: In a replicated trial of single-species plots at two field sites in Florida (Quincy, FL and Citra, FL), we compared 20 commercially available ornamental and wildflower plants grown under two treatments: full irrigation and limited irrigation. These 20 species included two species each of *Ilex, Gaillardia, Coreopsis, Salvia, Hibiscus, Bidens, Viburnum, Scutelleria, Conradina,* and *Mondarda*. Within each genus, one species is a well-developed non-native ornamental while the second species represents a commercially available native wildflower. We assessed the relative attractiveness of each plant species to pollinators and collected data on the following plant traits: flower density and duration of bloom, nectar volume and sugar content, pollen quantity, and pollen quality (pollen protein content). We additionally used potted plants of the same garden species grown under full and limited water treatments. From these potted plants, we measured floral volatile emissions to assess how water inputs change the scent bouquet of flowers and thereby affect pollinator attraction. Additionally, we used ultraviolet photography to examine how water inputs change flower color, thereby affecting pollinator attraction.

Field experiment: Field plots were prepared similarly in two locations. The first site was located at the UF North Florida Research and Education Center (NFREC) in north Florida (Quincy, FL, USDA cold hardiness zone 8b) and the second site was located at the UF Plant Science Research and Education Unit (PSREU) in northcentral Florida (Citra, FL, USDA cold hardiness zone 9a). To create full floral coverage, a minimum of two (mostly herbaceous) and a maximum of three (mostly woody) plants of each species were assigned to each plot, determined by their predicted size at full maturity. Once established (after 4 weeks), half of the plots were drip-irrigated for 2h per day, while the other half were irrigated at 10% volumetric soil moisture using a SMRT-Y-Soil Moisture Sensor Kit (Rainbird Inc., Tucson, AZ). Each month, plant height and perpendicular widths were measured for each plant at both locations to generate a maximum growth index ([height + (avg. width1 + width2)]/2 for the first year of the study. Also monthly, a floral survey was conducted for the entirety of the two-year study where the total number of flowers were counted for each plot across all treatments. Capitulate inflorescences (*Bidens*, *Coreopsis* and *Gaillardia*) were notated as a single flower. To quantify insect visitation rates, active sampling techniques were deployed within plots where each observer (consisting of 2- 4 people) walked down each row collecting foraging insects for a period of one to three minutes per plot. Specimens were placed in vials and stored in the freezer for subsequent identification.

Potted plant experiment: To further examine the effects of water stress in a more controlled environment, ten species (5 native and 5 non-native congeners) were grown in potted plants in a greenhouse and randomly assigned to full or limited watering (6 pots per treatment). At the beginning of the experiment, we weighed and measured plant height from the soil to the upper canopy for each of the potted plants. We watered the pots until they reached soil saturation, and weighed again until water ceased to runoff from pots. The amount of water held per pot at this point was the 'water-holding capacity' (WHC). We then weighed the plants daily and added a sufficient volume of water to each pot after each weighing to maintain 95% of the WHC for the control plants and to maintain 35–45% % of the WHC for the drought-stress treatment plants.

To examine the effects of water irrigation on plant height and flower traits (flower number, size, display), we recorded plant height, counted the number of flowers (capitulate flowers were counted as one flower), and measured flower size when all the plants under the drought stress treatments reached 45% WHC. We sampled nectar volume using microcapillary tubes from 5 to 10 flowers per potted plant also at this time.

RESULTS

Field experiment: Native plants were significantly larger than non-native congeners (Table 1) and had significantly more flowers and attracted significantly more insect pollinators than non-native congeners (Figure 1A and B). One notable exception was the non-native *Salvia longispicata x farinaceae*, which produced more flowers than the non-native *Salvia azurea*. While reduced irrigation in the field significantly reduced plant size (Table 1), it did not significantly affect the number of flowers or insect visits (Figure 1A and B). Different insects showed preferences for different plant genera and species, with honey bees and bumbles strongly preferring Salvia spp. and native, solitary (other) bees preferring *Coreopsis, Gaillardia,* and *Viburnum spp*. (Figure 2). Notably, there were 2.3 times more native bees collected from native plant species compared to non-native species, while honey bees, which are non-native to the United States, did not show a preference for native plants.

Potted plant experiment: Drought stress significantly reduced nectar volume and flower density across most of the ten plant species studied with the exception of *Gaillardia pulchella* (Figure 3).

Table 1. Maximum growth index (cm) for each of twenty plant species grown under two irrigation treatments (partial and full) at each location (north and northcentral Florida). For each planting location, means are presented ±SD with different letters indicating significant responses among full and partial irrigation treatments (P=0.05). Native species are indicated with a (N).

	North Florida growth index		Northcentral Florida growth index	
Species	Full (cm)	Partial (cm)	Full (cm)	Partial (cm)
Spanish needles-N	204.0 ± 12.8a	181.6 ± 14.8b	151.3 ± 7.0a	136.1 ± 13.5b
Goldilocks Rocks® bidens	83.7 ± 6.2a	76.6 ± 5.4a	44.8 ± 7.9 a	47.7 ± 7.8a
False Rosemary-N	61.5 ± 12.5a	68.2 ± 25.6a	85.6 ± 4.2a	79.2 ± 5.9a
Rosemary	78.4 ± 8.6a	84.4 ± 4.8a	64.2 ± 8.6a	63.3 ± 5.1a
Tickseed coreopsis-N	162.2 ± 47.4a	178.1 ± 16.9a	144.1 ± 15.6a	143.7 ± 16.6a
Jethro Tull coreopsis	95.5 ± 3.8a	86.5 ± 13.7a	83.1 ± 6.0a	69.7 ± 7.1b
Blanket-flower-N	193.7 ± 14.5a	173.3 ± 14.2a	150.7 ± 3.3a	154.3 ± 16.9a
Arizona sun blanket-flower	98.8 ± 7.3a	85.7 ± 7.5b	72.8 ± 13.4 a	65.4 ± 5.4b
Swamp rosemallow-N	184.8 ± 25.7a	186.3 ± 9.7a	143.6 ±12.7a	150.8 ± 12.8a
Ruffled Satin® rose of Sharon	68.6 ± 7.3a	60.3 ± 8.3a	39.6 ± 4.1a	39.9 ± 5.6a
Inkberry; Gallberry-N	106.4 ± 3.3a	105.2 ± 27.1a	90.0 ± 20.51a	78.9 ± 5.4b
Dwarf Burford holly	161.8 ± 5.7a	164.8 ± 43.1a	116.5 ± 12.7a	102.2 ± 12.3b
Spotted beebalm-N	224.5 ± 59.4a	161.5 ± 17.8b	199.7 ± 49.3a	180.0 ± 49.1b
Pardon my pink beebalm	64.9 ± 4.5a	57.2 ± 1.1b	54.3 ± 9.7a	45.9 ± 4.9a
Azure blue sage-N	159.1 ± 15.3a	167.3 ± 11.1a	144.8 ± 8.9a	143.1 ± 11.3a
Big blue salvia	162.6 ± 27.4a	150.4 ± 9.2a	142.7 ± 34.4a	131.18 ± 17.5a
Florida scrub skullcap-N	112.6 ± 14.2a	114.3 ± 6.8a	89.4 ± 6.0a	80.4 ± 15.0a
Malaysian skullcap	77.9 ± 5.8a	75.8 ± 5.5a	59.9 ± 7.1a	54.0 ± 6.1 a
Walter's viburnum-N	145.6 ± 10.0a	165.9 ± 61.8b	107.3 ± 9.4a	116.6 ± 11.8a
Sandankwa viburnum	114.3 ± 6.2a	102.9 ± 7.1b	91.6 ± 7.8a	87.3 ± 7.9a

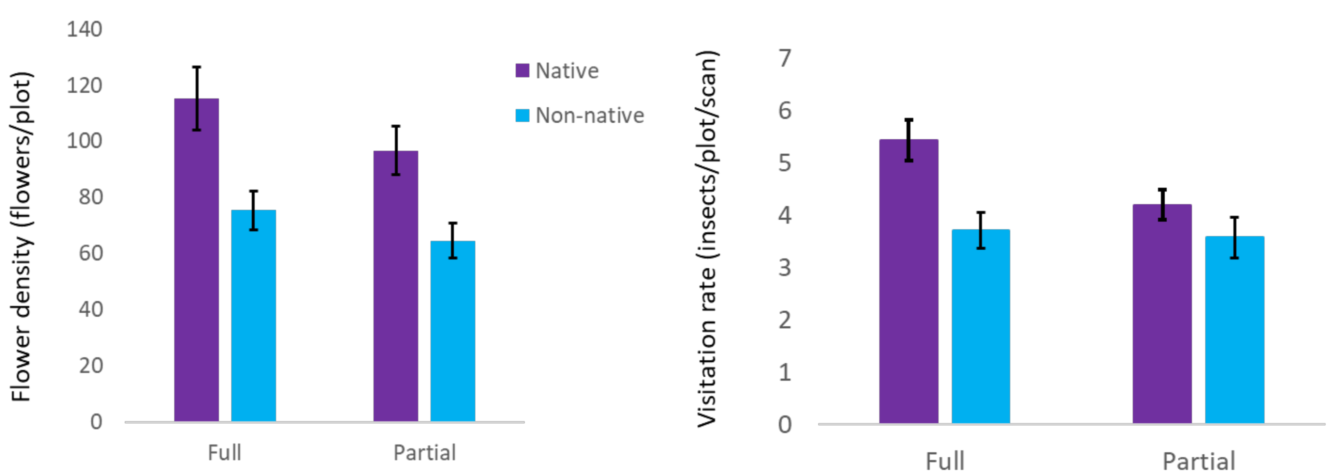


Figure 1. Flower density of (A) and insect visitation rate to (B) native and non-native congeneric plants grown under full and partial irrigation treatments in both north and northcentral Florida field locations.

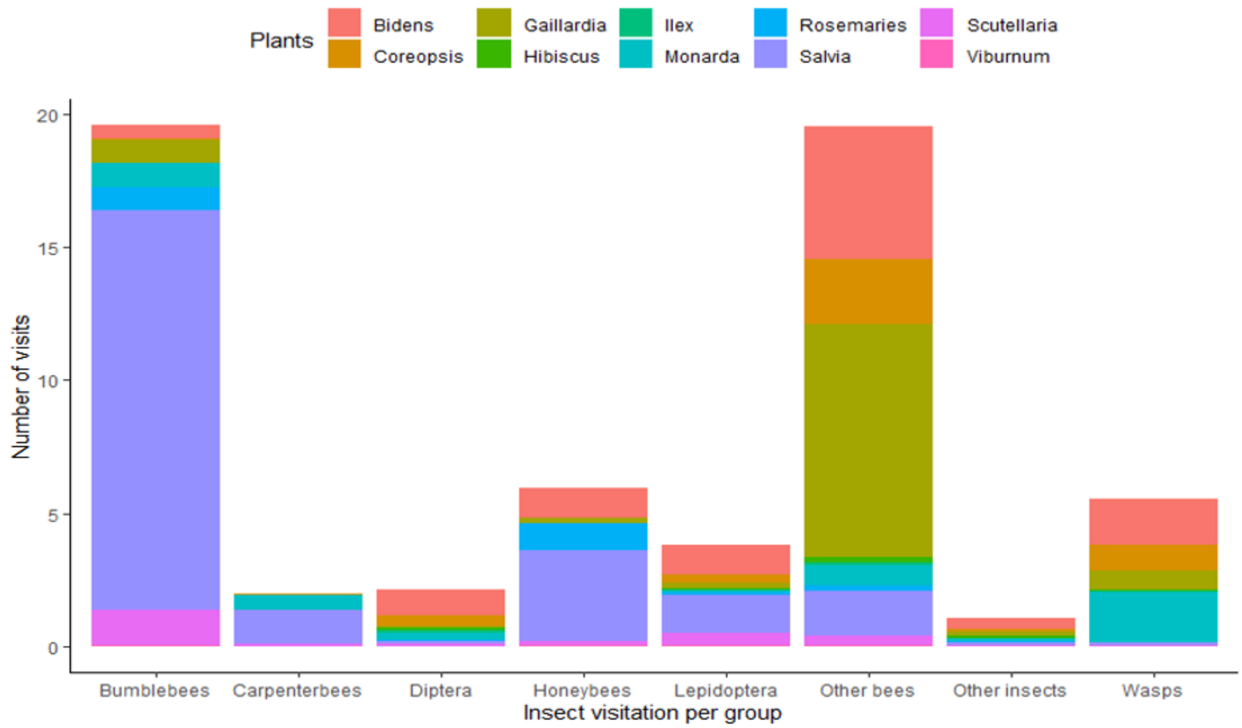
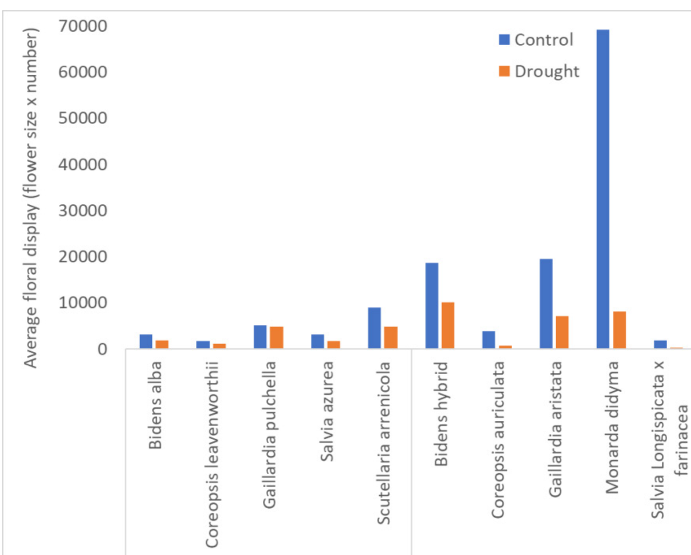


Figure 2. Insect visitation rates to 10 different plant genera in the field including bumble bees, carpenter bees, flies (Diptera), honey bees, butterflies (Lepidoptera), other bees, other insects, and wasps. Two field sites in north and northcentral Florida were observed.



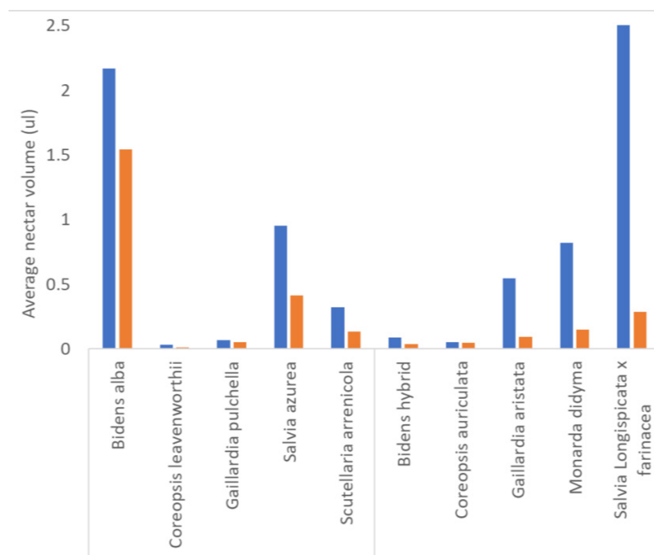


Figure 3. Average floral display and nectar volume from 10 plant species (5 native and 5 non-native congeners) grown under full irrigation and drought-stress conditions in potted plants in a greenhouse.

CONCLUSION AND NEXT STEPS

Our results show that overall native plants perform better than non-native congeners in terms of plant size, floral display, and attractiveness to insect pollinators. However, the non-native *Salvia longispicata x farinaceae* is a notable exception. Additionally, different insect pollinators show different preferences; while native plants are especially important to native bees, the non-native honey bee as well as butterfly pollinators readily visit non-native plants. Additionally, our results show that drought stress reduces floral display and nectar volume, with consequences for insect pollinators. However, some plants, in particular *Gaillardia pulchella*, performed nearly equally well under drought stress and would thus be a good choice for water-limited environments. Furthermore, in the field, while partial irrigation negatively affected plant size, it did not significantly affect floral display and insect visitation suggesting that, at least in relatively wet years, most of these plants do not require full irrigation to perform well as a pollinator resource.

Palm Nutrition Injection: Does it Work and for How Long?

PI: **Kimberly Moore, Environmental Horticulture | Ft. Lauderdale REC**
Co-PI: **Mica McMillan, ENH | FLREC**

ABSTRACT

A palm's response to fertilizer may not be evident for at least two years. A common complaint in the landscape industry is that most homeowners expect a palm's response to fertilizer to be an immediate frond green-up. When this does not happen, they often find another company that essentially re-applies even more fertilizer to the palm. Similar scenarios have been reiterated by homeowners that fail to realize that palms are not as responsive to fertilizers as other plants in the landscape. This has led to excessive and unnecessary overload of fertilizers in the landscape. However, some landscape companies have started to inject complete nutrient packages into palms, particularly as a last resort when the palm does not respond to granular fertilizer applications. While injecting insecticides and antibiotics into palms to fight insects and diseases is not novel, nutrient injection has only been studied with minor nutrients. Landscape companies are offering nutrient injection services but there is little data from UF/IFAS to determine if complete palm nutrient injection is effective and a sound management practice.

OBJECTIVES AND METHODS

1. To compare fertilization techniques on landscape palm species.
2. To compare duration and efficacy of all methods.
3. To evaluate the safety of injecting fertilizer into palms.
4. To develop environmentally safe and effective fertilizer regimes to improve palm health while reducing fertilizer loss to the environment.
5. To develop injection protocols using evidence-based research results.

Methods

Twenty-four [24] mature Foxtail *Wodyetia bifurcata* palms (20-gallon container specimens) were purchased from Ortega Nursery (Miami, FL) and planted into a native (Hallandale fine sand) soil field December 2022 at the Fort Lauderdale Research and Education Center. Palms were irrigated as needed to facilitate establishment and were arranged in a completely randomized design with 6 fertilizer treatment replications. Palms were acclimated to environment to eliminate any transplant stress influencing treatment response. Treatments (Table 1.) were initiated in April 2023, prior to Broward County blackout period, and will be evaluated on nutrient deficient indicator species *Wodyetia bifurcata* and will follow the current recommendation of fertilizing every 3-4 months outside of fertilizer restrictions or ordinances. Injections will occur once a year.

Palm parameters of height and total frond count were taken prior to treatment initiation. Pre-treatment soil analysis was also collected. Throughout the trial data collection included monitoring soil volumetric water content using a Spectrum TDR350 probe at 1.5, 3.0, and 4.8-inch depths. Chlorophyll levels were recorded using a SPAD 505DL chlorophyll meter. Visual quality (scale of 1-9 with 9=best overall quality and 1=dead palm) ratings were taken pre-treatment and throughout the trial. Post-experiment assessments to include re-measurement of palm parameters and palm deconstruction to determine vascular health. Our data will provide additional information about the release of nutrients of Palm Special due to season, rainfall, and temperature as it compares to other methods. Treatments will be compared to assess the most efficacious and cost-effective method for the end-user. All data will be subject to statistical analysis and significant means identified.

Table 1. Treatment specifics.

TREATMENT	N-P-K-Mg	METHOD-RATE	FREQUENCY
Palm Jet Mg (Arborjet)	1-2-2 + .75Mg	Injection-5ml.	1X/YR
Palm Special (Howard's Fertilizer Chemical Co.)	8-2-12 + 4Mg	Granular- 1.5lbs/100 sq.ft.	EVERY 3-4 MO
Sul-Po-Mag (Diamond R Fertilizer Co.)	0-0-22 + 4Mg	Granular-1.5lbs/100 sq.ft.	EVERY 3-4 MO
Untreated	---	---	---
			Within local ordinances

RESULTS

Height: At planting, palms receiving palm special were significantly shorter when compared to other treatments. However, four months after planting and prior to treatment application, statistical differences were not significant.

Frond Count: At planting and four months after planting, frond counts were not significant.

Visual Quality and SPAD: To date, treatments differences are not statistically significant.

Volumetric Water Content at 1.5", 3.0" and 4.8" Depths- To date, although some dates yielded statistically significant treatment differences, definitive conclusions cannot be drawn at this time.

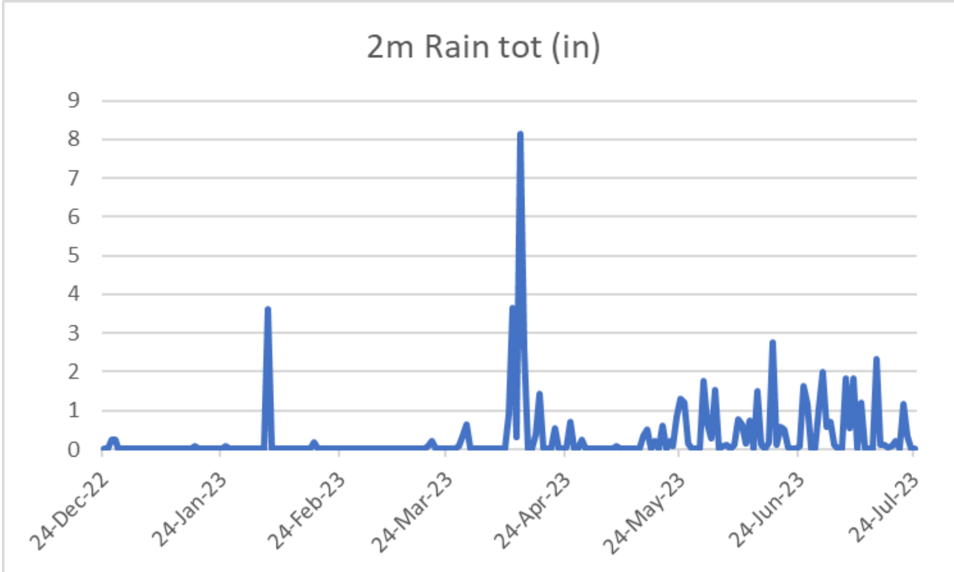


Figure 1. Precipitation for reporting period.

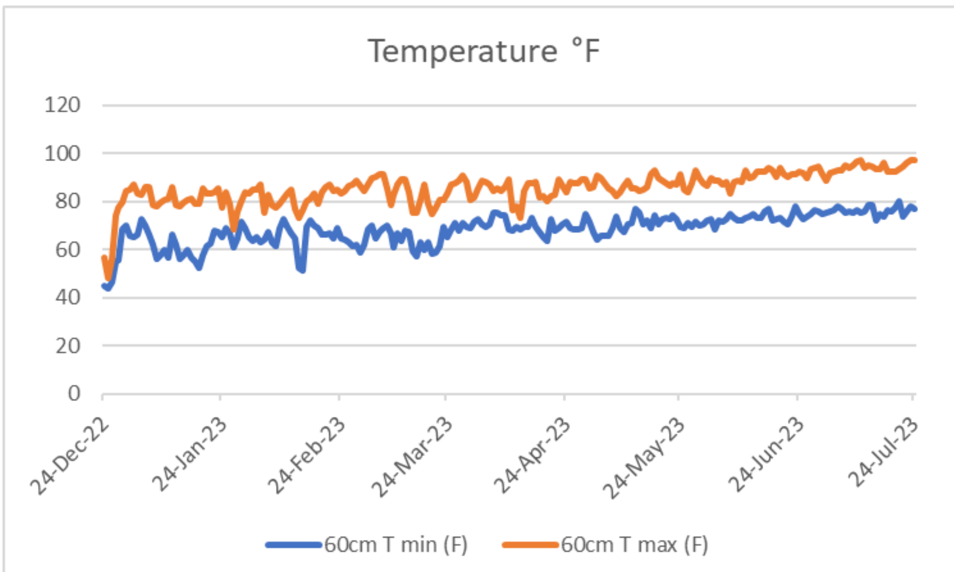


Figure 2. Minimum and maximum temperature for reporting period.

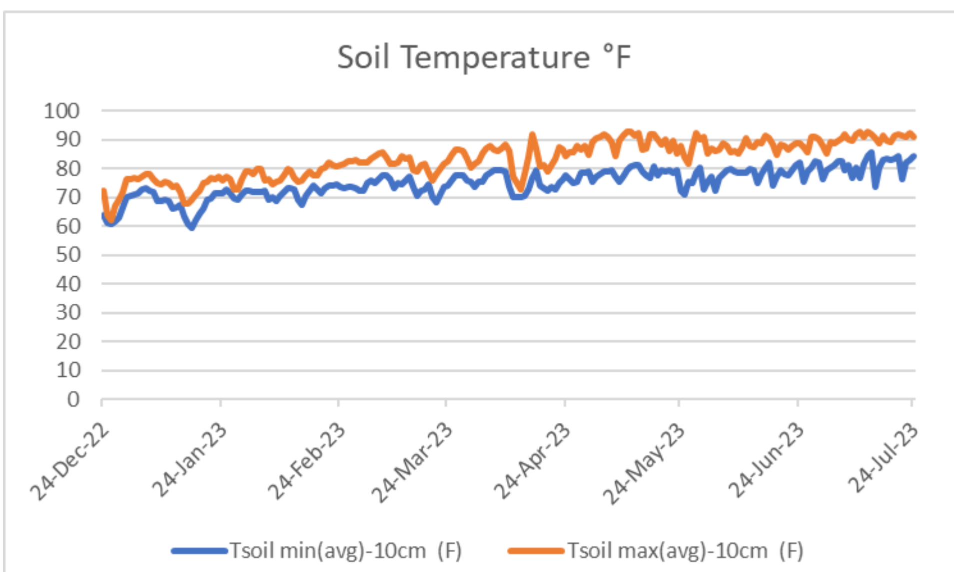


Figure 3. Minimum and maximum soil temperature for reporting period.

Table 2. Pre-treatment Wodyetia Tree Measurements.

TRT.	Height 1/3	Height 4/25	Frond Count 1/3	Frond Count 4/25
PALM JET	66.7a	66.8	5.7	5.8
PALM SPECIAL	48.5b	49.1	6.7	6.2
SULPOMAG	65.7a	65.8	6.2	6.3
UNTREATED	64.7a	64.9	6.3	5.7
SIGNIF.	***	ns	ns	ns

ns, +, *, **, and *** = P>0.10, P<0.10, P<0.05, P<0.01, P<0.001

Height = inches

Table 3. Visual Quality Ratings.

TRT.	1/5	2/16	3/13	4/25	5/8	6/11	6/28	7/17
PALM JET	7.6	7.1	5.8	5.7	7.1	6.9	7.3	7.3
PALM SPECIAL	7.6	7.3	5.3	5.5	7.2	7.1	6.8	6.9
SULPOMAG	7.5	7.3	5.3	5.6	7.1	7.2	7.1	6.9
UNTREATED	7.3	7.0	5.4	5.5	7.2	7.1	7.0	6.9
SIGNIF.	ns	ns	ns	ns	ns	ns	ns	ns

ns, +, *, **, and *** = P>0.10, P<0.10, P<0.05, P<0.01, P<0.001

Rating scale of 1-9 with 9=best, 6=minimally acceptable and 1=dead plant

Table 4. SPAD Percent Chlorophyll.

TRT.	1/5	2/16	3/13	4/25	5/8	6/11	6/28	7/17
PALM JET	56.6	52.3	48.9	47.3	44.0	48.5	50.5	48.7
PALM SPECIAL	58.2	52.9	48.7	46.7	47.8	34.7	50.8	53.1
SULPOMAG	61.3	53.0	51.4	45.9	45.0	41.0	45.9	36.1
UNTREATED	64.9	60.3	44.9	43.1	43.8	37.3	54.2	52.4
SIGNIF.	ns	ns	ns	ns	ns	ns	ns	ns

ns, +, *, **, and *** = P>0.10, P<0.10, P<0.05, P<0.01, P<0.001

IMPROVE PEST MANAGEMENT PRACTICES AND STRATEGIES

This priority area is defined as:

FNGLA supports research to develop new biological and chemical pest management tools that are effective and environmentally safe.

FNGLA supported four projects under this priority area, and those summaries are on pages 30-55.

Mitigating Risk and Developing More Efficient Management Tactics for Lethal Bronzing

PI: **Adam Dale, Entomology and Nematology**
Co-PIs: **Jacqueline Buenrostro, ENT ; Brian Bahder, ENT | FLREC ; Carrie Harmon, Plant Pathology**

ABSTRACT

Palms are a ubiquitous and iconic feature of Florida, dominating urban and residential areas where residents, tourists, and businesses are concentrated. Palms also represent a major economic impact and sizeable investments for the municipalities, businesses, and residents who purchase them for their landscapes. Unfortunately, palms are rapidly dying due to lethal bronzing disease (hereafter LB), an insect-transmitted phytoplasma. Current management includes immediate removal of infected palms, and recurring preventive antibiotic injections and insecticide applications to uninfected palms, which is often prohibitively time, labor, and resource intensive. Local urban landscape characteristics are known to influence sap-feeding insect pest densities. We leveraged two diagnostic lab databases of nearly 6,000 palm sample submissions over the past six years to investigate the seasonal and geographic distribution of phytoplasma infections, and identify local landscape characteristics that influence the likelihood of a palm becoming infected with LB. Using geographic information system software and satellite imagery, we measured local surface temperature, surrounding impervious surface cover, and the number of neighboring palms around each tree. We then asked if local temperature, impervious surface cover, or the number of neighboring palms influenced the likelihood of LB infection. We found that most phytoplasma sample submissions, and the highest disease detection rates, occurred in USDA Hardiness Zone 9, or the Central region of the state. In addition, phytoplasma detection rates were lowest during the third quarter (July-Sept), suggesting that sample submissions have the lowest return on investment during these months and that this time is better spent monitoring and managing for the vector. Phoenix palms were over four- and two-fold more likely to be infected with a lethal phytoplasma when planted in a relatively cool site with less than 46% surrounding impervious surface cover, respectively. Palms planted in landscapes with five or more neighboring palms were half as likely to become infected with a phytoplasma than palms with four or fewer palm neighbors. These results provide guidelines to inform planting site selection, phytoplasma monitoring efforts, and vector management inputs for palms in Florida landscapes. Our next goal is to refine, simplify, and disseminate these results to landscape industry professionals.

OBJECTIVES

1. Determine the seasonality and geographic distribution of lethal phytoplasma sample submission and detection across Florida.
2. Determine the effect of local environmental and landscape characteristics on lethal phytoplasma frequency across Florida landscapes.
3. Develop vector and disease monitoring, and palm planting, recommendations for palms in Florida landscapes.

METHODS

The study system

We used the state of Florida as a study system to investigate lethal phytoplasmas infecting palms from 2016 to 2022. Dr. Brian Bahder runs a lab at the UF IFAS Ft. Lauderdale Research and Education Center in Davie, FL where he offers a lethal bronzing diagnostic service for nursery and landscape industry professionals. Dr. Carrie Harmon runs the UF IFAS Plant Diagnostic Clinic on the main campus in Gainesville, FL where she offers a lethal bronzing diagnostic service for nursery and landscape industry professionals. Sample submissions from each diagnostic lab contain data including: 1) sample origin at the county, city, or property level; 2) palm species; 3) positive or negative detection of a lethal phytoplasma; and 4) date of submission. In total, there were 5,758 palm tissue samples submitted and diagnosed from locations in Florida between 2016 and 2022.

Objective 1. Determine the seasonality and geographic distribution of lethal phytoplasma sample submission and detection across Florida.

We used the entire database of 5,758 palm lethal phytoplasma samples to investigate the geographic and seasonal distribution of lethal phytoplasma sample submission and detection in Florida. For each sample, we assigned a USDA Hardiness Zone value as either 8, 9, or 10/11 based on the range of Florida hardiness zones where samples originated. We also categorized samples by the year and quarter they were submitted. Because 70% of samples were palms in the genus, *Phoenix*, we divided our datasets by Phoenix species and non-Phoenix species. Using these data, we mapped out the number of samples submitted and the percentage of submitted samples that tested positive for a lethal phytoplasma across Year and Quarter for each USDA Hardiness Zone. These figures allow us to visualize the geographic and seasonal distribution of sample submission and disease detection across the state.

Objective 2. Determine the effect of local environmental and landscape characteristics on lethal phytoplasma frequency across Florida landscapes.

To understand how local habitat traits affect risk of lethal bronzing infection, we filtered this dataset to only those entries tied to a specific address where the palm was planted, and where the property was 0.5 acres or smaller. Because each observation is associated with the property address of the tested palm, rather than the specific location of the palm on the property, filtering observations to those on 0.5 acre or smaller lots makes it more likely that our analyses capture the planting conditions around a tested palm. Filtering the dataset in this way resulted in 128 records across 27 counties tested for lethal phytoplasma infection between 2019 and 2022 (Fig. 1). All habitat traits were visualized and processed in ArcMap. Impervious surface data were obtained through the USGS Multi-Resolution Land Characteristics Consortium on a 30mx30m scale. Specifically, the percentage of impervious surface within a 25 m radius of the property center was calculated. Summer land surface temperature data were obtained through USGS Landsat 8 Collection 2, and the average surface temperature within 25 m of each property center was calculated. To determine the density of neighboring palms at each property, we counted the number of individual palms within 25 m of each property center using satellite imagery from Google Earth.

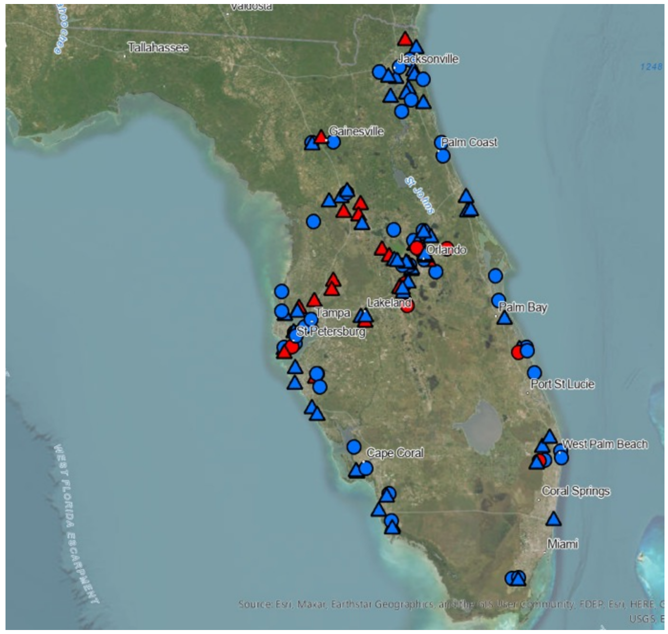


Figure 1. Map of 128 study sites used for Obj. 2. Triangles represent *Phoenix spp*. and circles represent non-*Phoenix spp*. Blue indicates a negative phytoplasma detection and red indicates a positive phytoplasma detection.

RESULTS

Objective 1. Determine the seasonality and geographic distribution of lethal phytoplasma sample submission and detection across Florida.

Our analysis of nearly 6,000 palm sample submissions between 2016 and 2022, illustrates several aspects of palm lethal phytoplasma detection across the state. As illustrated in Figure 2, sample submissions are highest, particularly in 2021 and 2022, for Phoenix palms. This is particularly driven by samples submitted from USDA Hardiness Zone 9, which represents most of central Florida. Very few samples have been submitted from Hardiness Zone 8, likely because *Phoenix spp*. are not cold hardy enough to survive cold winters that far north. Sample submissions have increased over time, likely due to a combination of increased disease prevalence and increased scouting and awareness of disease signs and symptoms. Similarly, phytoplasma detection rates have declined over time (Figure 3), most likely due to the significant increase in preventive disease monitoring efforts.

When exploring the seasonality of palm infection rates (Figure 4), our data indicate that non-Phoenix species have relatively static infection rates throughout the year, with the highest rates in USDA Hardiness Zone 9, followed by zone 10. For Phoenix palms, infection rates are lowest in Quarter 3 (July – September). This suggests that disease monitoring efforts have the lowest return on investment in Q3 and that they should be prioritized during the beginning and end of the year. This makes sense because Q3 is when the phytoplasma vector, Haplaxius crudus, is most actively feeding and reproducing in the landscape.

Objective 2. Determine the effect of local environmental and landscape characteristics on lethal phytoplasma frequency across Florida landscapes.

As predicted, our investigation of associations between local landscape characteristics and the likelihood of lethal phytoplasma infection revealed significant relationships with local surface temperatures and surrounding impervious surface cover. Likely driven by the large number of sample submissions, our findings are largely associated with Phoenix palm species. More specifically, Phoenix palms are about four times more likely to become infected with a lethal phytoplasma when planted in a relatively cool site compared to palms planted in a relatively warm site (Figure 5; Chi-Sq =5.14, P=0.02). There was a less pronounced, but opposite, effect of local surface temperature on non-Phoenix species. Palms planted at sites surrounded by less than 46% impervious surface cover are about twice as likely to become infected with a lethal phytoplasma than those planted in sites with more than 46% surrounding hardscape (Figure 6; Chi-Sq=6.11, P=0.013).

Contrary to previous studies that show a strong positive correlation between impervious surface cover and temperature, surface temperature was not correlated with surrounding impervious surface cover. Therefore, these effects appear to be independent of one another and may make site assessments more challenging than simply measuring impervious surface cover. Finally, our evaluation of palm density effects on lethal phytoplasma infection found a slight, but non-statistically significant effect (Figure 7; Chi-Sq=1.83, P=0.17). This finding suggests that increasing the number of neighboring palms at a given site may slightly reduce the likelihood of lethal phytoplasma infection, but this requires further investigation.

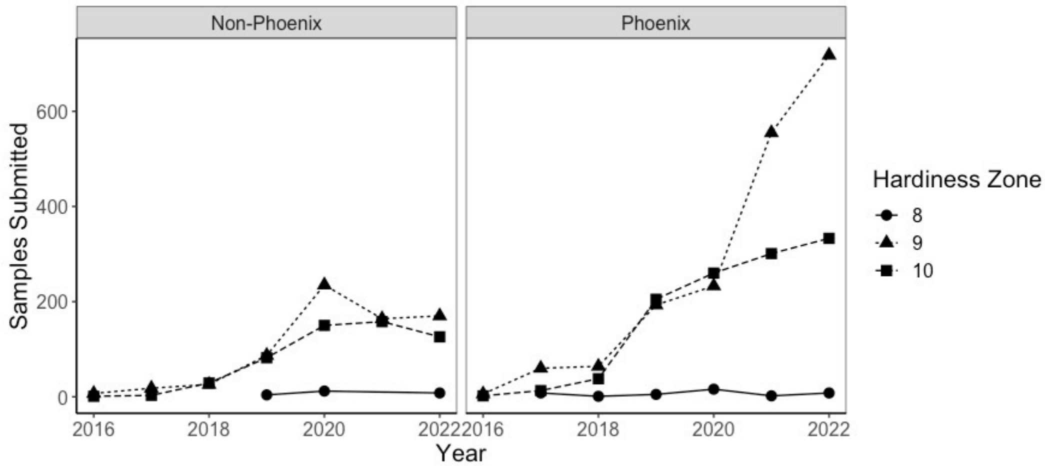


Figure 2. Palm sample submissions from 2016-2022, delineated between non-Phoenix and *Phoenix spp*. palms. The shape of data points indicates USDA Hardiness Zones 8-10.

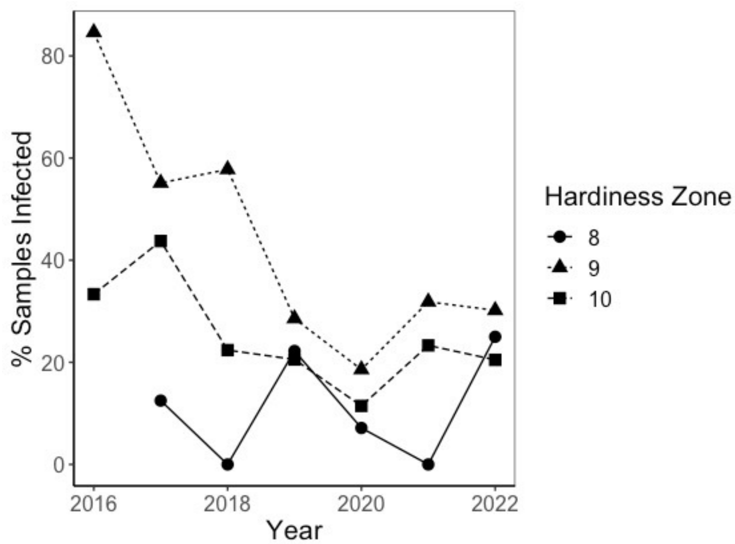


Figure 3. Percentage of palm samples with a positive detection of lethal phytoplasma per year delineated between USDA Hardiness Zones.

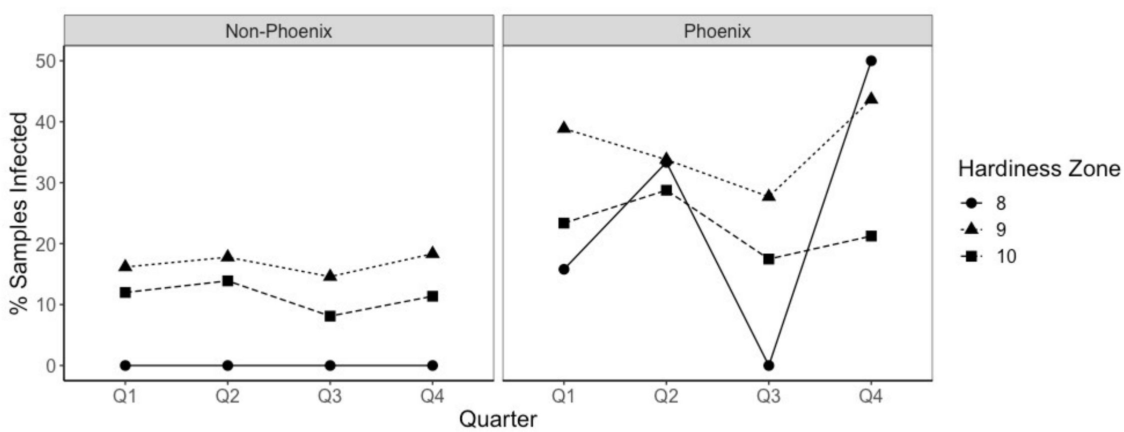


Figure 4. The percentage of palm sample submissions that tested positive for a lethal phytoplasma delineated between non-Phoenix (left) and *Phoenix spp*. palms (right) and time of year by Quarter. Shape of data points indicates USDA Hardiness Zones 8-10.

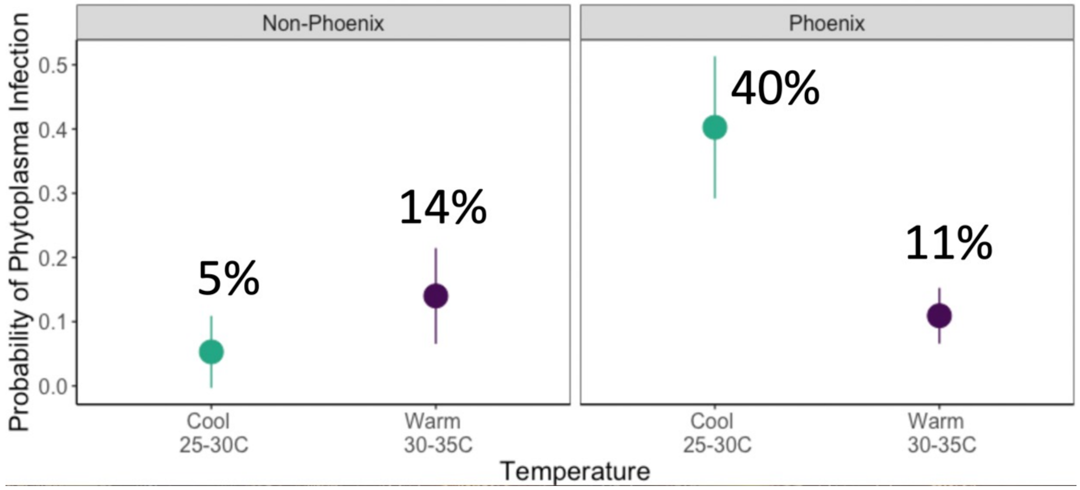


Figure 5. The probability of lethal phytoplasma infection in non-Phoenix (left) and Phoenix (right) palm species located in relatively Cool and relatively Warm sites in Florida's urban and residential landscapes.

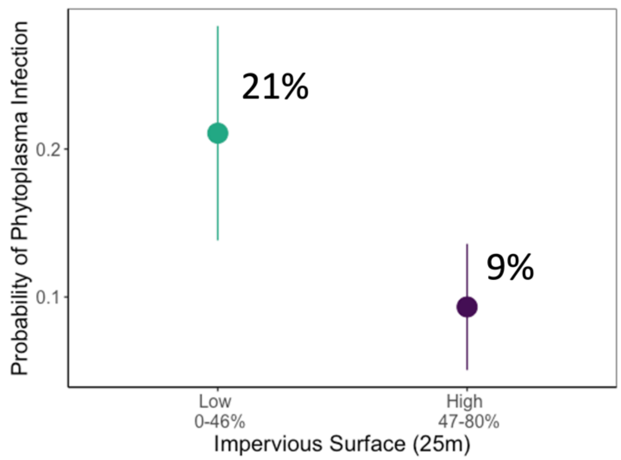


Figure 6. The probability of lethal phytoplasma infection in palms located at sites with Low (0-46%) and High (47-80%) surrounding impervious surface cover within a 25m radius of the lot.

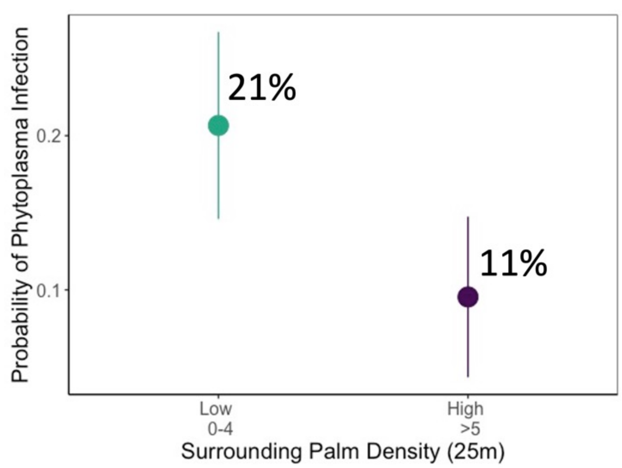


Figure 7. The probability of lethal phytoplasma infection in palms located at sites with Low (0-4 palms) and High (>5 palms) density palm plantings within a 25 m radius of the lot.

CONCLUSION AND NEXT STEPS

Our investigation of lethal phytoplasma geographic and seasonal variability, and associations between local landscape characteristics and the likelihood of lethal phytoplasma infection, has revealed several relationships that may help guide palm installation and maintenance in Florida's urban and residential landscapes. While this may not directly benefit nursery growers, it should translate to benefits for those to spec and install palms in landscapes as well as landscape maintenance professionals and homeowners who work with palms during and after installation. For example, we now know that palm sample submissions should be targeted at the beginning or end of the calendar year to maximize the likelihood of lethal phytoplasma detection and the return on investment associated with sample collection and submission. It is also evident that palms located in USDA Hardiness Zone 9 are most likely to become infected with a lethal phytoplasma, further directing monitoring efforts.

At the local landscape level, our results indicate that Phoenix palms are at the highest risk of infection when planted at low densities (fewer than four palm neighbors) in relatively cool sites (40% infection rate) with less than 46% surrounding impervious surface cover (21% infection rate). These palms are good candidates for preventive phytoplasma management with tools like OTC injections and systemic insecticide applications. While it may seem difficult to know if a site is relatively cool or quantify the amount of surrounding impervious surface cover, this can be done using a combination of site assessment tactics. For example, impervious surface can be easily measure using the Pace-to-Plant technique and relative temperature can be estimated by evaluating the number of trees and shrubs in the local area (more vertical vegetation translates to cooler temperatures). These finding also suggests that Phoenix palms can be utilized in high densities (groups of more than five palms) at relatively hot sites (not many shrubs or trees) with high amounts of impervious surface cover because these are less likely (9% infection rate) to become infected.

Monitoring and Testing of Management Strategies for *Thrips parvispinus* (Karny) in Palm Beach County

PI: **Lance Osborne, Entomology & Nematology | Mid-Florida REC**
Co-PIs: **Muhammad Ahmed, USDA ARS ; Cindy McKenzie , USDA ARS ; John Roberts, Palm Beach County Extension**

ABSTRACT

Thrips parvispinus (Karny) (Thripidae) was first detected in the continental United States in August 2020 within an ornamental greenhouse located in Orange County, Florida. This species has since been observed in other counties throughout the state. Initially, T. parvispinus was observed on Hoya sp. and *Anthurium sp.* plants, however, the species is a well-documented polyphagous feeder and known to impact a variety of commercial plant species. Of particular concern for Palm Beach County are nurseries and landscapes that contain *Gardenia sp., Dipladenia sp., Ficus sp., Hoya sp., and Anthurium sp.* – common ornamentals that are understood to be susceptible to T. parvispinus. Additionally, vegetable and fruit crops such as peppers (*Capsicum sp.*), strawberries (*Fragaria x ananassa*), and papaya (*Carica papaya*) are demonstrated hosts. Eradication is not likely because of resistance to many pesticides. Growers in Apopka have quit growing impacted crops because they could not obtain control. The wide array and abundance of host plants throughout Florida will likely make this insect pest a persistent challenge for growers and landscape professionals throughout much of the state.

METHODS AND RESULTS

1. Extension articles including field guides and website

Thrips (Thysanoptera) are major global pests of vegetables and ornamentals grown within protected agriculture. Thrips feeding activity deprives the plant of nutrients, causes physical damage that could lead to plant death, and may transmit viral pathogens. This can ultimately lead to reduced crop yield, aesthetic value, marketability, regulatory consequences, and economic losses. Many of the thrips' problems we have in foliage plant production in Florida greenhouses are the result of 3 primary species: *Echinothrips americanus, Scirtothrips dorsalis*, and most recently, the invasive *Thrips parvispinus*. Recent studies using the large predatory thrips *Franklinothrips vespiformis* native to Florida have shown very promising results for *E. americanus* control in greenhouses. This predator also is effective in managing whiteflies and spider mites in the crop. This species can also be maintained on banker plants containing an alternative prey, and studies are currently being conducted on the best practices for a banker plant system. During the summer of 2023, we released this predatory thrips in a gardenia landscape that was heavily infested with an established population of *T. parvispinus*. Four releases were made: May 3, May 25, June 30, and July 7 in a residential landscape on Palm Beach Island. Control was great. Hedges that had not flowered for two years made a comeback and began to bloom. However, recovery was short-lived when we deplenished our lab colony supply of predators. Our studies have shown the addition of supplemental food, such as decapsulated brine shrimp eggs, to the crop can promote the persistence of *F. vespiformis* during periods when prey is absent and we would like to investigate this in the landscape. We were invited to write an article on the banker plant system of thrips with a focus on *T. parvispinus* (Schoeller et al. 2023). This extension article will help growers explore the potential availability of biological control options for *T. parvispinus* in Florida. We prepared a laminated field guide card containing information about the early diagnostics of the pest for distribution among extension agents, ornamental growers, master gardeners, and the public during their regular meetings (Ahmed et al. 2023a). We also built a website containing information about the early diagnostics, field scouting, biology, and management options of *T. parvispinus* for the first time globally (Ahmed et al. 2023b).

GrowerTalks invited us to write an article about *T. parvispinus* to introduce our website (Ahmed et al. 2023c). Our field guide and website are helping the FNGLA community keep an eye on this new emerging pest in the nurseries and greenhouses across the state.). We were invited to write a blog article by the University of Florida on *T. parvispinus* to highlight our website. Overall, our website was featured in six additional media articles, including by Morning AgClips on March 29, Hortidaily and Floral Daily on March 30, Greenhouse Grower on April 5, South Dade NewsLeader on April 7, and Greenhouse Management on April 11.

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- Ahmed M.Z., C.L. McKenzie, and L.S. Osborne. 2023a. Field guide for common ornamental dark thrips in Florida (adult females), with a focus on *Thrips parvispinus* March 1, 2023.

- Ahmed, M.Z., A. Revynthi, C.L. McKenzie, and L.S. Osborne. 2023b *Thrips parvispinus* (Karny), an emerging invasive and regulatory pest in the United States. May 4, 2023. https://mrec.ifas.ufl.edu/lsolab/thrips/thrips-parvispinus/ (More than 7,000 hits since 1/1/23).

- Ahmed, M.Z., C.L. McKenzie, and L.S. Osborne. 2023c. *Thrips pavispinus* (Kamy), an emerging invasive and regulatory pest in the United States. Growertalks. June 1, 2023. https://www.growertalks.com/Article/?articleid=26308.

2. Presentations:

We presented our work at the *Thrips parvispinus* Task Force Meeting on February 16, Garden Expo in Jenson Beach on February 25, vegetable session of the Citrus Show in Florida on April 13, and through online webinars by the University of Florida Extension on May 4, and The American Hort Foundation, tHRIve on May 10. We also presented information in a New Pest workshop at MREC, Apopka on June 26 and the FNGLA Landscape Show 2023 August 23. In addition we will be presenting multi-county workshops in Palm Beach, Broward, and Dade counties September 19-20. These talks contain information about the identification, scouting, and potential controls of *T. parvispinus* for extension agents, ornamental and vegetable growers, master gardeners, and the public to guide them in management and to slow down its further spread in Florida.

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2. Ahmed, MZ, McKenzie, CL, Osborne, L. 2023. The biggest threats of *Thrips parvispinus* in Florida. The *Thrips parvispinus* Task Force Meeting, Tropical Agricultural Research and Extension, University of Florida, Homestead, Florida February 16, 2023.

3. Osborne, LS. 2023. Thrips management. *Thrips parvispinus* Task Force Meeting, Tropical Agricultural Research and Extension, University of Florida, Homestead, Florida February 16, 2023.

4. McKenzie, CL and MZ Ahmed. 2023. *Thrips parvispinus* coming to a store near you. Jenson Beach Garden Expo, Jenson Beach, FL, February 25, 2023.

5. McKenzie, CL, Ahmed, MZ, Osborne, L. 2023. *Thrips parvispinus*: a Florida prospective. Vegetable Session, Florida Citrus Show at the UF/IFAS IRREC and USDA ARS, Fort Pierce, FL, April 13, 2023.

6. Ahmed, MZ. McKenzie, CL, Osborne, L. 2023. What is the biggest threat of *Thrips parvispinus* in Florida? Vegetable Session, Florida Citrus Show at the UF/IFAS IRREC and USDA ARS, Fort Pierce, FL, April 13, 2023.

7. Ahmed, MZ, McKenzie, CL, Osborne, L. 2023. What is the most challenging with *Thrips parvispinus* in Florida. *Thrips parvispinus* Webinar Research & Extension Update. May 4, 2023. https://www.youtube.com/watch?v=hsi9gtPIajg&t=620s

8. McKenzie, CL. 2023. *Thrips parvispinus* - New Invasive Pest: A Florida Prospective. *Thrips parvispinus* Webinar Research & Extension Update. May 4, 2023. https://www.youtube.com/watch?v=hsi9gtPIajg&t=620s

9. Osborne, LS, Ahmed, MZ, Roberts, J., McKenzie, CL. 2023. History and field identification of *Thrips parvispinus* in Florida. Horticultural Research Institute, The AmericanHort Foundation, tHRIve, FREE Webinar. May 10, 2023. https://www.americanhort.org/events/thrips-parvispinus-identification-scouting-and-potential-controls/

10. McKenzie, CL and Lance Osborne. 2023. *Thrips parvispinus* – New Invasive Pest: A Florida Prospective. New Pest Workshop, MREC, Apopka, FL June 26, 2023.

11. McKenzie, CL, Ahmed, MZ, Osborne L. 2023. *Thrips parvispinus* - New Invasive Pest: A Florida Prospective. The FNGLA Landscape Show 2023: Knowledge College. Orange County Convention Center, Orlando, FL, August 23, 2023.

12. Osborne, L.S., M. Ahmed, and CL McKenzie. 2023. Thrips and Resistance Management. FNGLA Landscape Show 2023: Knowledge College. Orange County Convention Center, Orlando, FL, August 23, 2023.

Future Presentations (this month)

Landscape and Nursery Workshops for *Thrips Parvispinus* Tour (Palm Beach, Broward, and Dade Counties). Tuesday, September 19th and 20th, 2023. Organized by Dr. John Roberts, UF/IFAS Palm Beach County Extension, Dr. Mike Orfanedes, UF/IFAS Broward County Extension, and Henry Mayer and Dr. Qingchun Liu, UF/IFAS Miami-Dade County Extension. 6 presentations.

3. Review and Biology.

All available literature on *T. parvispinus* was reviewed and our team is writing an article for the Journal of Integrated Pest Management. Our review concluded that there are 23 thrip species reported from ornamental plants, including 11 with dark bodies, including *T. parvispinus*, 5 with light to dark bodies, and 7 with light-colored bodies. *Thrips parvispinus* is a dark-colored thrips with a brown head, yellow thorax, and black abdomen, and its female is nearly 1 mm long, making it one of the smallest thrips in Florida. It is native to the Asian tropics and has been reported to be present in at least 17 countries [Burundi, China, India, Indonesia, Japan, La Reunion, Malaysia, Mauritius, Myanmar, Netherlands, Philippines, Singapore, Taiwan, Tanzania (Dar-el-Salam), Thailand, Uganda (Kampala), USA (Hawaii, Georgia, South Carolina, North Carolina. Ohio and Colorado samples are pending APHIS confirmation)] and intercepted in at least ten countries (Australia, France, Greece, Netherlands, New Guinea, New Zealand, Solomon Islands, Spain, Switzerland, UK) from five continents (Africa, Antarctica, Asia, Australia/Oceania, Europe, and North America, and South America) in the last three decades (Ahmed et al. in preparation). It is a polyphagous pest, reported feeding on at least 43 plant species from 19 families from different crop types, including fiber crops, fruits, legumes, ornamental plants, tobacco crops, and vegetables. This list is expected to grow (Ahmed et al. in preparation). It completes its life cycle in 13–14 days on a chili pepper in a greenhouse. It inserts its eggs into leaves, and larvae hatch after four to five days and feed on leaves and flowers while completing two molts in four to five days. Afterward, larvae pupate in soil for two to three days. The reproduction reported is sexual. A female thrips lays about 15 eggs and lives for nine days. Adult males live for about six days. Adult and immature of this species feed on leaves and flowers and cause damage similar to that of broad mites or/and of virus-infected plants. Scouting should be conducted by beating foliage over a white clipboard, and the number of adult and immature thrips should be counted immediately.

4. Scouting data analysis.

We observed that the thrips inside Dipladenia flowers did not come out of flowers during beating on white clipboards even though they were visible inside flowers. In some cases, they were only seen after dissecting the flowers, for example, in roses. The number of thrips per flower was not found to be associated with visual damage rankings and perhaps is not an excellent indicator for scouting but could be used for detection since this species seems to be hiding for protection in flowers. In addition, the number of thrips per beat was significantly associated with visual damage rankings (Figure 1; n=13).

5. Surveys.

During January, February, and March of 2023, surveys were conducted by Drs. McKenzie, Ahmed, and Roberts in Palm Beach County to determine the extent of infested plant material being sold in large retail nursery chains. In 14 stores throughout the county, we evaluated presence/absence of *Thrips parvispinus* on known hosts identified by our literature review for this pest in Florida. Some of the hosts evaluated included *Dipladenia, Gardenia*, Peppers, *Plectranthus, Ruellia, Schefflera*, 'Trinette' variegated arboricola, *Ixora*, and *Vinca*. Other known host plant species (e.g., papaya, guava, eggplant, mango, ficus, heliconia, and hibiscus) were also inspected but showed no presence of thrips through our surveys. Thrips were collected and placed in 95% ETOH and transported back to the USDA-ARS, where they were identified to species. We determined that 13 of the 14 stores (~93%) had *T. parvispinus* infested plants present in their outdoor nurseries and available for customers to purchase. The positive host plants consistent from each store location were *Dipladenia, Gardenia*, and pepper transplants. Because of these findings, we decided to expand the survey in April 2023 to include large retail stores in 9 additional northern counties along the I-75, I-10, and I-95 corridors (Figure 2). We collected samples in Ocala (Marion), Gainesville (Alachua), Lake City (Columbia), Jacksonville (Duval), Yulee (Nassau), St. Johns (St. John), Palm Coast (Flagler), Port Orange (Volusia), Melbourne (Brevard). Every nursery visited in the 9 additional counties was determined to contain *T. parvispinus* infested plants. Prior to this survey, the most northern county known to have *T. parvispinus* infested plant material was Lake County. Because these plants were not planted in the ground, this type of positive detection is classified as an interception and does not represent an established population. Currently, we believe that this pest has been detected in 26 Florida Counties when you add DPI positive county finds together with the counties reported herein, but only 5 are considered established.

6. Molecular Analysis (Because of space concerns, the data and results are available on request).

Our genetic analysis confirms the population of *T. parvispinus* found on pepper recently is the same as the one found previously on ornamental plants including Gardenia.

7. Biological Control.

The predatory thrips, *Franklinothrips vespiformisis* known to be an excellent predator of Chilli thrips and the Poinsettia thrips. We have developed methods to rear it using spider mites, thrips, and whiteflies, as well as commercially available pollen and Artemia cysts. We released lab-reared adult *Franklinothrips* in a residential property on Palm Beach Island. The homeowner reported not having any gardenia flowers for more than two years which was attributed to *T. parvispinus*. After releasing the predators, the homeowner reported the plants looked the best they had in a couple of years, with the hedges beginning to flower. Once we quit releasing the biological control agents, *T. parvispinus* returned and caused significant damage. Greenhouse trials will be conducted this fall to demonstrate the utility of the predator. We will also continue our work with green lacewing eggs. We have demonstrated that releases of green lacewing eggs were effective at controlling *T. parvispinus* in a commercial greenhouse. The issue was the rates used were excessive, and the cost would not be acceptable to the grower. We will revisit this issue and evaluate much lower release rates to determine if we can cut the cost while maintaining efficacy.

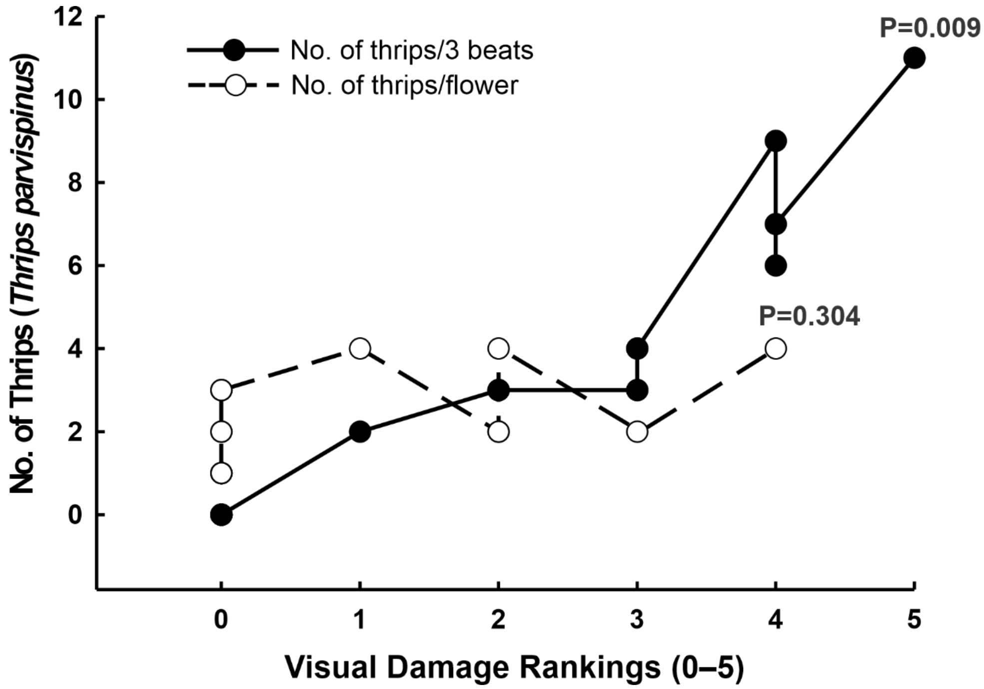

Figure 1.

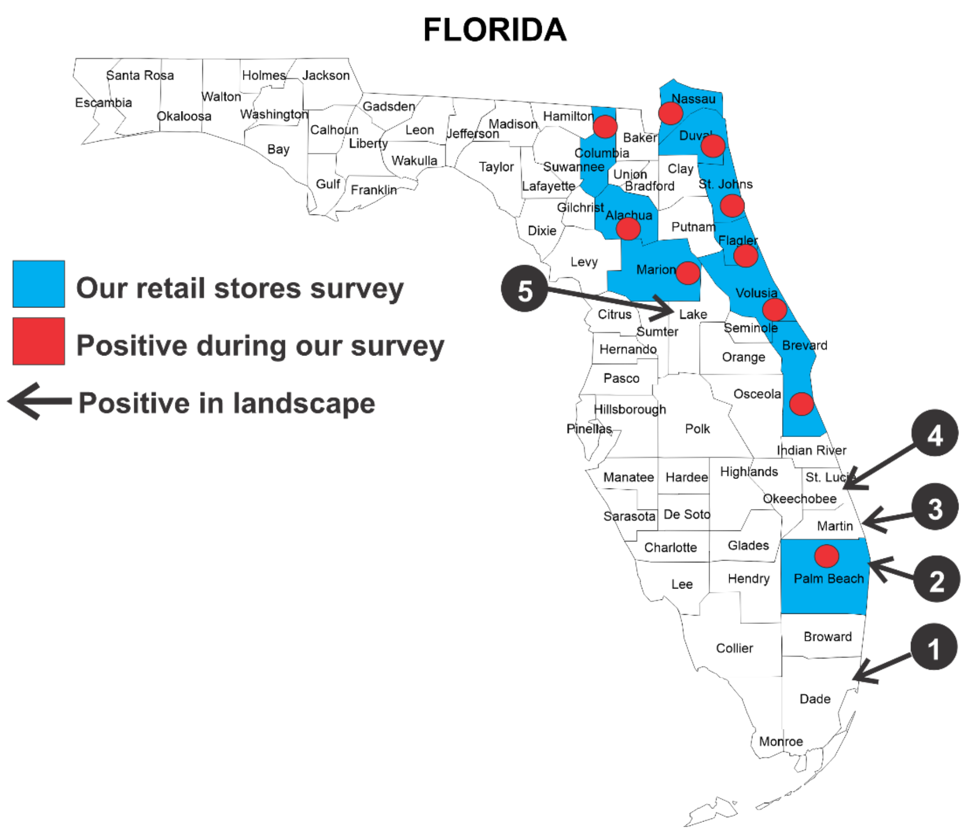

Figure 2.

ISSUES

• Permit: We received our permit to have a colony of *Thrips parvispinus* on 2/24/2023. After an inspection and revision, we were only allowed to work with this pest in a containment room in a secure building. The revision required us to keep the infested plants within an ultra-fine mesh enclosure with an aperture size of 160 µm which greatly limited what we could research. In the interim, *T. parvispinus* was detected in our greenhouses. We are treating in the same way as if we were a nursery. Nothing that might be contaminated with the thrips can leave the greenhouse without being double bagged and put in a landfill or autoclaved. We initiated one chemical control evaluation which we describe under the Pesticide heading. We will begin fumigation trials soon to see if we can eradicate the infestation in what was our clean greenhouse. Oddly enough, *T. parvispinus* is no longer detectable in any of our other greenhouses even though we have not sprayed and there are many suitable hosts within them. Either the heat or a biological control agent or both could have caused a crash in the populations to non-detectable levels. These negative greenhouses have ants, predatory mites and the predatory thrips *Franklinothrips vespiformis*.

• Pesticide trails on private property or cooperating nurseries were not conducted because growers were afraid of the negative impacts that could result from the knowledge, they have an active thrips population. We were also denied access to conduct trials at the Palm Beach Extension office because of similar concerns and the proximity of Mount Botanical Gardens.

• A single pesticide trial was conducted using jalapeno peppers that we obtained for a commercial grower. We received 3 shipments of clean pepper seedlings to conduct our trials. The seedlings were free of detectable pests, and they hadn't been treated with pesticides. The experiment was designed to evaluate preventative pesticide treatments of various rotational schemes. We potted a single seeding in each of 30 4" square pots, added ¼ tsp of Osmocote 15-9-12 fertilizer on 6/26/23. The plants were placed in a greenhouse with a low infestation of *T. parvispinus*. A pre-count was conducted on 7-12-23. Very few adult *T. parvispinus* were found so we began our treatments on 7/13/23. The plants were sprayed to runoff and placed in randomized complete blocks after treatment. The treatments were:

A = water treated control
B= Talstar 1.70ml/L
C= Conserve 0.47ml/L
D= Pylon 0.78ml/L
E= Mainspring 1.24ml/L
F=Sarisa 2.11ml/L

We counted thrips weekly but discontinued the experiment because of contamination by broad mites, aphids, and Chilli thrips. *Thrips parvispinus* never established a population on any of the plants in any treatment. When we terminated the study, the Talstar (bifenthrin) plants were devastated by Chilli thrips while all other chemically treated plants were healthy. The controls we acceptable as well which we attribute to being contaminated by the predatory thrips and predatory mite (*Amblyseius swirskii*). Future experiments will require us to use a host plant that is not so attractive to Chilli thrips and broad mites.

Implementation Of Rapid Testing Kit in Commercial Nurseries to Distinguish Lebbeck Mealybug (*Nipaecoccus Viridis*) from Other Mealybugs in Florida

PI: **Nicole Quinn, Entomology & Nematology | Indian River REC**
Co-PIs: **Muhammad Ahmed, USDA ARS & Lance Osborne, ENT | MREC**

ABSTRACT

Nipaecoccus viridis is an invasive mealybug that threatens a wide range of commodities in Florida, including those grown in nursery and ornamental settings. This project focused on the implementation of a new and improved species-specific testing kit for *N. viridis*, as well as providing training in the biology, identification, and management of mealybugs. We successfully developed a new testing kit that is safer and easier for stakeholders to use. We shared our findings at a mealybug diagnostic workshop hosted at the UF/IFAS Indian River Research and Education Center. The session was recorded and is freely available. Kit materials were given to attendees, with more available for any who might be interested that could not attend the session. Growers now have the kit and the knowledge of how to use it, as well as an improved understanding of mealybugs in their production systems generally.

OBJECTIVES AND JUSTIFICATION

Objectives: We propose to 1) design field diagnostic kits based on their results and distribute the kits among nursery growers, and 2) conduct hand-on training for nursery growers to demonstrate how this kit works.

Justification: Mealybugs are the most common among the regulatory pests in the USA, especially in Florida. *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae), also known as Lebbeck mealybug has invaded Florida very recently (Ahmed et al. 2019). As an actionable pest, there is zero tolerance for mealybugs in commercial nurseries or exports. The host range of Lebbeck mealybug is quite broad, with feeding documented on plants spanning more than 140 genera and 50 families throughout its invaded range across the globe (García Morales et al. 2016). In Florida, Lebbeck mealybug has been documented feeding on many plants important to the ornamentals industry, including pagoda flower, jasmine, oleander, honeysuckle, gardenia, and bottle palm (Diepenbrock personal communication). Recently, heavy infestations of Lebbeck mealybug were observed on oleander and jatropha in Palm Beach County (Olabiyi et al. submitted). In citrus, where the majority of work on this pest has been conducted in Florida, Lebbeck mealybug infestations can cause fruit distortion and even tree death (Diepenbrock and Ahmed 2021). Although Lebbeck mealybug infestations in the United States currently are limited to Florida, it has been intercepted in exports to other states on at least one occasion on gardenia (FDACS-DPI Database, 2022).

Little work on Lebbeck mealybug has been conducted in nursery and landscape plants, despite the eminent threat it poses to the $31.4 billion industry in Florida (Novakovic 2022). In order to protect the continued viability of ornamental plant production and exports in Florida, there is a need to proactively improve management of this pest. One important aspect of management is detection and accurate identification, which is difficult given that Lebbeck mealybug hides and feeds in cryptic locations on plants at early infestation and can be very difficult to detect before export or sale of the plant. The prevention of Lebbeck mealybugs' spread to more hosts and locations will be dependent on rigorous field diagnostic tests. To this end, a new, species-specific, low-cost field-testing has been developed by Ahmed and Deeter (2022) and Ahmed et al. (in preparation). We propose to 1) design field diagnostic kits based on their results and distribute the kits among nursery growers, and 2) conduct hand-on training for nursery growers to demonstrate how this kit works.

POTENTIAL BENEFITS TO INDUSTRY

This project will directly benefit the industry by allowing for rapid, accurate, low-cost determination of the presence of Lebbeck mealybug in commercial nurseries. Heavy infestation of Lebbeck mealybug includes all life stages and obvious damage symptoms, but early infestations contain either eggs with an adult female or first instar immatures (crawlers) that could be very challenging to differentiate from other common mealybug species in the field. The field diagnostic kit by Ahmed and Deeter (2022) and Ahmed et al. (in preparation) could distinguish all life stages of Lebbeck mealybug from other mealybugs and will help nursery growers in Florida and plant inspectors working in state and federal regulatory agencies in confirming the species of Lebbeck mealybug in the field at this stage. This will prevent disruptions to growers' operations caused by failed state and federal inspections. Additionally, nursery growers will be trained in how to scout for mealybugs and use the kit themselves while preparing plants for export within or outside of Florida, introducing further cost- and time-savings to their operation.

METHODS

Ahmed et al. (2022) developed a kit in which potassium hydroxide (KOH) was an essential ingredient. When the hemolymph (blood) of Lebbeck mealybug contacts potassium hydroxide, the solution turns green in color, a result which does not occur with any other mealybug species in Florida. However, potassium hydroxide is a skin and eye irritant, and therefore not ideal for regular use in the field without sufficient protective equipment. To optimize the kit, solutions of varying pH and chemistries on Lebbeck mealybug and other mealybugs to see if a similar result with a safer solution could be identified. The resulting kit would be shared at a workshop, in which stakeholders would be trained to identify Lebbeck mealybug using the kit and become more knowledgeable in mealybug biology and management generally. The session would be recorded.

RESULTS

Objective 1: Designing field diagnostic kits and distributing among nurseries growers. Of the chemical solutions tested in (Ahmed et al. 2023), 5% NaOH of 11, 12, 13 and 14 pHs were found to be effective in producing a green color when put in contact with Lebbeck mealybug hemolymph (Ahmed et al. 2023) (Figure 1). We designed the kit using 5% NaOH (pH 14) and conducted the field tests. We tested the 5% NaOH (pH 14) solution in the field using two tools: (1) a strip of white wipe of Wypall L40 (Kimberly-Clark Professional) cut in a dimension of 8″ length × 3″ width and (2) a white plastic squeezable dropper with a cap (Wowlife Clear) filled with 5% NaOH (pH 14). A live specimen of Lebbeck mealybug with little or no wax was selected from an infested citrus tree branch. It was picked with a strip, squashed between the ends of the strip, and the coloration of the squashed body on the strip was observed. Afterward, a drop of 5% NaOH (pH 14) was placed on the squashed body of a mealybug from a dropper and observed the purple color on the strip changed into a dark green color (Figure 2). The design of the kit was published in Ahmed et al. (2023). We added a step demonstrating the field diagnostic kit in the field guide of Lebbeck mealybug from Diepenbrock and Ahmed (2020) and Olabiyi et al. (2023) (Figure 3). This updated field guide was included in the field diagnostic kit of Lebbeck mealybug and provided to growers and scouts through diagnostic workshops and the University of Florida extension offices.

Our field diagnostic kit was highlighted as a news on the main page of the USDA-ARS on August 23, 2023. The news was further featured in seven media outlets, including WHBL News on August 30, Morning AgClips on August 27, Growing Produce, Life Technology, PHYS.ORG, PRIME NEWS PRINT on August 24, and Science Magazine on September 6. In addition, it was shared at online platforms by Penn State Agriculture, My Wabash Valley News on August 23, and Michigan Master Gardener Association on August 23.

Research Publication Under this Project:

1. Ahmed, M. Z., Dorado, C., von Ellenrieder, N., Quinn, N. F., Roda, A., Schoeller, E. N., McKenzie, C. L., Osborne, L., Diepenbrock, L. M. 2023. Development of a species-level field diagnostic kit for *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae), an invasive and regulatory pest in the United States. Journal of Applied Entomology, 00, 1–

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1. Diepenbrock, L. M., Ahmed, M. Z. 2020. First report of *Nipaecoccus viridis* (Hemiptera: Pseudococcidae) associated with citrus production in the United States. Journal of Integrated Pest Management, 7, 1–10.

2. Ahmed, M. Z., & Deeter, L. 2022. Rapid species-level hemolymph color test for all life stages of *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae), an invasive and regulatory pest in the United States. Journal of Applied Entomology, 00, 1–7.

3. Olabiyi, D., Middleton, E., Ahmed, M. Z., Osborne, L. S., McKenzie, C. L., & Diepenbrock, L. 2023. Hibiscus mealybug (Hemiptera: Pseudococcidae)—Biology, host plants, current management practices, and a field guide for North America. Journal of Integrated Pest Management, 14(1), 3.

Objective 2: Conducting hand-on training for nursery growers to demonstrate how this Field Diagnostic kit works. In order to efficiently share our findings, we organized a mealybug workshop under this project titled "Best Management Practices for Controlling Mealybugs" on April 25, to help others keep an eye on this new emerging pest in nurseries and ornamental landscapes. PI Dr. Quinn and Co-PIs Dr. Osbourne and Ahmed delivered presentations on outlook and upcoming research on diagnostics and management of Lebbeck mealybug. The purpose of the workshop was to train stakeholders how to use the field diagnostic kit in an effort to halt its further spread in Florida. Registration for this event was free. At this workshop, stakeholders were provided with diagnostic kits, field guide and instructions, complete with one-on-one walkthroughs of the testing process using diagnostic kits on live mealybugs. Approximately 70 people attended, representing a wide range of stakeholders, including extension agents, master gardeners, scouts, ornamental growers, students, and industry representatives. Only 10 out of about 70 people in audiences have seen Lebbeck mealybug before. Our presentations and hand-on trainings helped them see and compare it with other mealybug species for the first time. The recording of the session has been shared with UF/IFAS faculty and extension, allowing for continued education and benefit to stakeholders remotely. The diagnostic kit talk is also available online for others through the University of Florida website. We were invited to write a blog article by the University of Florida on April 20 to highlight our workshop. Overall, our workshop was featured in four media articles, including Morning AgClips on April 23, Griffin Fertilizer Company, Citrus Industry Magazine on April 24, and Floral Daily on May 2.

Additionally, we organized a symposium titled "Management of Invasive Mealybugs of the Southeastern US: Challenges and Opportunities" in the Southeastern Branch Meeting, Little Rock, Arkansas, on March 14 and presented our diagnostic kit in front of 8 researchers from the Southeast states. We also presented our diagnostic kit in front of 45 stakeholders, researchers, and students from Florida at the 2023 Florida Entomological Society meeting, Jupiter, Florida on August 2 and during Landscape Show 2023, Orlando, Florida on August 23 in front of about 70 stakeholders. This project was acknowledged at the end of each presentation.

Presentations Under this Project:

1. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for *Nipaecoccus viridis*. Booth Presentation, Citrus Insect, Mite, and Nematode Management Workshop, Citrus Research and Education Center, University of Florida, Lake Alfred, Florida, January 19, 2023.

2. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for *Nipaecoccus viridis*. Management of Invasive Mealybugs of the Southeastern US: Challenges and Opportunities Symposium, Southeastern Branch Meeting, Little Rock, Arkansas March 13–15.

3. Quinn, N.F. 2023. "Feasibility of classical biological control of Nipaecoccus viridis in Florida." Entomological Society of America Southeastern Branch Meeting. Little Rock, AR March 13-15.

4. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for Lebbeck mealybug, *Nipaecoccus viridis*. Florida Citrus Show, UF/IFAS IRREC and USDA ARS, Ft. Pierce, April 13, 2023 https://irrec.ifas.ufl.edu/media/irrecifasufledu/florida-citrus-show-/New-Diagnostic-Kit-for-Lebbeck-Mealybug.pdf

5. Osborne, L. 2023. Mealybugs: hibiscus or Lebbeck mealybug, an ornamental perspective. Mealybug Workshop, "Best Management Practices for Controlling Mealybugs," UF/IFAS IRREC and USDA ARS, Ft. Pierce, April 25, 2023

6. Quinn, N. 2023. Feasibility of classical biological control of Lebbeck mealybugs. Mealybug Workshop, "Best Management Practices for Controlling Mealybugs," UF/IFAS IRREC and USDA ARS, Ft. Pierce, April 25, 2023

7. Ahmed M. Z. 2023. Developing species-level diagnostic kit for Lebbeck mealybug, *Nipaecoccus viridis*. Mealybug Workshop, "Best Management Practices for Controlling Mealybugs," UF/IFAS IRREC and USDA ARS, Ft. Pierce, April 25, 2023

8. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for Lebbeck mealybug, *Nipaecoccus viridis*. Mealybug Workshop, "Best Management Practices for Controlling Mealybugs," UF/IFAS IRREC and USDA ARS, Ft. Pierce, April 25, 2023

9. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for *Nipaecoccus viridis*. Biological Control of Invasive Species in Florida Symposium. Florida Entomological Society, Jupiter, Florida, July 30-August 2, 2023

10. Quinn, N.F. 2023. "Feasibility of classical biological control of *Nipaecoccus viridis* in Florida." Biological Control of Invasive Species in Florida Symposium. Florida Entomological Society, Jupiter, Florida, July 30-August 2, 2023

11. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for *Nipaecoccus viridis*. Booth Presentation, Citrus Expo, Florida State Fairgrounds, Tempa, Florida, August 16, 2023

12. Ahmed, M. Z. 2023. Developing species-level diagnostic kit for *Nipaecoccus viridis*. The FNGLA Landscape Show 2023, Knowledge College. Orange County Convention Center, Orlando, Florida, August 23, 2023 https://www.thelandscapeshow.org/2023/Public/Content.aspx?ID=1542

SUMMARY

We recently found heavy infestations of Lebbeck mealybug for the first time from the residential ornamental landscape in Palm Beach County, Florida (Figure 4) on two common ornamental plant species, oleander and jatropha. This proliferation of Lebbeck mealybug outside of the agricultural setting further underscores the pest's ability to cause economic damage in a variety of environments. The development and availability of the field diagnostic kit will help others confirm its identity in nurseries to halt its spread in the ornamental landscapes. The kit is inexpensive to assemble and easy to use. It is also not copyrighted, meaning that it is freely available for use without a fee. Attendees of the workshop found the kit to be easy to use, and many took several kits home with them for future use. The informational aspects of the workshop were well-received and prompted robust discussion among attendees and presenters. Overall, this proposal was a success in that it delivered an immediately implementable diagnostic kits directly to end users (stakeholders). In the future, it could be used to tailor integrated pest management of mealybugs, allowing for the rapid identification of Lebbeck mealybug and subsequent implementation of effective treatments for Lebbeck mealybug when it is detected positively, which is very important given how quickly its populations can grow. Lebbeck mealybug and other mealybugs present difficult challenges to growers in Florida, but tools such as this are an important first step towards their effective management.

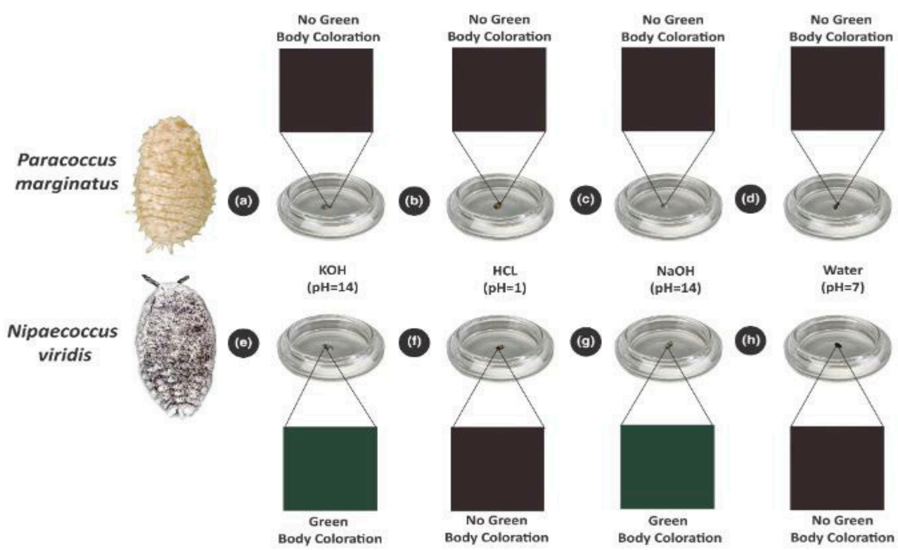


Figure 1. Hemolymph color tests for *Paracoccus marginatus* (as a negative control; a-d) and *Nipaecoccus viridis* (e-h) in 10% KPH (pH 14) (a,e), HCL (pH 1), NaOH (pH 14) (c,g) and deionized water (pH 7) (d,h). Modified from Ahmed et al. (2023).

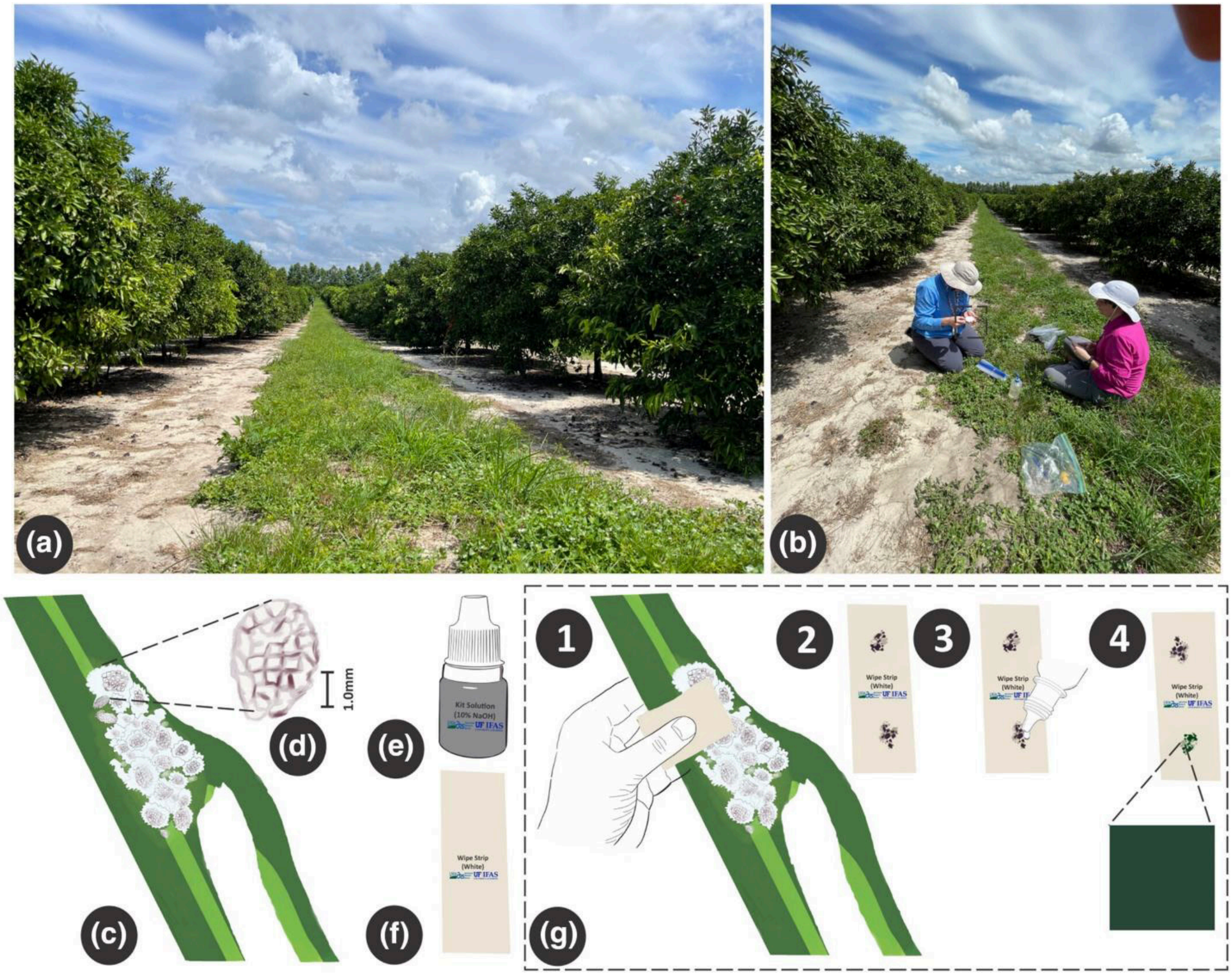


Figure 2. Field color test of Lebbeck mealybug was conducted in a field (a) by Drs. Ahmed and Quinn (b), by picking a branch with an infestation containing specimens (either adults or immatures) (c), selecting a specimen with little or no wax (d), taking a white plastic squeezable dropper with a cap (Wowlife Clear) filled with 5% Pure Lye® (NaOH) solution of pH 14 (e), and using a strip of white wipe of Wypall L40 (Kimberly-Clark Professional) in a dimension of 8″ × 3″ (f). The field color test was conducted in the following four steps (g): collecting a specimen with little or no wax with a strip and squashing it between the ends of the strip (1), observing the dark purple coloration on the strip in case of Lebbeck mealybug (2), adding a drop of 5% Pure Lye® (NaOH) solution on top of the dark purple coloration (3) and observing if green coloration appeared a few seconds after adding a drop of solution (4).

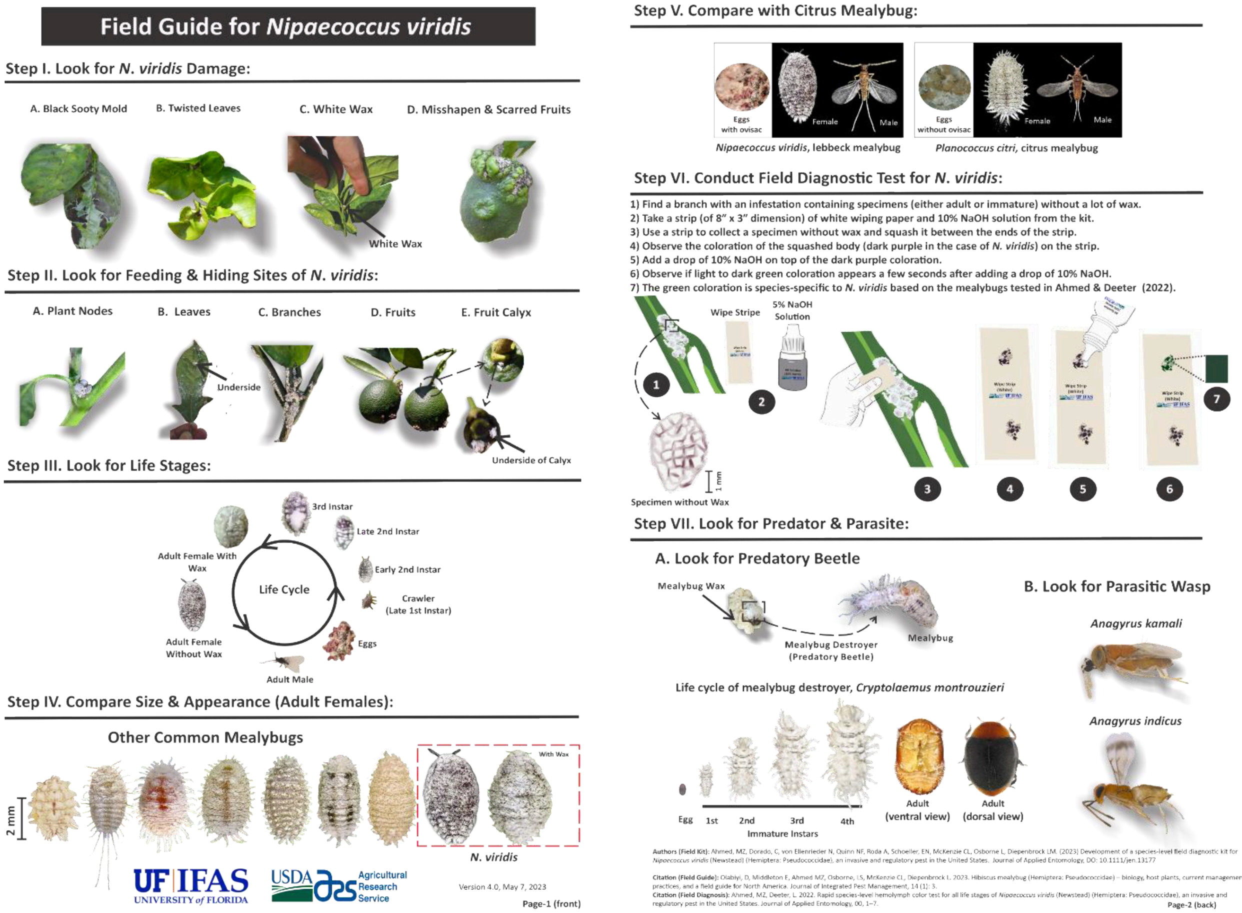


Figure 3. The demonstration and instructions of the field diagnostic kit (Step VI) in the field guide of Lebbeck mealybug (Ahmed et al. 2023).

Figure 4. Infestation of Lebbeck mealybug on oleander and jatropha in ornamental landscape, Palm Beach, Florida. a) Adult females with ovisacs co-infested with phantasma scale on jatropha (naked eye view). b) Clusters of adult females on oleander (naked eye view).

Evaluation of the Parasitoid *Catolaccus hunteri* as a Biocontrol Agent of the Hibiscus Bud Weevil

PI: **Alexandra Revynthi, Entomology & Nematology | Tropical REC**

ABSTRACT

Catolaccus hunteri (Hymenoptera: Pteromalidae) is a polyphagous ectoparasitoid known to target 17 species of *Curculionidae* and two species of *Bruchidae*. The hibiscus bud weevil (HBW) *Anthonomus testaceosquamosus* is an invasive species initially found in Mexico and currently expanding its range in Texas and Florida, where it has become a significant concern for ornamental crop production in southern Florida – a region where the industry is heavily reliant on hibiscus production. This research's goal was to evaluate the parasitoid *C. hunteri* as a biocontrol agent of HBW. We aimed at identifying the preferred HBW stage for parasitoid feeding and development as well as its optimum release rate. Two laboratory experiments, where all HBW developmental stages were offered to the parasitoid either exposed or concealed within a flower bud, were conducted. Results showed that the parasitoids prefer the first instar HBW larval, but they did not reproduce on any of the offered HBW stages. Subsequent laboratory experiments aiming to evaluate three release rates of HBW and parasitoid. Cages with 15 infested buds and 0, 1, 2 or 3 female parasitoids were set. Results showed that there was no difference in mortality caused by the different release rates. To evaluate these three rates under more natural conditions, a greenhouse experiment was conducted using female and male parasitoids. Hibiscus plants infested with the HBW received 0, 1, 2 or 3 parasitoid pairs. Mortality rates were not affected by the parasitoid release rate nor differed from the control. However, when only one pair was released the HBW mortality rate was higher in comparison to the other treatment. These results suggest that there might be a conflict between male and female parasitoids and that the presence of the former may interfere with the female performance. Although this study shows that there is potential for *C. hunteri* as a biocontrol agent of HFW more research is needed to estimate parasitism rates and population growth of this parasitoid. *Catolaccus hunteri* is expected to be commercially available in the US market in the future.

OBJECTIVES

Catolaccus hunteri (Hymenoptera: Pteromalidae) is a polyphagous ectoparasitoid known to target 17 species of *Curculionidae* and two species of *Bruchidae* (Cross and Mitchell 1969, Cross and Chesnut, 1971). Additionally, it has been identified as a parasitoid of some *Anthonomus* species (Coleoptera: Curculionidae), including *A. vestitus, A. grandis, A. eugenii, and A. macromalus* across South, Central and North America (Bárcenas et al. 1997, Berry 1947, Burks 1954, Cross and Mitchell 1969, Hunsberger and Pena 1997, Townsend 1912). The hibiscus bud weevil (HBW) *Anthonomus testaceosquamosus* is an invasive species initially found in Mexico and currently expanding its range in Texas and Florida, where it has become a significant concern for ornamental crop production in southern Florida – a region where the industry is heavily reliant on hibiscus production (Revynthi et al. 2022). Given the regulatory considerations in the management of this invasive pest and the predominant reliance on chemical pesticides of the ornamental industry, exploring alternatives to chemical pesticides becomes crucial in establishing a sustainable IPM approach. No information is available on the potential of *C. hunteri* as a biological control agent of the HBW.

The commercial use of *C. hunteri* against other *Anthonomus* species has been challenged by observations of low levels of parasitism, such as 42% of parasitized larvae of *A. grandis* after field releases (Cortez-Moncada 2004), parasitism ranging from 5% to a s much as 35% on *A. eugenii* larvae (Wilson 1986, Riley and Schuster 1992), and parasitism below 1% in the case of *A. macromalus* (Hunsberger and Peña 1997). However, observations have been also made in relation to its potential for suppressing pest injury, such as the reduction of pepper infested fruit after releasing the natural enemy under field conditions (Schuster 2007). The latter may not be necessarily caused by parasitism, but with host feeding and/or injury on host immature stages caused by female parasitoids that result on fewer adult weevils emerging (Schuster 2007). The latter warrants research in relation to the host suitability of the HBW developmental stages and the chances that the parasitoid can reduce pest infestation by either parasitizing, hosts feeding or injuring the concealed HBW larvae.

This research's goal was to evaluate the parasitoid *C. hunteri* as a biocontrol agent of HBW. This natural enemy can potentially provide control of the developing larvae in the hibiscus buds and complement other biological control tactics, that are also being investigated such as entomopathogenic fungi and bacteria and entomopathogenic nematodes. In this project we are addressing the following questions:

1. Which HBW developmental stage is the most appropriate for parasitoid control?
2. How is the performance of the parasitoid in the most preferred developmental stage?
3. Which is the best release rate for this biocontrol agent?

METHODS, RESULTS, AND CONCLUSIONS

Insect Colonies

The *C. hunteri* individuals were taken from a colony maintained under laboratory conditions (25 ± 2 °C, 60-70% RH and 12:12 photoperiod), using the cowpea weevil, *Callosobruchus maculatus* (Coleoptera: Bruchidae) as a host. Adult weevils were obtained from a colony maintained under growth chamber conditions using fresh flower buds (var. Painted Lady) as food and oviposition substrate. The weevil stock colony was held in a climate-controlled incubator (Percival I-36LL, Percival Geneva Scientific, Williams Bay, WI, USA) at 27 ± 1°C, 12:12 h L:D and 70 ± 10% RH.

<u>Objective 1: Identify the most appropriate HBW developmental stage for *C. hunteri*</u>

An experiment under laboratory conditions (27 ± 1°C, 12:12 h L:D and 60% RH) was performed using flower buds of 1, 2, 5, 8 and 14 days after being infested in cages, in a 1:1 weevil: bud ratio. These buds were later dissected, at the same time, in the search of eggs and 1st (L1), 2nd (L2), 3rd (L3) instar larvae, and pupae, respectively. Fifty individuals of each developmental stage (Egg, L1, L2, L3 and pupa) were selected and set in 10 groups (replicates) of 5 each (subsamples) on a plastic Petri dish (experimental unit), where individuals were compartmentalized to prevent cannibalism but open to interact with parasitoids (Fig 1). A pair of parasitoids (male and female) were released to each experimental unit for 24 hours. In these Petri dishes honey was offered ad libitum to adult parasitoids. Control treatments included the same number of subsamples and replicates but without parasitoids. Observations of mortality and parasitism were made 72 hours after parasitoid release considering that this is the time that HBW eggs take to eclosion (Revynthi et al. 2022).

Direct evidence of parasitism was observed only in two individuals where parasitoid eggs were laid on a third instar larva and a pupa, respectively (Fig 2), that later died, and no recovery of adult parasitoids was possible. Analysis of the proportion of dead individuals indicate that this variable was affected by treatment ($\chi 2 = 5.02$; df = 1; P = 0.024), however post-hoc tests only confirmed that mortality was significantly lower in the control for second instar larvae (Fig 3). Differences among stages were also evident ($\chi 2 = 94.53$; df = 4; P < 0.001), with first instar larvae dying in a higher proportion than any other developmental stage, the later probably due to neonates dying after three days without access to food, while mortality was the lowest on egg and the pupal stages. No interaction between treatment and stage was detected ($\chi 2 = 4.99$; df = 4; P = 0.287). As the mortality on the egg and pupal stages was the lowest, an additional analysis was performed excluding the egg and pupal stages, to compare only the three larval stages. In this additional analysis there was a confirmation that differences between the control and the parasitoid Petri dishes were only significant for the second instar larvae, indicating that this is probably the most targeted developmental stage by adult parasitoids if they were directly encountering these individuals.

<u>Objective 2: Evaluate the performance of the parasitoid in the most preferred HBW developmental stage</u>

The testing arenas developed in the previous experiment were devised to allow direct contact of the parasitoids with any of the individual HBW host stages, which it is distant from natural conditions under which parasitoids and hosts are expected to interact. HBW larvae are concealed within the flower bud and a parasitoid is required to parasitize and or kill through the flower bud tissues. Therefore, we developed an experiment under the same laboratory conditions described before and using flower buds of 1, 2, 5, 8 and 14 days after being infested in cages. These buds were assumed to have eggs and 1st, 2nd and 3rd instar larvae, and pupae, respectively (Revynthi et al. 2022). Fifty buds containing each developmental stage were selected and set in 10 groups (replicates) of 5 each (subsamples) on a plastic Petri dish (experimental unit) (Fig 4). A pair of parasitoids was released in each experimental unit for 24 hours. Control treatments included the same number of subsamples and replicates but without parasitoids. Observations of mortality and parasitism were made two weeks after parasitoid release, considering that this is the time that both host HBW individuals and *C. hunteri* take to complete their development (Rodriguez-Leyva et al. 2000, Revynthi et al. 2022).

Direct evidence of parasitism was not observed, but mortality was affected by treatment ($\chi 2 = 10.55$; df = 1; P = 0.001), and by host developmental stage ($\chi 2 = 30.40$; df = 4; P < 0.001), with a significant interaction between treatment and the developmental stage ($\chi 2 = 32.99$; df = 4; P < 0.001) (Fig 5). Mortality was higher on first instar hosts exposed to the parasitoids (58%), being the only case in which there was a significant difference in comparison to the mortality of the control (7%). Greater level of mortality at more advanced instars in the control treatments could be associated with a prevalence of cannibalism within the flower buds (Revynthi et al. 2022). As developmental stages are concealed within the flower buds, we hypothesize that the mortality caused by the parasitoid was not due to host feeding but associated with injury caused by females by piercing in the bud's tissues and laying eggs. However, we are not able to exclude any feeding by parasitoid's larvae, although no observation of parasitoid larva was available.

<u>Objective 3: Identify the optimum release rate for the parasitoid</u>

To address our third and final question in relation to estimating the best release rate of the parasitoid a pilot experiment was developed, using 30.5 x 30.5 x 30.5 cm mesh cages as replicates, as a preparation to set a trial under greenhouse conditions. A cage (replicate) containing 15 infested buds (proxy for an individual plant) was left in contact with different rates of parasitoid females (0, 1, 2 and 3 females), leaving a ratio of 1:1 male to female. Parasitoids were allowed to stay in the cages for 4 days, where sugar solution and pollen were provided ad libitum. To secure that the buds had L1 and L2 larvae, they were infested 10 days prior to the start of the experiment. Eight HBW females and two males were released in each cage to infest the buds. The adult weevils were allowed to feed and oviposit for three days after which they were removed. Each treatment was replicated four times. Observations were be made one week after the parasitoids were removed, collecting 5 buds, and observing the number of live larvae and number of parasitized larvae. The other ten buds were left for an additional week, time after which we score parasitism, and mortality of HBW individuals. Preliminary observations after one week of parasitoids exposure evidenced only one parasitized host in the treatment where one female per cage was released. After two weeks, parasitism was observed on two individuals of the treatments where two and three females were released, respectively.

The analysis of mortality indicates treatment effects ($\chi 2 = 17.25$; df = 3; $P < 0.001$), with host mortality being significantly lower in the control treatment than that of the different female rates, that did not differ from each other (Fig 6). This pilot showed the potential of testing the rates of 1, 2 and 3 females per each 15 buds, which is a proxy for the average number of active growing buds that are usually present in one plant.

Subsequently, hibiscus plants were individually placed in cages under greenhouse conditions and were infested with two pairs of HBW adults. Three days after the infestation a release of different rates of *C. hunteri* individuals was made per plant, including one parasitoid couple, two couples, and three couples per plant. Four plants (replicate) were used per treatment. Plants where no releases of the parasitoids were made served as a control. Two weeks after the release of the parasitoids all buds were collected from each plant and the number of larvae, pupae and adults were counted by dissecting the collected buds.

No observations of parasitism were made in any of the rates tested, and even though the number of surviving individuals (larvae, pupae, and adults) per infested bud tended to be lower when one couple was released per plant, there were not statistical differences among means ($F = 2.37$; df = 3, 12; $P = 0.121$) neither any rate-dependent trends (Fig 7).

There was a negative effect of the number of males available per cage as the proportion of mortality tended to be greater when one couple was released per plant (Fig 8). No statical differences were found among treatment means ($F = 1.57$; df = 3, 12; $P = 0.247$), however, additional replicates of this experiment could help in demonstrating higher proportion of mortality in plants where one couple of the parasitoids is released. Also, additional experiments could also consider maintaining the number of males to the minimum or even exclude them from the cages, to avoid females undergoing interruptions of their oviposition/killing behavior by persistent males.

Figure 1. Plastic Petri dish arena (replicate) where five host HBW individuals (in this case pupae) are offered to a couple of *C. hunteri* for 24 hours. The compartments are devised to impede cannibalism mostly among larvae, while allowing contact with parasitoids.

Figure 2. Pupae of HBW with two eggs of *C. hunteri* at the lower dorsal. Even though cases of parasitized larvae were scarce, a few instances demonstrated that HBW is a suitable host.

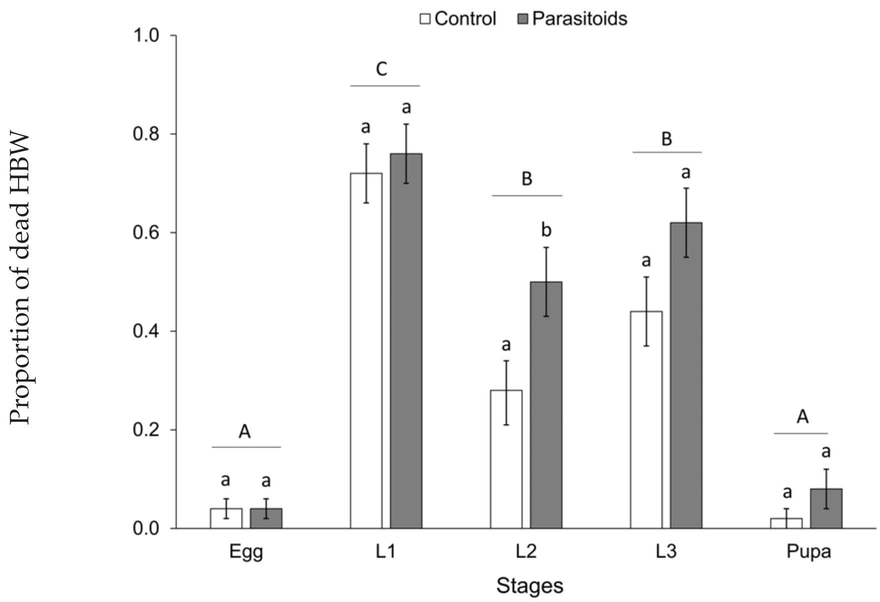


Figure 3. Mean mortality (± SEM) of HBW individuals of all developmental stages after direct contact with a couple of *C. hunteri* parasitoids for 24 hours. Observations were made 72 hours after parasitoid release. Different upper-case letters indicate different means between stages, while lower-case letters indicate different means between treatments within the same developmental stage (Tukey adjustment, $\alpha = 0.05$).

Figure 4. Plastic Petri dish arena (replicate) where five hibiscus flower buds containing different developmental stages of HBW individuals (in this case L2) were offered to a couple of *C. hunteri* for 24 hours.

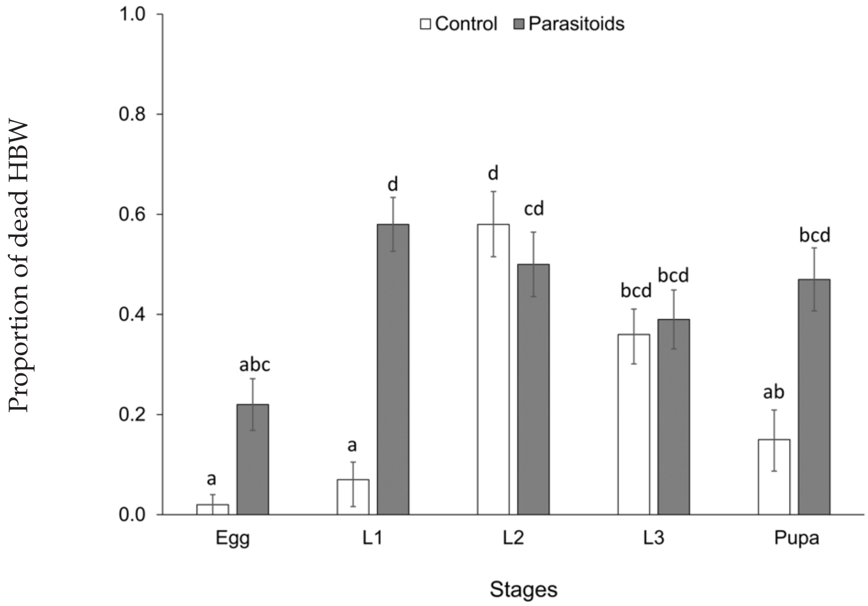


Figure 5. Mean mortality (± SEM) of HBW after contact with a couple of *C. hunteri* parasitoids for 24 hours with concealed individuals of several developmental stages. Observations were made two weeks after parasitoid release. Lower-case letters indicate different means between treatments and developmental stage combinations (Tukey adjustment, $\alpha = 0.05$).

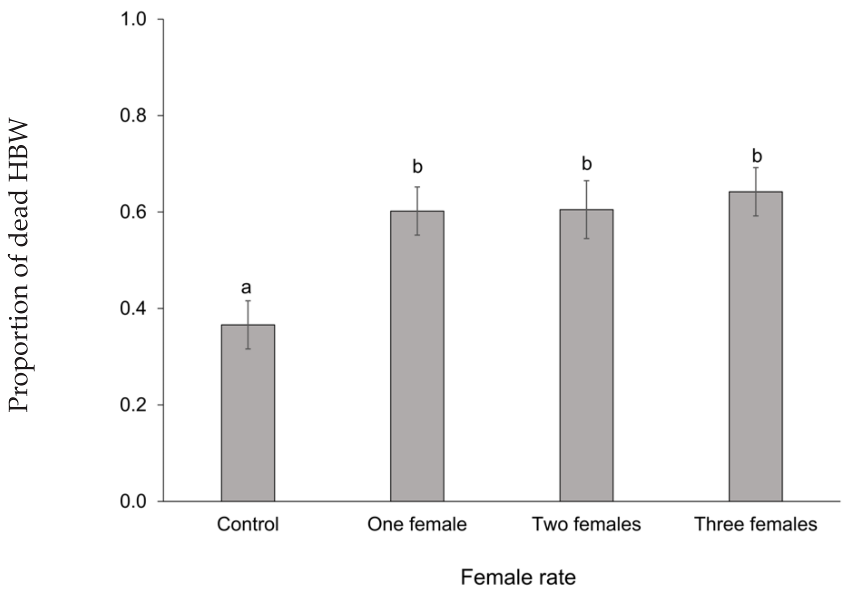


Figure 6. Mean mortality (± SEM) of HBW after contact with different couple rates of *C. hunteri* parasitoids for 4 days with 15 buds containing host individuals between second and third instar. Observations were made two after setting the experiment. Lower-case letters indicate different means between treatments (Tukey adjustment, $\alpha = 0.05$).

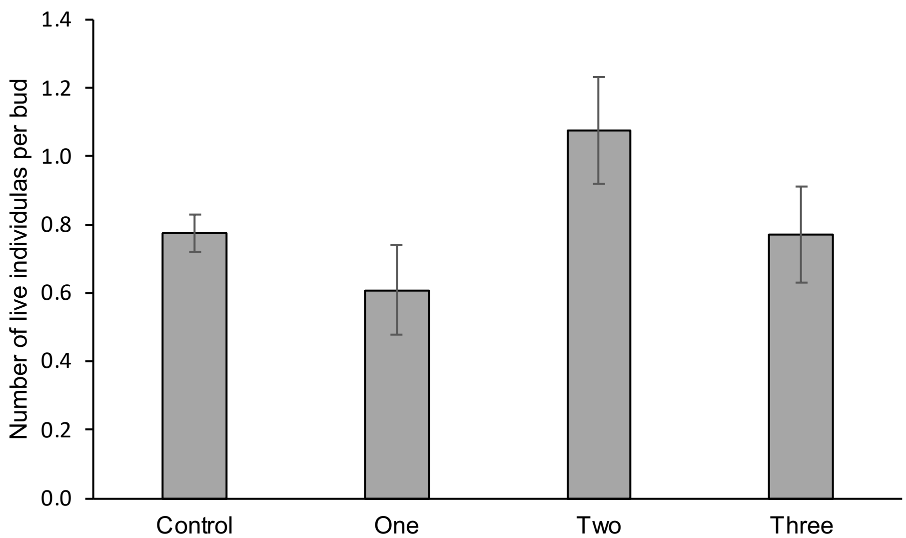


Figure 7. Mean number of live individuals per infested bud (± SEM) of HBW (larvae, pupae, and adults) two weeks after the release of one, two and three couples per plant of the parasitoid *Catolaccus hunteri*.

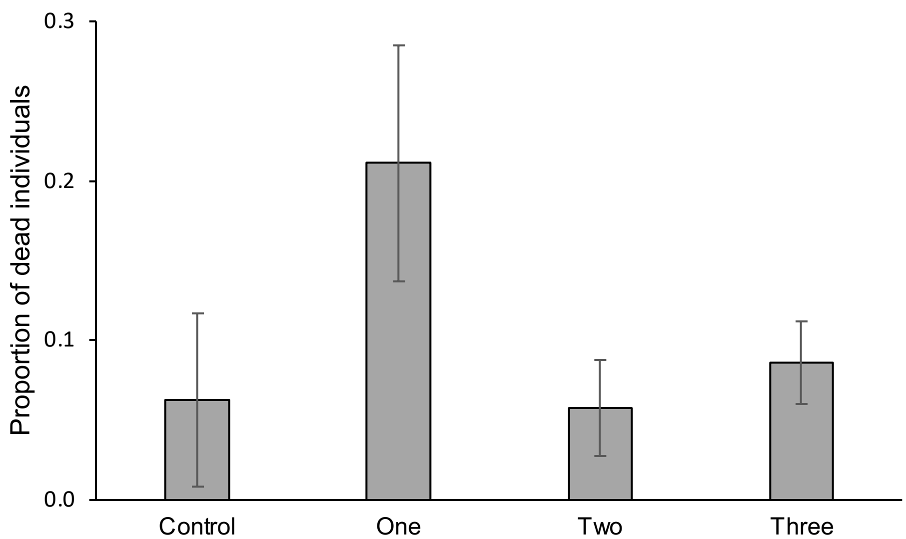


Figure 8. Mean proportion of dead individuals per treatment (± SEM) of hibiscus bud weevil (larvae, pupae, and adults) two weeks after the release of one, two and three couples per plant of the parasitoid *Catolaccus hunteri*.

List of FNGLA Funded Projects Since 2005-06

2005-2006

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Statewide Expansion of South Florida BMP Effort
William Crow	Entomology & Nematology	Gainesville Campus	Biological Control of Root-Knot Nematodes on Woody Ornamentals
Forrest Howard	Environmental Horticulture	Ft. Lauderdale REC	Biology and Management of West Indies Mahogany Scale, Conchaspis cordiae (Hemiptera: Conchaspididae)
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Genetic Sterilization of Lantana
David Clark	Environmental Horticulture	Gainesville Campus	Development of New Coleus Cultivars for Better Foliage Color Stability and Use as Groundcovers
James Gibson	Environmental Horticulture	West Florida REC	Consumer Purchase Patterns in Florida (3-year study) Study 1 (completed): The Impact of In-House Displays on Impulse Buying Behavior; Study 2 (ongoing project): The Impact of Display Gardens on Identifying Consumer Needs, Trends, and Preferences; Study 3: (Proposed): Developing Employee Plant Knowledge to Effectively Educate Consumers and Increase Sales

2006-2007

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
James Barrett	Environmental Horticulture	Gainesville Campus	Evaluating Flowering Annuals and Herbaceous Perennials for the Florida Climate
Monica Elliott	Plant Pathology	Ft. Lauderdale REC	Determine the etiological agent for a new disease affecting Syagrus romanzoffiana (queen palm) in landscapes and nurseries
Kati Migliaccio	Agricultural & Biological Engineering	Tropical REC	Designing Irrigation BMPs Considering Capillary Rise for Production Cost Savings
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Fertilization Effects on Water Requirements of Container Grown Ornamentals during Establishment in the Landscape
Wagner Vendrame	Environmental Horticulture	Tropical REC	Potential Horticultural and Disease Management Benefits of Silicon Fertilization of Potted Orchids
Tom Yeager	Environmental Horticulture	Gainesville Campus	Expanded BMP Education

2007-2008

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Organic Matter and Irrigation Frequency Effects During Shrub Establishment
Tom Yeager	Environmental Horticulture	Gainesville Campus	BMP Workshops for Field-Grown Plant Producers
Michael Dukes	Agricultural & Biological Engineering	Gainesville Campus	Development of Programming Recommendations for Smart Irrigation Controllers
Gurpal Toor	Soil & Water Sciences	Gulf Coast REC	Characterization of Organic Compounds in Nursery Reclaimed Water
Monica Elliot	Plant Pathology	Ft. Lauderdale REC	Fusarium Decline of Palms: Pathogen, Hosts, Diagnosis and Control
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Toward Sterilizing Nandina: Inducing Tetraploids for Development of Sterile, Non-Invasive Triploid Nandina
Francisco Escobedo	School of Forest Resources & Conservation	Gainesville Campus	The Benefits of Florida's Urban Forests on Environmental Quality

2008-2009

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Richard Beeson	Environmental Horticulture	Mid-Florida REC	Commercial Evaluation of Automated Irrigation Control for Overhead Irrigation Based on Daily Weather
Geoffrey Denny	Environmental Horticulture	Gulf Coast REC	Validation of Nitrogen Fertilizer Recommendations for Florida Landscape Plants
Michael Dukes	Agricultural & Biological Engineering	Gainesville Campus	Irrigation Controller Programming Guidelines by Multimedia Methods
Paul Fisher	Environmental Horticulture	Gainesville Campus	Onsite Monitoring of Water Treatment Technologies in Recycled Irrigation Water for Florida Nurseries
Paul Monaghan	Agricultural & Biological Engineering	Gainesville Campus	Using Community Based Social Marketing to Evaluate Homeowner Attitudes Towards Florida Friendly Waterfront Landscapes
Brian Pearson	Environmental Horticulture	Mid-Florida REC	Quantification of Stormwater Nutrient Runoff in the Environment
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Effects of Organic Matter and Tillage on Plant Establishment and Nutrient Losses in an Residential Landscape
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Production Strategies for Water Savings in the Landscape

2009-2010

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Jianjun Chen	Environmental Horticulture	Mid-Florida REC	Improving the Quality of Recycled-Irrigation Water by Minimizing Algal Density Using Plant-Friendly Chemicals
Geoffrey Denny	Environmental Horticulture	Gulf Coast REC	Validation of Nitrogen Fertilizer Recommendations for Florida Landscape Plants
Rosanna Freyre	Environmental Horticulture	Gainesville Campus	Breeding of Sterile and Non-Invasive Ruellia Cultivars
Jason Keith Kruse	Environmental Horticulture	Gainesville Campus	Determining Required Width of Unfertilized Buffer Strips to Limit Fertilizer Movement Into SurfaceWater Bodies
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Evaluation of Soil Physical and Chemical Properties at Newly Constructed Residential Home Sites to Improve Plant Growth and Environmental Quality
Tom Yeager	Environmental Horticulture	Gainesville Campus	Developing a BMP Manual for Field-Grown Plant Producers
Tom Yeager	Environmental Horticulture	Gainesville Campus	Automatic Irrigation Control Based Upon Plant Need

2010-2011

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
David Clark	Environmental Horticulture	Gainesville Campus	The University of Florida Sensory Gardens
Catharine Mannion	Entomology & Nematology	Tropical REC	Impact of Insecticides and Method of Application on Natural Enemies in the Landscape
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Use of Reclaimed Waste Water to Grow Greenhouse Ornamental Plants
Kati Migliaccio	Agricultural & Biological Engineering	Tropical REC	Interactive Tool for Improving Water Management in Landscapes
Robert Stamps	Environmental Horticulture	Mid-Florida REC	Evaluation and Identification of Effective and Safe Herbicides, Herbicide Formulations and Application Rates for Landscape and Nursery Use
Tom Yeager	Environmental Horticulture	Gainesville Campus	Development of an Economic Decision Support Tool for Container Nursery Management
Tom Yeager	Environmental Horticulture	Gainesville Campus	Enhanced Decision Capabilities for Irrigation of Container Plants

2011-2012

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Gul Shad Ali	Plant Pathology	Mid-Florida REC	Development of a Rapid and Sensitive Diagnostic Kit for Ornamental Plant Pathogens Using Loop-Mediated Isothermal Amplification and Recombinase Polymerase Amplification
Erin Alvarez	Environmental Horticulture	Gainesville Campus	The University of Florida Sensory Gardens
Eileen Buss	Entomology & Nematology	Gainesville Campus	Gall-Maker Management in Live Oak Nurseries
Aaron Palmateer	Plant Pathology	Tropical REC	Management of High Consequence Bacterial
Amy Shober	Soil & Water Sciences	Gulf Coast REC	Evaluation of Nutrient Leaching From Mixed Landscapes
Tom Yeager	Environmental Horticulture	Gainesville Campus	Continued Development of an Economic Decision Support Tool for Container Nursery Management

2012-2013

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Tom Yeager	Environmental Horticulture	Gainesville Campus	Evaluating the Effect of Plant Species on Water Usage to Improve Container Nursery Irrigation BMPs
James P. Cuda	Entomology & Nematology	Gainesville Campus	Mass Rearing of the South American Psyllid Calophya terebinthifolii (Hemiptera: Calophyidae), a Candidate Biological Control Agent for Brazilian Peppertree
Gary Knox	Environmental Horticulture	North Florida REC	New Crapemrytle Cultivars for the Southeastern U.S. An Extensive Evaluation of Field Resistances to Fungal, Bacterial and Abiotic Disorders and Plant and Flower Characteristics
Tesfamariam Mengistu	Entomology & Nematology	Gainesville Campus	Development of a New Molecular Method to Detect Major Root-Knot Nematodes (Meloidogyne spp.) Occurring in Florida Nurseries
Gul Shad Ali	Plant Pathology	Mid-Florida REC	Implementation and Field Testing of a Rapid and Sensitive Diaignostic Kit for Ornamental Plant Pathogens Using Loop-Mediated Isothermal Amplification Integrated with Lateral Flow Devices
Monica Elliott	Plant Pathology	Ft. Lauderdale REC	Fungicide Movement, Distribution and Persistence in Palms
Robert Stamps	Environmental Horticulture	Mid-Florida REC	Development of Control and Eradication Methods for a Weed Posing a Nursery Quarantine Risk and a Weed Posing Human Health and Environmental Risks
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	Developing Superior Native Plant Varieties for the Florida Nursery and Landscape Industry

2013-2014

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Steven Arthurs	Entomology & Nematology	Mid-Florida REC	Processed Coffee Grounds to Manage Cycad Aulacaspis Scale in Landscapes
Jianjun Chen	Environmental Horticulture	Mid-Florida REC	Developing Color-Leaved Ficus Plants Through Biotechnology Approaches
Huangjun Lu	Horticultural Sciences	Everglades REC	Enhancing St. Augustinegrass for Drought Tolerance
Paul Monaghan	Agricultural & Biological Engineering	Gainesville Campus	Increasing Tree Sales and Survivability in Urban Areas Community Tree Stewardship Programs
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Determination of Salt Tolerance of Container Grown Ornamental Shrubs
Quisto Settle	Agricultural & Biological Engineering	IFAS Center for Public Issues Education	Understanding Public Opinion of Issues Facing the Nursery and Landscape Industry in Florida
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Enhancing Irrigation in Container Nurseries Using Mobile Device App
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Develop Video to Promote BMPs

2014-2015

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Bala Rathinasabapathi	Horticultural Sciences	Gainesville Campus	Toward a Novel Biopesticide to Control Fall Armyworms: Beebalm Phytochemicals
Tom Yeager	Environmental Horticulture	Gainesville Campus	A Mobile Device App for Enhancing Irrigation in Container Nurseries
Aaron Palmateer	Plant Pathology	Tropical REC	Using Plant Diagnoistic Reports as a Tool for Preventative Disease Management in Florida Nurseries and Landscapes
Ronald Cave	Entomology & Nematology	Indian River REC	Biological Control of Green Croton Scale on Ornamental Plants
Stephen Marble	Environmental Horticulture	Mid-Florida REC	Increasing the Accuracy and Effectiveness of Herbicide Applications in Florida Nurseries
Mathews Paret	Plant Pathology	North Florida REC	Rose Mosaic: Management of Destructive Rose Virus Complex Using Early Detection and Novel IPM Strategies
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Weed Management Options for Tropical Ornamentals
Erica Goss	Plant Pathology	Gainesville Campus	New Method to Detect Hybrid Phytophthora in Nursery Production
Catharine Mannion	Entomology & Nematology	Tropical REC	Contributing Factors in Ficus benjamina Decline

2015-2016

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Mace Bauer	Horticultural Sciences	Gainesville Campus	Improve Environment and Resource Management
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Weed Management Options for Tropical Ornamentals
Paul Fisher	Environmental Horticulture	Gainesville Campus	Delivering Adequate Oxygen for Rooting of Plant Cuttings
Paul Fisher	Environmental Horticulture	Gainesville Campus	Lowcost and Automated Sensorbased Technology for Improving Irrigation Strategies
Stephen Marble	Environmental Horticulture	Mid-Florida REC	Determining the Impact of Metsulfuron a Turf Herbicide on Growth and Establishment of Ornamental Trees and Shrubs in Florida's Landscapes
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	Varying Leaching Fractions and Waste Water Blends to Grow Containerized Foliage Plants
Bart Schutzman	Environmental Horticulture	Gainesville Campus	Expansion and Enhancement of the Gardens at Fifield for Research, Teaching and Extension
Tripti Vashisth	Horticultural Sciences	Citrus REC	Evaluate the Use of Plant Growth Regulators and Different Growing Media to Accelerate the Rate of Germination and Growth in Citrus Rootstock Seedlings and Budded Trees
Tom Yeager	Environmental Horticulture	Gainesville Campus	Using Leaching Fraction to Achieve Appropriate Irrigation Application Amounts

2016-2017

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Brian Bahder	Entomology & Nematology	Ft. Lauderdale REC	Evaluation of Insects in Areas Impacted by Texas Phoenix Palm Decline for Their Potential as Vectors
Nathan Boyd	Horticultural Sciences	Gulf Coast REC	Preemergence Herbicides for Weed Control in Allamanda,Bird of Paradise, Firebush and Hibiscus
Adam Dale	Entomology and Nematology	Gainesville Campus	Novel Cultural Strategies for Managing Insect Pests of St. Agustinegrass
Paul Fisher	Environmental Horticulture	Gainesville Campus	Remediating Agrichemicals from Irrigation Water Using an Activated Carbon Filter
Rosanna Freyre	Environmental Horticulture	Gainesville Campus	Breeding Sterile Dwarf Mexican Petunia (Ruellia Simplex) at the University of Florida
Catharine Mannion	Entomology and Nematology	Tropical REC	Managing Ficus Whitefly Without Pesticides
S. Chris Marble	Environmental Horticulture	Gainesville Campus	Impact of Herbicide Application Carrier Volume on Weed Control in the Absence of Rainfall or Irrigation for Activiation
Xavier Martini	Entomology and Nematology	North Florida REC	Investigating Potential Alternative Vectors and Reservoirs of Rose Rosette Virus in the Florida Panhandle
Bryan Unruh	Environmental Horticulture	West Florida REC	A Mobile Web Application for Geolocating Fertilizer Ordinance Jurisdictions

2017-2018

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Charles Guy	Environmental Horticulture	Gainesville Campus	Assessing Human Health Benefits of Gardening
Raymond Odeh	Environmental Horticulture	Gainesville Campus	
Allan Bacon	Soil and Water Science	Gainesville Campus	Long-term Recovery of Compacted Residential Soils
Eben Broadbent	Forest Resources and Conservation	Gainesville Campus	
Adam Dale	Entomology and Nematology	Gainesville Campus	Investigating the Causal Agent of Bud Galls on Florida Ornamental Plants
Gul Shad Ali	Plant Pathology	Mid-Florida REC	
Erin Harlow	Duval County Extension	IFAS Extension	
Rhuanito Ferrarezi	Horticultural Sciences	Indian River REC	Accelerated Production of Citrus Nursery Trees Using Automated Ebbandflow Subirrigation
Basil Iannone	Forest Resources and Conservation	Gainesville Campus	Planting Stormwater Ponds: Determining the Benefits and Best Management Practices for Ornamental Plants in an Underutilized Portion of Residential Landscapes
Michelle Atkinson	Manatee County Extension	IFAS Extension	
Mary Lusk	Soil and Water Science	Gulf Coast REC	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Redefining Irrigation Permit Allocations for Nurseries
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Developing dPCR for Detecting Phytoplasmas in Palms
Heqiang "Alfred" Huo	Environmental Horticulture	Mid-Florida REC	Development of Genetically Engineered Banker Plants for Biological Control of Whiteflies in Greenhouses
Lance Osborne	Entomology and Nematology	Mid-Florida REC	
H. Dail Laughinghouse	Agronomy	Ft. Lauderdale REC	Developing Effective Management Options for *Nostoc* spp. in Florida Nurseries
Chris Marble	Environmental Horticulture	Mid-Florida REC	
David Berthold	(No Unit Affiliation)	Ft. Lauderdale REC	
Mathews Paret	Plant Pathology	North Florida REC	Recent Widespread Damage of Commercial and Landscape Roses In Florida To Crown Gall Disease: Characterizing the Bacterial Strains and Establishing Management Strategies
Gary Knox	Environmental Horticulture	North Florida REC	

2018-2019

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Andrew Koeser	Environmental Horticulture	Gulf Coast REC	Determining Root Space Requirements for Florida Street Trees
Deb Hilbert	Environmental Horticulture	Gulf Coast REC	
Heidi Radunovich	Family, Youth and Community Sciences	Gainesville Campus	Identifying the Impacts of Opioids on Florida Nursery, Growers and Landscapers
Christa Court	Food and Resource Economics	Gainesville Campus	
Heqiang "Alfred" Huo	Environmental Horticulture	Mid-Florida REC	Development of Salinity Tolerant Petunia Through CRISPR/Cas9 GeneEditing
Linhchi Nguyen	Environmental Horticulture	Mid-Florida REC	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Use of Reclaimed Water in Production Nurseries
Shawn Steed	Hillsborough County Extension	IFAS Extension	
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Evaluating vector potential of Haplaxius crudus and Idioderma virescens
Thomas Chouvenc	Entomology and Nematology	Ft. Lauderdale REC	Measuring the Impact of a New Invasive Ant Species (Plagiolepis alluaudi) on Plant Feeding Insects in South Florida Nurseries
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	
Andrea Lucky	Entomology and Nematology	Gainesville Campus	
Chris Marble	Environmental Horticulture	Mid-Florida REC	Improving Nursery Weed Control by Choosing Herbicides Based on Application Timing Flexibility and Formulation
Chris Marble	Environmental Horticulture	Mid-Florida REC	Developing Postemergence Weed Control Strategies for Nonturf Groundcovers in Florida
Sandra Wilson	Environmental Horticulture	Gainesville Campus	Introduction of New Native Plants to Florida's Green Industry
Carlee Steppe	Environmental Horticulture	Gainesville Campus	

2019-2020

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Andrew K. Koeser	Environmental Horticulture	Gulf Coast REC	Tree Preservation Ordinances in the State of Florida – How does Policy Impact Canopy Coverage?
Deborah R. Hilbert	Environmental Horticulture	Gulf Coast REC	
Drew C. McLean	Environmental Horticulture	Gulf Coast REC	
Alexander J. Reisinger	Soil and Water Sciences	Gainesville Campus	Quantifying Nitrogen Leaching from Residential Soils in Florida
Eban Bean	Agricultural and Biological Engineering	Gainesville Campus	
Mark Clark	Soil and Water Sciences	Gainesville Campus	
Tom Yeager	Environmental Horticulture	Gainesville Campus	Automated Rain Gauge Device to Monitor Container Drainage for Irrigation Management
Jeff Million	Environmental Horticulture	Gainesville Campus	
Laura Warner	Agricultural Education and Communication	Gainesville Campus	Environmentally Friendly Landscaping: Addressing a Need for the Communications Research
Michael Dukes	Agricultural and Biological Engineering	Gainesville Campus	
Esen Momol	Center for Landscape Conservation & Ecology	Gainesville Campus	
Eban Bean	Agricultural and Biological Engineering	Gainesville Campus	Optimizing Soil Amendment Characteristics for Improving Environmental and Resource Sustainability
Michael Dukes	Agricultural and Biological Engineering	Gainesville Campus	
Wagner Vendrame	Environmental Horticulture	Tropical REC	Pilot Study on Management Strategies of Hibiscus Bud Weevil
Catharine Mannion	Entomology and Nematology	Tropical REC	
Romina Gazis	Plant Pathology	Tropical REC	
Adam G. Dale	Entomology and Nematology	Gainesville Campus	Determining the Effects of St. Augustinegrass Cultivar Diversity on Belowground Ecosystem Processes
Dorota Porazinska	Entomology and Nematology	Gainesville Campus	
Xavier Martini	Entomology and Nematology	North Florida REC	Survey of the Invasive Mite *Phyllocoptes Fructiphilus* Rose Rosette Virus (RRV) and of its Predatory Mites in Northern Florida
Austin N. Fife	Entomology and Nematology	North Florida REC	
Catharine Mannion	Entomology and Nematology	Tropical REC	Hibiscus Bud Weevil – A New Threat to Hibiscus Production
William Schall	IFAS Extension	Tropical REC	
Alfred Huo	Environmental Horticulture	Mid-Florida REC	Effect of Carbon and SiO2 Nanoparticles on Rooting and Growth of Different Ornamental Plants
Roger Kjelgren	Environmental Horticulture	Mid-Florida REC	

2020-2021

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Mysha Clarke	School of Forest, Fisheries, and Geomatics Sciences	Gainesville Campus	The role of gardening activities on resilience quality of life (especially during the COVID-19 pandemic)
Andrew Koeser	Environmental Horticulture	Gulf Coast REC	Determining Minimum Planting Widths for the Small-Stature Trees in Compact Developments
Deb Hilbert	Environmental Horticulture	Gulf Coast REC	
Drew McLean	Environmental Horticulture	Gulf Coast REC	
Marco Schiavon	Environmental Horticulture	Ft. Lauderdale REC	Construction of plots for long term evaluation of effects of effluent water on turfgrass
Bryan Unruh	Environmental Horticulture	West Florida REC	Establishment and Evaluation of Mixed Species Landscapes Comprising Perennial Grasses and Legumes
Ann Blount	Agronomy	North Florida REC	
Adam Dale	Entomology and Nematology	Gainesville Campus	
Thomas Yeager	Environmental Horticulture	Gainesville Campus	Reducing Nutrient Loss from Containers
Jeff Million	Environmental Horticulture	Gainesville Campus	
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Measuring degradation of insect and phytoplasma DNA on sticky traps
Adam Dale	Entomology and Nematology	Gainesville Campus	Developing methods for biodiversity-certified ornamental plant production
Jaret Daniels	Floridam Museum of Natural History	Gainesville Campus	
Chris Marble	Environmental Horticulture	Mid-Florida REC	Finding, Evaluating, and Fine-tuning Herbicide Alternatives to Glyphosate for the Florida Landscape Industry
Anthony Witcher	Tennessee State University		
Gary Vallad	Plant Pathology	Gulf Coast REC	Viburnum Foliar Disease Management; Downy Mildew & Cercospora Leaf Spot
Shawn Steed	Extension Agent III	Hillsborough City	
Fernando Alferez	Horticultural Sciences	Southwest Florida REC	Improving seed production and availability of major citrus rootstocks by determining seed viability during maturation and storage
Manjul Dutt	Horticultural Sciences	Citrus REC	

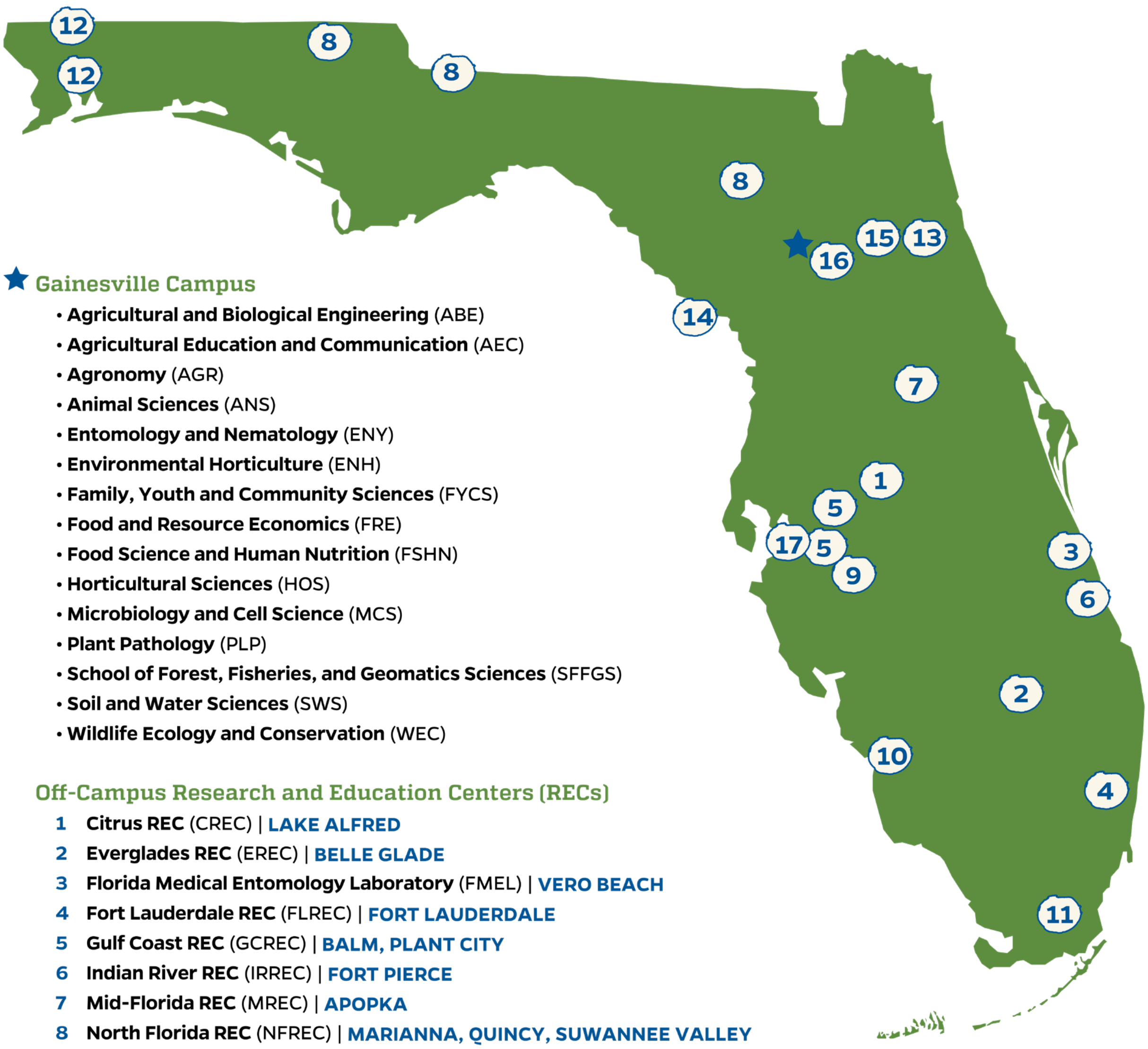
2021-2022

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Basil Iannone	Forest, Fisheries & Geomatics Sciences	Main Campus	How does plant diversity, vegetation structure, and management contribute to ecosystem services in residential landscaping?
Jesse Jones	Forest, Fisheries & Geomatics Sciences	Main Campus	
Brian Bahder	Entomology and Nematology	Ft. Lauderdale REC	Assessment of insecticides for control of Haplaxius crudus, the vector of lethal bronzing
De-Fen Mou	Entomology and Nematology	Ft. Lauderdale REC	
Braham Dhillon	Plant Pathology	Ft. Lauderdale REC	Detecting overlap of pathogen presence and trunk rot in palms
Adam Dale	Entomology & Nematology	Main Campus	Integrating Pest and Pollinator Management Strategies for Ornamental Plant Production
Jaret Daniels	Florida Museum of Natural History	Main Campus	
Bernadette Mach	Entomology & Nematology	Main Campus	
Ramdas Kanissery	Horticultural Sciences	Southwest Florida REC	"Place it and forget it" - Super absorbent medium for long-term weed suppression and plant-safe herbicide placement in nursery production
Stephen "Chris" Marble	Environmental Horticulture	Mid-Florida REC	Finding, Evaluating, and Fine-tuning Herbicide Alternatives to Glyphosate for the Florida Landscape Industry: PART II
Gary Vallad	Plant Pathology	Gulf Coast REC	Viburnum Foliar Disease Management: Disease mitigation during plant propagation
Shawn Steed	Environmental Horticulture	UF/IFAS Extension	
Wael Elwakil	Hillsborough County Extension	UF/IFAS Extension	
Wagner Vendrame	Environmental Horticulture	Main Campus	Improved Foliage Production Using Micropropagation - The Monstera Model
Jianping Wang	Agronomy	Main Campus	Developing a rapid molecular method to assess sugarcane mosaic virus (SCMV) load in turfgrass breeding materials
Kevin Kenworthy	Agronomy	Main Campus	
Philip Harmon	Plant Pathology	Main Campus	

2022-2023

PI/Co-PI NAME	HOME UNIT	LOCATION	TITLE
Brooks Parrish	Environmental Horticulture	Gulf Coast REC	Developing Sterile, Non-invasive Porterweed for the Florida Nursery and Landscape Industry and its Consumers
Zhanao Deng	Environmental Horticulture	Gulf Coast REC	
Sandra Wilson	Environmental Horticulture	Main Campus	
Jianping Wang	Agronomy	Main Campus	Detecting Genetic Variation of Sugarcane Mosaic Virus (SCMV) in St. Augustinegrass Cultivars
Camila Sanchez	Agronomy	Main Campus	
Paul Fisher	Environmental Horticulture	Main Campus	Next Level Young Plant Environmental Control
Rachel Mallinger	Entomology & Nematology	Main Campus	Developing Water-efficient Pollinator Plants for Florida
Xavier Martini	Entomology & Nematology	North Florida REC - Quincy	
Mica McMillan	Environmental Horticulture	Ft. Lauderdale REC	Palm Nutrition Injection - Does it Work and For How Long?
Kimberly Moore	Environmental Horticulture	Ft. Lauderdale REC	
Adam Dale	Entomology & Nematology	Main Campus	Mitigating Risk and Developing More Efficient Management Tactics for Lethal Bronzing
Jacqueline Buenrostro	Entomology & Nematology	Main Campus	
Brian Bahder	Entomology & Nematology	Ft. Lauderdale REC	
Carrie Harmon	Plant Pathology	Main Campus	
Lance Osborne	Entomology & Nematology	Mid-Florida REC	Monitoring and Testing of Management Strategies for *Thrips parvispinus* (Karny) in Palm Beach County
Muhammad Ahmed	USDA Agricultural Research Service	Ft. Pierce	
Cindy McKenzie	USDA Agricultural Research Service	Ft. Pierce	
John Roberts	County Extension	Palm Beach County	
Nicole Quinn	Entomology & Nematology	Indian River REC	Implementation of Rapid Testing Kits in Commercial Nurseries to Distinguish Lebbeck Mealybug (*Nipaecoccus Viridis*) from Other Mealybugs in Florida
Muhammad Ahmed	USDA Agricultural Research Service	Ft. Pierce	
Lance Osborne	Entomology & Nematology	Mid-Florida REC	
Alexandra Revynthi	Entomology & Nematology	Tropical REC	Evaluation of the Parasitoid *Catolaccus hunteri* as a Biocontrol Agent of the Hibiscus Bud Weevil

UF/IFAS Research Units



★ Gainesville Campus

- **Agricultural and Biological Engineering** (ABE)
- **Agricultural Education and Communication** (AEC)
- **Agronomy** (AGR)
- **Animal Sciences** (ANS)
- **Entomology and Nematology** (ENY)
- **Environmental Horticulture** (ENH)
- **Family, Youth and Community Sciences** (FYCS)
- **Food and Resource Economics** (FRE)
- **Food Science and Human Nutrition** (FSHN)
- **Horticultural Sciences** (HOS)
- **Microbiology and Cell Science** (MCS)
- **Plant Pathology** (PLP)
- **School of Forest, Fisheries, and Geomatics Sciences** (SFFGS)
- **Soil and Water Sciences** (SWS)
- **Wildlife Ecology and Conservation** (WEC)

Off-Campus Research and Education Centers (RECs)

1 **Citrus REC** (CREC) | **LAKE ALFRED**
2 **Everglades REC** (EREC) | **BELLE GLADE**
3 **Florida Medical Entomology Laboratory** (FMEL) | **VERO BEACH**
4 **Fort Lauderdale REC** (FLREC) | **FORT LAUDERDALE**
5 **Gulf Coast REC** (GCREC) | **BALM, PLANT CITY**
6 **Indian River REC** (IRREC) | **FORT PIERCE**
7 **Mid-Florida REC** (MREC) | **APOPKA**
8 **North Florida REC** (NFREC) | **MARIANNA, QUINCY, SUWANNEE VALLEY**
9 **Range Cattle REC** (RCREC) | **ONA**
10 **Southwest Florida REC** (SWFREC) | **IMMOKALEE**
11 **Tropical REC** (TREC) | **HOMESTEAD**
12 **West Florida REC** (WFREC) | **JAY, MILTON**

Research and Demonstration Sites

13 **Hastings Agricultural Extension Center** (HAEC) | **HASTINGS**
14 **Nature Coast Biological Station** (NCBS) | **CEDAR KEY**
15 **Ordway-Swisher Biological Station** (OSBS) | **MELROSE**
16 **Plant Science Research and Education Unit** (PSREU) | **CITRA**
17 **Tropical Aquaculture Laboratory** (TAL) | **RUSKIN, APOLLO BEACH**

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