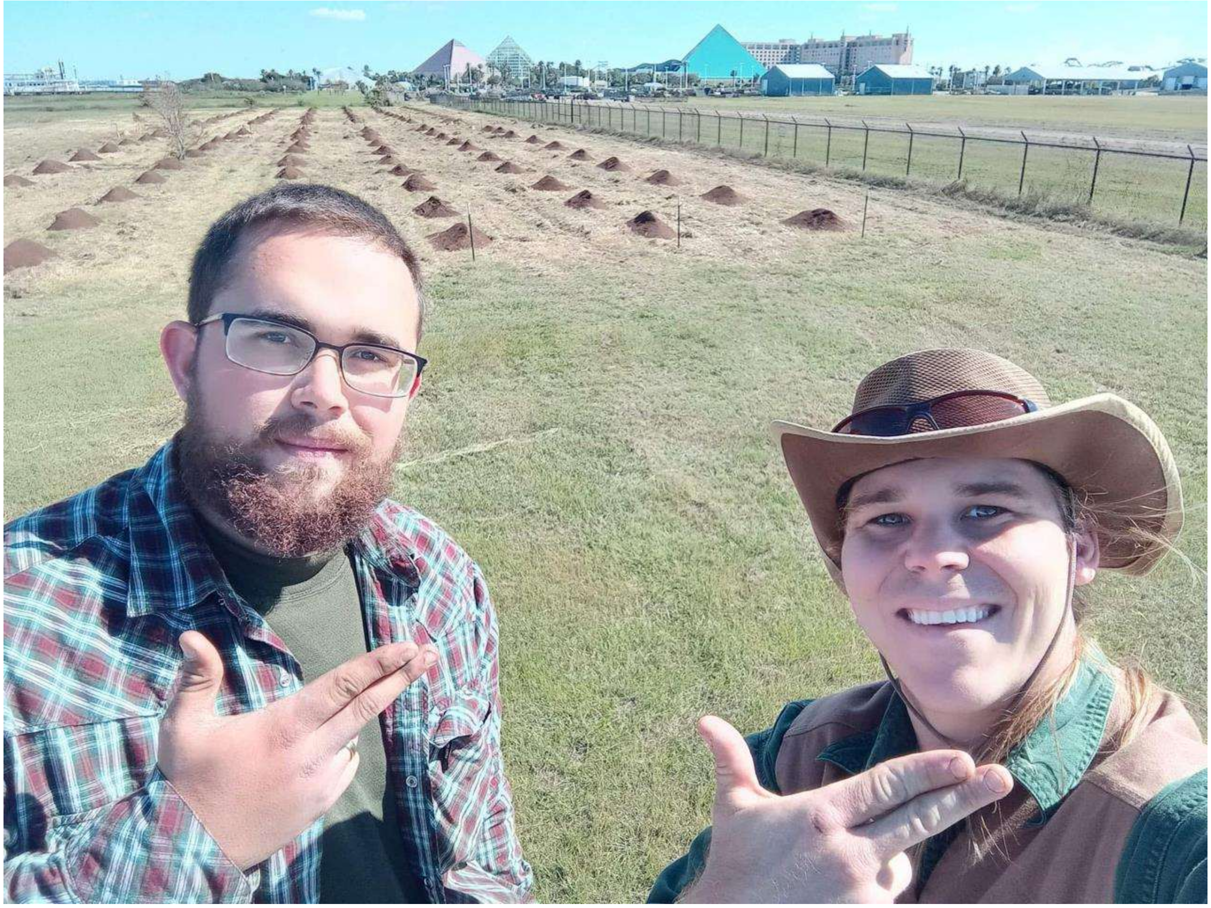
CLIMATE RESILIENT ORNAMENTALS FOR A 21ST CENTURY GALVESTON ISLAND

2020-2024



DR. DAVE CREECH
DIRECTOR, SFA GARDENS
STEPHEN F. AUSTIN STATE UNIVERSITY
NACOGDOCHES, TX 75962-3000
EMAIL: dcreech@sfasu.edu
Cell: 936-679-3460

TABLE OF CONTENTS

CLIMATE RESILIENT ORNAMENTALS FOR A 21ST CENTURY GALVESTON ISLAND

This report details the progress of a project that was initiated in 2016 as a cooperative venture between SFA Gardens, Stephen F. Austin State University, Nacogdoches, TX, and Moody Gardens on Galveston Island. The 2016-2019 Report is available on line here:

https://www.sfasu.edu/docs/sfa-gardens/projects-final-report-for-moody-foundation-aug-2019.pdf

INTRODUCTION

This report focuses on activities in the Jan 2020 – Dec 2024 time frame. For the record, in March of 2020, this project came to a standstill with the advent of the Covid19 pandemic and did not get back on track until the Fall of 2021.

This report includes various reports and images provided to Moody Gardens in the last 4 years, edited as needed. The original research plot was established in 2016

PUBLICATIONS AND PAPER PRESENTATIONS 2020-2024

David Creech*, Steve Wagner, Kenneth Farrish, Elif Ilhan and Rachel Murray. 2022. Evaluating Ornamentals in a Salt-Challenged Environment at Moody Gardens, Galveston Island, Texas. ASHS Annual conference in Chicago, July 30 – August 4, 2022. Published abstract. **HortScience** 57(9) Supplement (Part 1) — 2022 ASHS Annual Conference: S195.

Canetti, Barbara. Feb 22, 2022. Coast Monthly magazine, March issue, a feature article on our tree evaluation work at Moody Gardens, Galveston, Texas: 'Garden Variety Tree Test.' https://www.coastmonthly.com/homegarden/gardenvariety/tree%20test/article_790e8e02-a93e-57ea-ae1d-ec7a36eb0cb4.html

David Creech[1], and Mengmeng Gu[2]. (2023). Status on the Impact of the February 2021 Winter Storm Uri on Woody Ornamentals in Texas. [1]2900 Raguet St., Stephen F. Austin State University, Nacogdoches, TX 75965, [2]Department of Horticulture and Landscape Architecture, Box 1173, Colorado State University, Fort Collins, CO 80523. (dcreech@sfasu.edu) – a presentation at the ASHS SR annual conference, Feb 2-5, 2023, Oklahoma City, OK. 22 attendees.

Creech, David. May/June 2023. Climate-Resilient Plants for a 21st Century Texas. **Texas Gardener** vol. XLII (4): 32-35.

Creech, David. Sept/Oct 2024. Evaluating Landscape Plants for a 21st Century Gulf Coast. **Texas Gardener** Vol XLIII (6): 34-37.

Creech, David. Aug 14, 2024. Climate Resilient Ornamentals for a 21st Century Texas – Reducing Water Use with the Right Species. Texas Nursery and Landscape Association Conference and Convention, San Antonio, Texas. 92 attendees.

THESIS COMPLETIONS:

Fowler, Elaine, "Assessment and Characterization of Microbial Communities in Salt Affected Soils on Galveston Island" (2017). *Electronic Theses and Dissertations*. 76. https://scholarworks.sfasu.edu/etds/76

Harris, Elaine, "Soil Amelioration and Plant Establishment on Sodium Affected Soils on Galveston Island, Texas" (2019). Electronic Theses and Dissertations. 249. https://scholarworks.sfasu.edu/etds/249

Morgan, Daniel, "Evaluation of Groundwater Sodium and Sodium Uptake in Taxodium and its Hybrids on Galveston Island, Texas" (2020). *Electronic Theses and Dissertations*. 340.
https://scholarworks.sfasu.edu/etds/340

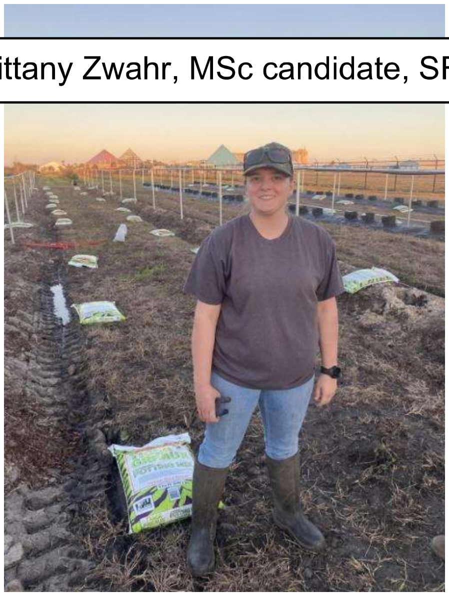
ilhan, Elif, "Effect of Mycorrhizae Inoculation on the Growth and Success of Three Taxodium distichum hybrids in Saline-Impacted Coastal Soils" (2022). *Electronic Theses and Dissertations*. 438. https://scholarworks.sfasu.edu/etds/438

Murray, Rachel. "Soil Salinity of Galveston and Pelican Islands, Texas" 2022. Electronic Theses and Dissertations. 466. https://scholarworks.sfasu.edu/etds/466/

THESIS PROJECTS UNDERWAY IN LATE 2024

Brittany Zwahr. SFA Forestry GRA. "Nursery Production Strategies in a salt-heavy environment on Galveston Island, TX" – in process, SFA provides $20,000 GRA

Will Dunford. LSU Horticulture GRA. "Nursery Production of Hardwoods in a high wind environment on Galveston Island, TX" – in process, LSU provides $20,000 GRA



Brittany Zwahr, MSc candidate, SFA

Will Dunford, MSc candidate, LSU

ASHS PAPER PRESENTATION

This abstract is presented here because it serves as an overview of the five MSc thesis projects accomplished by this project since inception in 2016.

David Creech*, Steve Wagner, Kenneth Farrish, Elif Ilhan and Rachel Murray. 2022. Evaluating Ornamentals in a Salt-Challenged Environment at Moody Gardens, Galveston Island, Texas –Stephen F Austin State University, PO Box 13000, Nacogdoches, TX 75962-3000. ASHS Annual Conference (S195) in Chicago, IL., July 30 – August 4, 2022. **HortScience** 57(9) Supplement (Part 1) — 2022.

Beginning in 2016, SFA Gardens, Nacogdoches, Texas, partnered with Moody Gardens, Galveston, Texas, to create a research plot on the island. The site is located on the west side of Moody Gardens near Offatt bayou, 1.3m above sea level, occasionally inundated by high-salt bay water during storms or hurricanes. A drip irrigation system utilizes partially deionized water(.8mS/cm) provided by the Moody Gardens desalination plant. A record Winter Storm Uri in Feb 2021 damaged a wide range of marginally hardy materials (-8^{o}C). While the primary objective of the project is ornamental plant evaluation, five MS thesis projects have been completed with titles and abbreviated results as follows: 1) Evaluation of Groundwater Sodium and Sodium Uptake in Taxodium and its Hybrids on Galveston, Island, Texas; six Taxodium clones were monitored for three years (plant height and diameter breast height (dbh); growth of hybrids was good in spite of leaf tissue Na+ values varying from 6000 to 11000 PPM Na$^{+;}$ 2) Assessment and Characterization of Microbial Communities in Salt Affect Soils on Galveston Island, Texas; samples from bedded and non-bedded plots treated with gypsum, mulch, or both were assessed for microbial populations and there were no consistent statistical differences in microbial populations or respiration measurements among the treatments. 3) Soil Amelioration and Plant Establishment on Sodium Affected Soils on Galveston Island, Texas; bedded and non-bedded plots treated with gypsum, mulch, or both were used to test three species of plants, live oak (*Quercus virginiana*), hybrid bald cypress (*Taxodium distichum* 'T406'), and yellow hibiscus (*Hibiscus hamabo*); plants were measured for increase in height and diameter over three growing seasons which resulted in no significant differences in treatments. 4) Effect of Mycorrhizae Inoculation on the Growth and Success of *Taxodium distichum* in Saline-impacted Coastal Soils. Treatments were: mycorrhizae inoculation, fertilizer application, and a combination of mycorrhizae inoculation and fertilizer application, and there were no significant effects on height and diameter breast height, leaf nutrient concentration, soil microbial functional diversity, as well as soil respiration; 5) Soil Salinity of Galveston and Pelican Islands, Texas; this project evaluated soil salinity levels on both Galveston and adjacent Pelican Islands in over 200 locations to produce GIS-generated soil salinity heat maps that aid in planning revegetation projects. Funded by Moody Gardens, this project has provided graduate and undergraduate students with a real-world opportunity to study a wide range of ornamentals in a salt and climate challenged environment.

July 15, 2021 REPORT

February 2021 Freeze

The mega freeze of mid-February 2021 was a record-breaking event. Nacogdoches, TX, experienced -4F as a low temperature on February 16, 2021. Galveston island suffered temperatures into the mid-teens during that week long event. At the research plots, many species that had performed admirably with freezing events into the twenties in the last five years, were damaged, and a few were killed totally. The database of plant materials there is ranked for freeze damage on a 0-6 scale, with 6=no damage, 0=dead. This data along with other observations on the Island are being added to a database being created by Dr. Mengmeng Gu, Texas Agrilife Extension Specialist, College Station, Texas and I. We are working on this as a collaborative project with a goal to create a statewide assessment of the impact of the February freeze. For example, the impact at SFA Gardens, Nacogdoches, Texas, is extensive, and the plant materials inventory is extensive. With temperatures to -4°F, we have numerous species that were killed or badly damaged, or came through the event unscathed. While the impact on commonly encountered landscape plant materials i(commodities) is obvious, there is value in determining what happened with species that are rare, unusual or rarely encountered.

Trees moved to other landscapes on the island.

As part of the program, it's important we move plant material out of our research plots and replace them with newer materials. We know they work or they don't. The 12' tall rule for the plots because of the adjacent airport was another impetus to move plants. Many have grown surprising well in the research plot location. The off-island soil used for the long beds, good fertilization and weed control for the establishment phase resulted in fast growing specimens. I am particularly pleased that many of the superior performers have been moved to other locations on the island.

1. Moody Early Childhood Center, San Jacinto Park, 1901 Avenue L
2. Galveston Dog Park on 83rd street across from Schreiber Park
3. Bernard-Davis Field, 81st and Joe Giusti Drive

Kudos go out to Priscilla Files of the Galveston Island Tree Conservancy, city officials, civic and community enthusiasts, and Donita Brannon, Moody Gardens, for managing the tree moving. We think this year's effort is a fine model for the future. Evaluate plants, destroy the poor performers, move the best to Galveston Island landscapes.

---------- Forwarded message ---------
From: **Robyn** <rbush1147@aol.com>
Date: Tue, Jun 15, 2021 at 12:40 PM
Subject: CONGRATULATIONS and THANK YOU.... Our beautiful new dog park!
To: XXXX

Good afternoon, everyone... a belated - yet none-the-less very sincere - **THANK YOU** to everyone involved in making this wonderful new dog park a reality! I so appreciate!

I'm so proud of ALL that Galveston does - and continues to do - to make this beautiful island city even BETTER! And especially...the partnerships between the City, GISD, Moody Gardens, Tree Conservancy... oh, my goodness... these partnerships are one of our very best assets!

"Luna" and I look forward to spending a lot of time at the new park, and I know that many of my neighbors will look forward to spending time there as well.

THANKS AGAIN... Best, robyn

Robyn R. Bushong, *Project Editor*
Signature Travel Network Expert - *Select*
2622 Gerol Court
Galveston Island, Texas 77551-1581
409.744.7848 (office); 409.740.2336 (fax); 409.739.0684 (cell)

Robyn R. Bushong, *Publicist*
The Grand 1894 Opera House
2622 Gerol Court
Galveston Island, Texas 77551-1581
409.744.7848 (office); 409.740.2336 (fax); 409.739.0684 (cell)
The Grand is the "Official Opera House of the State of Texas"

<u>Constraints</u>: The tree moving process took a bit longer than expected. Wet soils, Covid19 and a rush to find the funds for moving the trees was responsible for any delays. The activity of getting in to the plots and moving the trees also destroyed the irrigation system which we will repair in the Fall when we replant. In addition, we have many holes to fill and beds to smooth out. That will involve bringing in a few loads of off-island sand which we have done before when we created the plots. Because the last trees didn't leave the plots until late spring, I decided to hold new plant material destined for the plots and not plant them until Fall. That material is at SFA Gardens and was bumped up into three to five-gallon containers and placed in our nursery at SFA Gardens. Besides new plant materials, we have also propagated a good number of the superior performers for later planting at the plots, at Moody Gardens or in other locations on the island. I am slated to drive to Florida in October and will be picking up some interesting plant materials from my friends at the University of Florida, Gainesville, and through friends at various specialty nurseries.

Ilif Ilhan, MS Biology student on mycorrhizal associations in the plots and Devin Stage, SFA Gardens Technician, assisting with the plots

The Podocarpus variety collection was unaffected by the freeze. Holes from dug trees will be filled with soil and replanted this Fall.

Phoenix coming back from the ashes of the freeze event and trees moved to Galveston parks

Taxodium clones cut back in winter to serve as source of vigorous cutting wood

A SOIL SALINITY SURVEY OF GALVESTON ISLAND, TEXAS

Dr. Ken Farrish and Rachel Murray (M.S Student), Environmental Science

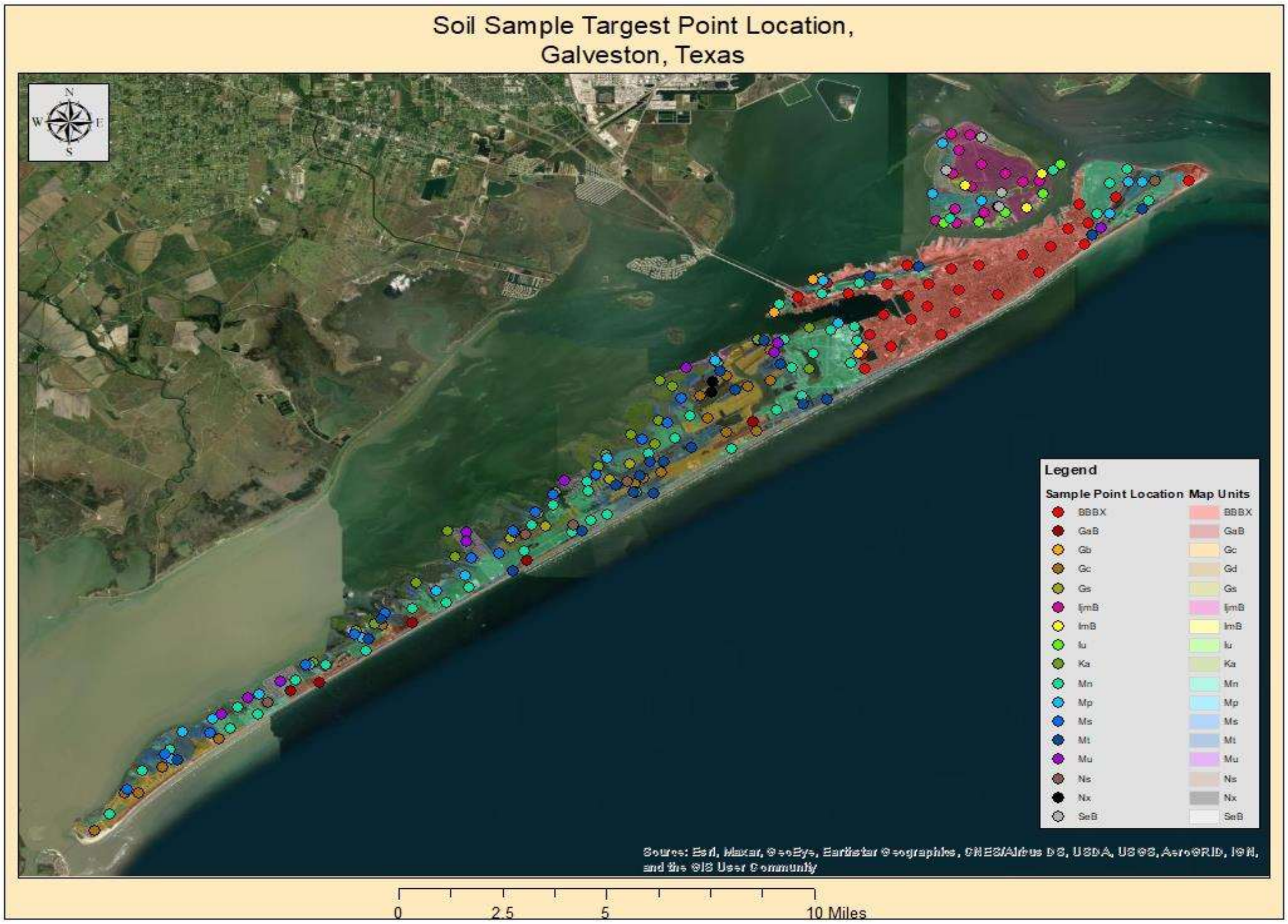
Galveston Island, Texas is frequently affected by hurricanes. In 2008, Hurricane Ike inundated much of the Island with seawater, causing elevated soil salinity levels that killed much of the vegetation on the Island, including tens of thousands of trees. Residual salinity in soils and groundwater has hampered vegetation re-establishment in some areas. The purpose of this project is to evaluate current soil salinity levels on both Galveston and adjacent Pelican Islands, and to produce soil salinity maps that will aid in planning vegetation reestablishment for the Islands.

Existing USDA Natural Resources Conservation Service (NRCS) Galveston County Soil Survey map units were used as a base for the project. ArcGIS Desktop software was used to establish a sampling design with randomly located sampling points within each soil survey map unit. A total of 200 points were selected with each point representing approximately 135 acres (Figure 1). Because of expected access challenges to some properties, the actual number of point locations may be somewhat less. Once the point shapefile was created, it along with the map unit polygons was published to ArcGIS Online and Collector App. The actual sample locations then could be determined and modified if needed (Figure 2).

On June 15th – June 17th, 2021, samples were collected at 50 of the points on the eastern part of Galveston Island, (Figure 3). At each sampling point, a surface sample of 0 to 10cm was collected using soil push probes. In addition, when possible, a bucket auger was used to collect a soil sample at 50cm depth. Sampling will continue Galveston on June 30th -July 2nd to gather more samples.

In the laboratory for the soil samples are initially tested for pH, (Figure 4). Eventually, the samples will also be tested for macro- and micronutrients, sodium adsorption ratio (SAR), and electrical conductivity (EC). These data will be entered into ArcGIS for analyses. Soil salinity (EC and SAR) will be presented spatially by using heat maps. Geospatial statistical analyses will also be conducted.

Image is Rachel Murray collecting soil samples from the Island.



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1: A map showing the target sample point locations and the map units on Galveston and Pelican Islands, Galveston, TX

Figure 2: A screenshot of the Collector App displaying the sample point locations and the map units on Galveston and Pelican Islands, Galveston, TX

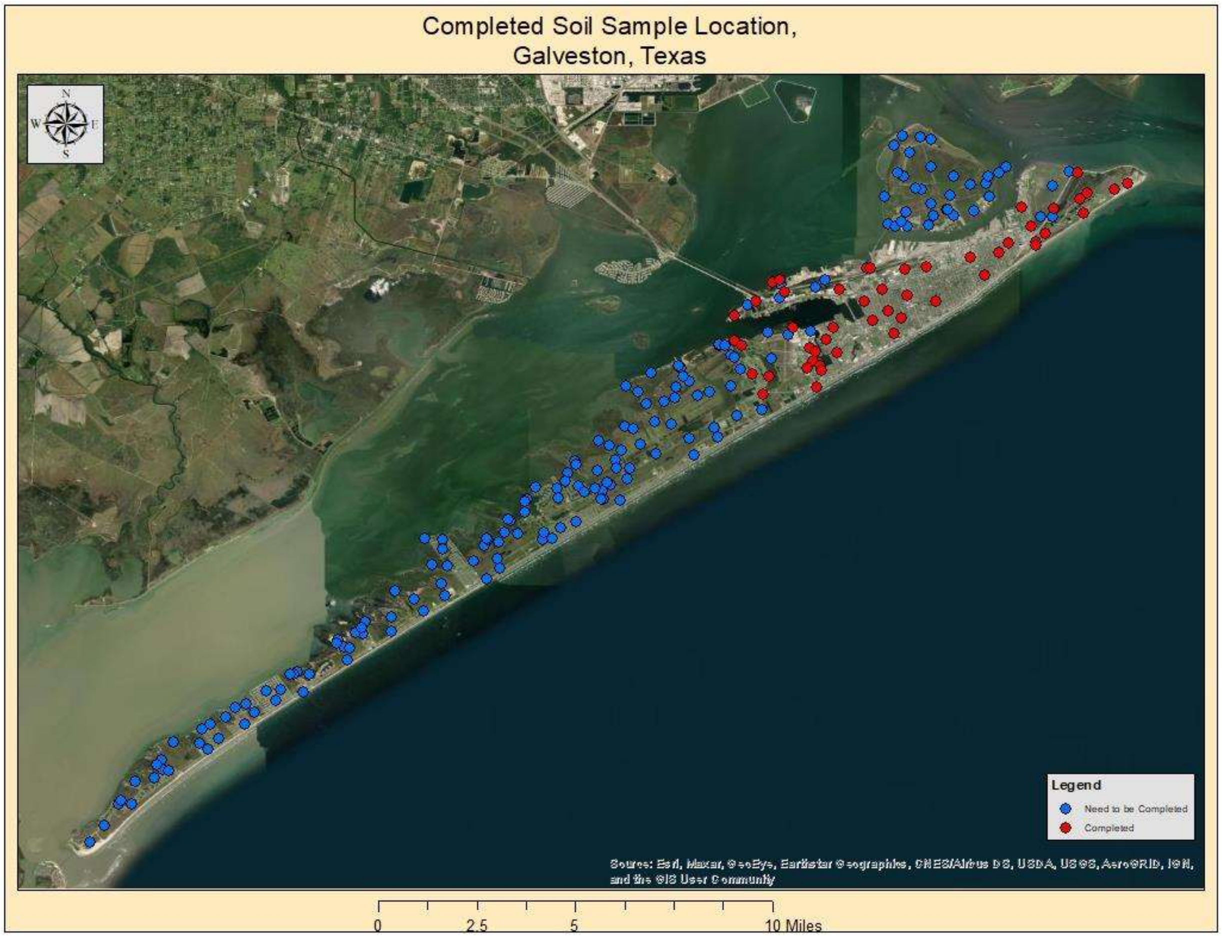


Figure 3: A map showing the completed sample point locations on Galveston and Pelican Islands, Galveston, TX

Figure 4: Soil samples from Galveston Island in SFASU's Environmental Science Lab prior to drying and analysis.

EFFECT OF MYCORRHIZAE INOCULATION ON THE GROWTH AND SUCCESS OF *TAXODIUM DISTICHUM* IN SALINE IMPACTED COASTAL SOILS

Directed by Stephen Wagner and Josephine Taylor

Even though microorganisms compose less than 1% of a given soil's mass, they play an intricate role in the growth, health, and success of plants growing in that soil. Beneficial organisms, such as mycorrhizal fungi and nitrogen-fixing microbes not only promote plant growth and health but also help reduce the need for nitrogen and phosphorus fertilization. We have investigated the role that these microbes have on the growth of plant species being studied at the Moody Gardens research site. We are continuing these ongoing studies as well as expanding to new areas of study during this second period of funding. This part of the project will continue to be directed by Drs. Stephen Wagner and Josephine Taylor, faculty members in the SFASU Department of Biology. We are focusing on 3 specific areas of research: 1) continue to assess microbial populations and activities at the Moody Gardens Research Site, 2) test the efficacy of mycorrhizae inoculants on plant species being evaluated at the Moody Gardens site, and 3) introduce leguminous tree/shrub species and rhizobia inoculants.

Effect of Endo/Ecto-Mycorrhizae Inoculation of *Taxodium* Candidate Genotypes. A study was initiated in 2018 to determine the effect of inoculation of three candidate genotypes of cypress trees with a commercial endomycorrhizae/ ectomycorrhizae consortium on the plants' growth and development. These genotypes (405, 407 and 502) were 3 different selections of crosses made between *Taxodium distichum* var *distichum* and *T. distichum* var *mexicanum*. Trees of each genotype were treated with the following amendments: 1) no additives of fertilizer or mycorrhizae (CONT); 2) fertilizer alone (FERT); 3) mycorrhizae alone (MYCO); 4) both fertilizer and mycorrhizae inoculant (MYC0/FERT).

After suspending most of our research from March 2019 until October 2020 due to the COVID 19 pandemic, we were able to reinitiate this study in November 2020. The trees were re-inoculated with the commercial endomycorrhizae/ectomycorrhizae to prepare for the 2021 growing season. Research during this growing season is being conducted by Elif Ilhan (Master of Science Candidate, Environmental Science) for her thesis project. In April and May of 2021, the trees were again treated with fertilizer and mycorrhizae to initiate the 4th season of research of this study. During this summer and early fall we are collecting the following data:

1. Tree growth as determined by tree height and diameter at breast height (dbh). The first set of this data was collected on June 10, 2021

2. Leaf tissue nutrient levels. We are planning to collect leaf samples on July 7, 2021.

3. Soil microbial diversity via Biolog microplate technique. We are planning to collect soil samples on July 7, 2021 and subsequently conduct analyses in labs at SFA in July and August.

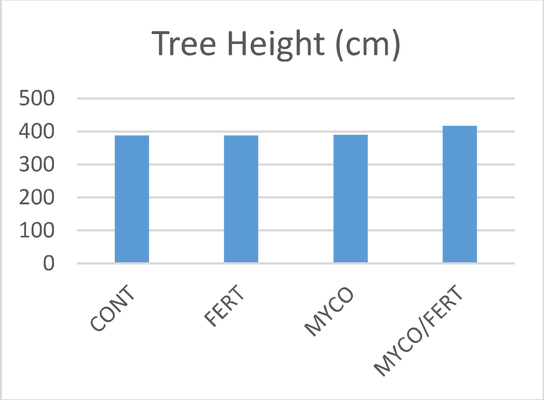
4. Soil respiration rates via a field respirometer. We are planning to collect this data in August or September.

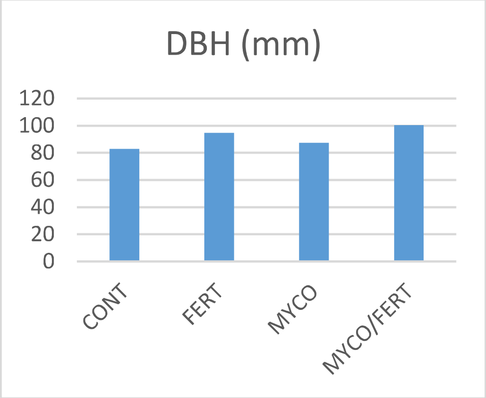
Taxodium –Mycorrhizae Study at Moody Gardens

Elif Ilhan Inoculating *Taxodium* Trees and Collecting Tree Growth Data

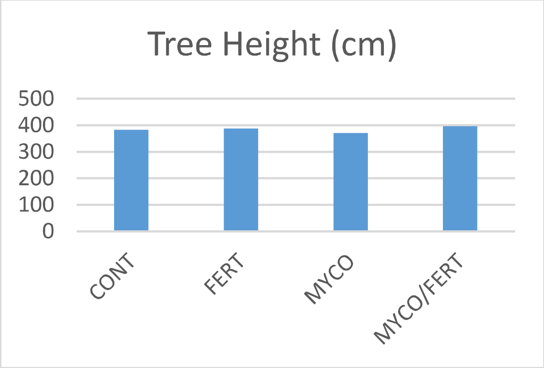
Ms. Ilhan has generated the following bar graphs of treatment means. She is currently organizing and conducting statistical analyses of these data to determine if the treatment effects are significantly different.

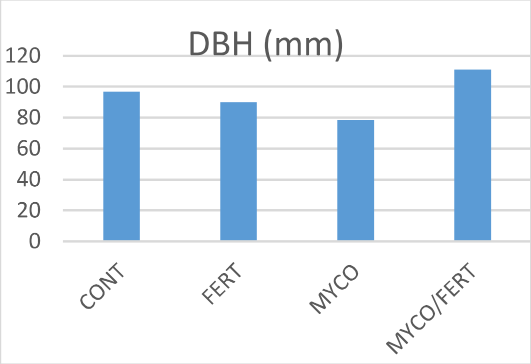
June 10, 2021 Taxodium 405 Growth Data



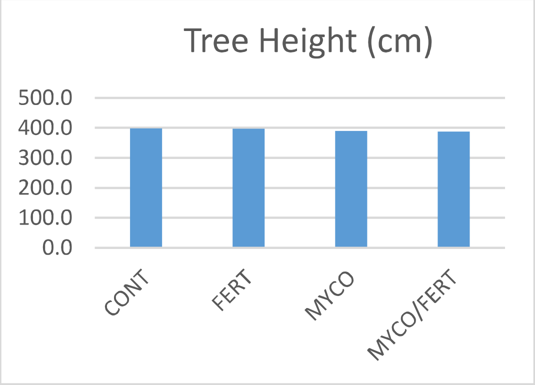


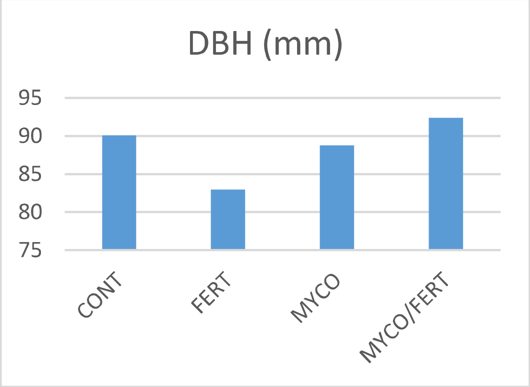
June 10, 2021 Taxodium 407 Growth Data





June 10, 2021 Taxodium 502 Growth Data





NATIVE MICROBIAL POPULATION AND ACTIVITY ASSESSMENT

A research site has been established at Galveston's Moody Gardens to study the growth of *Hibiscus hamabo*, *Quercus virginiana,* and *Taxidium distichum* in salt-impacted soils. The site contains 48 plots, half of which are bedded with nonnative bank sand soil. These soils were treated with one of the following amendments: 1) no additives; 2) gypsum; 3) pine bark mulch; 4) gypsum + pine bark mulch. Because microbial species play an intricate role in the success of the *Hibiscus hamabo*, *Quercus virginiana,* and *Taxodium distichum* plants growing at the Moody Gardens study site, research included assessing indigenous microbial populations and activity. In addition to previous work completed by Elaine Fowler for her MS thesis project, we collected soil samples to determine mycorrhizae populations via most probable number greenhouse studies at SFA (carried out in 2018 and 2019). Analysis of these data was delayed during the spring of 2019 and fall of 2020 because of the COVID 19 closures and restrictions at SFA. Consequently, laboratory analysis of MPN samples was delayed until this spring and summer. Olivia Plaza, Undergraduate Research Assistant, is currently analyzing these samples; we anticipate these analyses to be completed at the end of the summer or early fall semester. We plan to use the results as the final part of a journal publication we are preparing on this work.

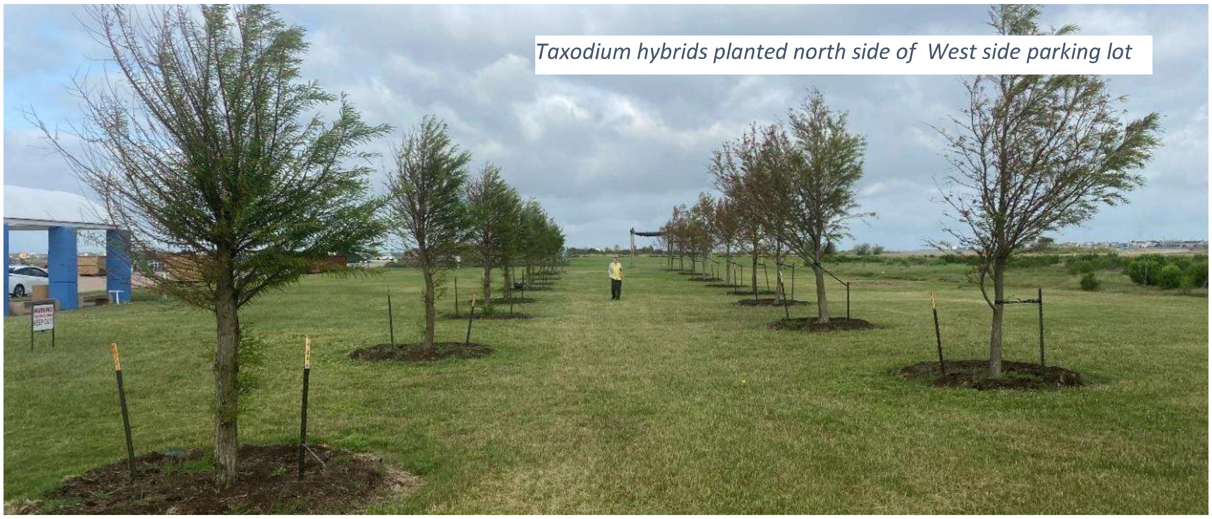
July 15, 2022 REPORT

Since the last research status update, I can report the following:


Research plots are ready for Phase 2

We have a blank slate at the 2-acre Moody Gardens Evaluation Plots. The place has been emptied! We are now ready for phase 2.

In spite of their good size, most of the trees and shrubs have been moved to locations at Moody Gardens and other spots on the island. A terrific alee of Taxodium X ‘T406” has been created at the west end parking lot of Moody Gardens. This research plot is to be visualized as a revolving door nursery focused on screening ornamental plants, many never tested on the island. There’s a great contribution to be made there. Evaluate a wide range of plants, discard the failures and celebrate the winners by giving them a new home, and having he data to recommend their use. I’m very pleased that so many of the best specimens managed to leave the place for a new home on the island. With the leadership of Priscilla Files, Galveston Island Tree Conservancy and Donita Brannon and others at Moody Gardens, a collaboration was created. Galveston Parks and Recreation, the Galveston Independent school district, Moody Gardens and others dug and moved some great trees into a wide range of landscapes on the island. Some of the trees ended up at the new West End Dog Recreation Area on 83rdStreet.


Taxodium hybrids planted north side of West side parking lot

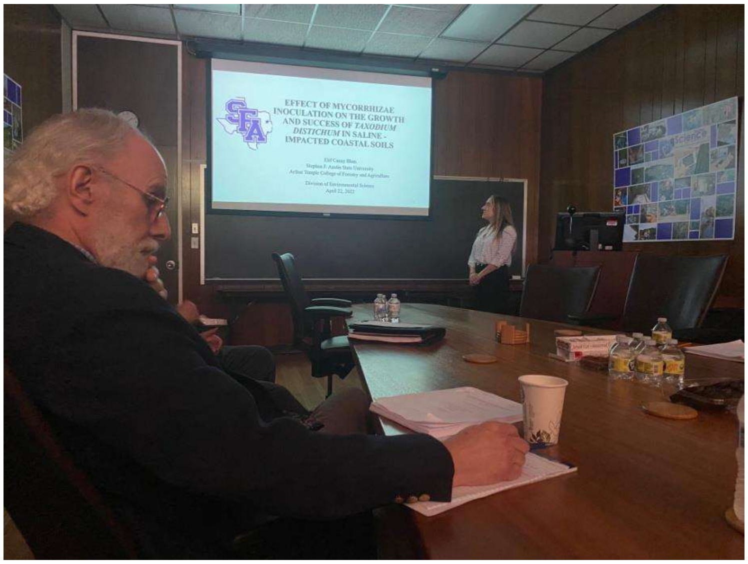
Taxodium hybrids near West side parking lot

Araucaria angustifolia to left is a much hardier version of the Norfolk Island Pine and has good salt tolerance. This monkey puzzle tree is one of the remaining ornamentals left behind in the plots. It’s been on its own for a year. Image below is new planting at west end dog park.

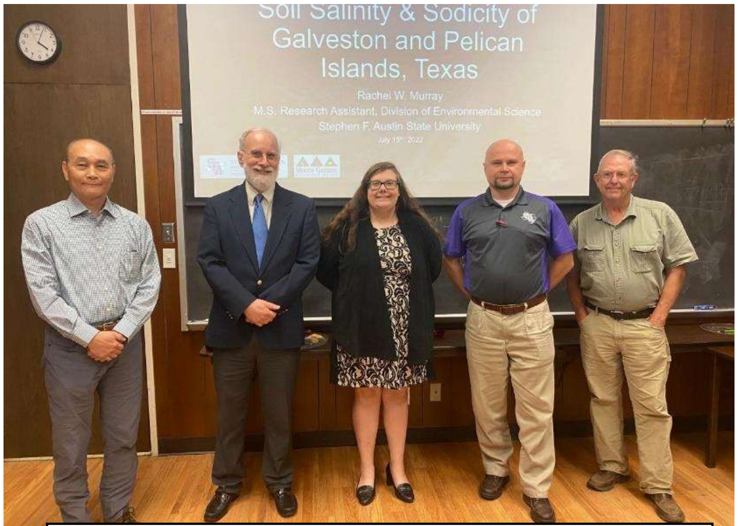
Two Thesis Projects Completed

Since the last update, we have graduated two MS thesis students, Elif Ilhan and Rachel Murray, their projects described below. This will bring the total to five successful Masters student thesis projects assisted by Moody Gardens.   The theses are being bound at this writing and will be provided to Moody Gardens in the near future.

Ilhan, Elif Canay. 2022. Effect of Mycorrhizae Inoculation on the Growth and Success of Three *Taxodium distichum* hybrids in Saline-impacted Coastal Soils. Project was partially funded by the Moody Gardens grant. Elif defended her thesis April 22, 2022. Thesis can be found here:
https://scholarworks.sfasu.edu/cgi/viewcontent.cgi?article=1480&context=etds



Elif Ilhan MS Thesis defense. Committee: Drs. Steve Wager, Kenneth Farrish, Josephine Taylor and Dave Creech



Ikai Huang, Kenneth Farrish, Rachel Murray, Franta Majis, Dave Creech

Rachel Murray in Environmental Science wrapping up her survey of Galveston Island salinity and she defended her Master's thesis July 15, 2022. Her research project, "Soil Salinity and Sodicity of Galveston and Pelican Islands, Texas", has produced the first ever Geographical Information Systems salinity heat map of the island, a platform we can build on in the years ahead and one that should be useful to land and vegetation managers on the island.

PLAN OF WORK:

What's next on the project? We have a new tranche of ornamental candidates that will be planted this Fall. A good many are here at SFA Gardens and we have others "waiting" for pickup at several cooperating nurseries and universities in the Gulf South. Before that happens, we will be adding 60 cubic yards of off-island soil to the plots, mainly to fill holes left by dug trees and to rebuild the modest “beds” that define the rows. A thin layer of composted pine bark fines will be added to the beds as a mulch. The irrigation system will be repaired and weeds killed down the rows before planting. The plots will be back in the evaluation business in November 2022. With Rachel Murray and Elif Ilhan’s successful completion of their MS thesis projects, we have a remaining balance of over $90,000 which will carry us through 2023 and beyond.

MICROBIOLOGY PROJECT STATUS

Stephen Wagner, SFASU Professor of Biology

Taxodium/Mycorrhizae Project

Goal: Continue work on completing Elif Ilhan’s (Master of Science, Environmental Science) thesis project entitled “Effect of Mycorrhizae Inoculation on the Growth and Success of Three *Taxodium Distichum* Hybrids in Saline - Impacted Coastal Soils” and prepare it for journal article publication.

Project Team Members Involved: Elif Ilhan, Stephen Wagner, Kenneth Farrish, Josephine Taylor and David Creech.

Other SFASU Personnel Involved: Carmen Montana-Schalk, Kim Johnson, Cassidy Owens

Progress Made: Elif successfully navigated through the process of analyzing study results, including performing and interpreting statistical analyses of much of the data collected during the first year of her project. Under Dr. Wagner’s guidance, she then had to construct many data tables and graphs to properly report this data in her thesis. These tables and graphs were then incorporated into a narrative describing and interpreting the results as well as comparing them to related studies. After several rewrites, reviews and help from her faculty mentors, Ms. Ilhan successfully presented and defended her thesis before her graduate advising committee on April 22, 2022. The SFASU Graduate School approved the final draft of this thesis on May 3, 2022 and released it for publication on the university’s Thesis and Dissertation section of ScholarWorks. Dr. Creech will provide Moody Gardens with a bound copy. Here is the abstract from her thesis:

"In 2008, Galveston Island was severely impacted by Hurricane Ike, resulting in high salt deposition in the soil and groundwater. This caused a loss of many native plant species. A study initiated to determine effective ways to promote the growth conditions of three bald cypress genotypes (*Taxodium distichum* var *distichum* and *Taxodium distichum* var *mexicanum* crosses) in salt-affected soils. The treatments applied were mycorrhizae inoculation, fertilizer application, and a combination of mycorrhizae inoculation and fertilizer application. A total of sixty (60) trees planted in plots of three rows and divided into five randomized replication blocks of four treatments each were used. Plants were measured for total height and diameter at breast height (DBH), and tree leaf nutrient concentration over the 2021 growing season. The effect of these treatments on soil health was determined by measuring the soil microbial functional diversity and soil respiration. None of the three treatments had a significant effect on height, diameter breast height, leaf nutrient concentration, soil microbial functional diversity, or soil respiration. This could be because of the limited spacing between the trees and the age of the trees. However, treatment with mycorrhizae alone and a combination of mycorrhizae and fertilizer showed the potential to improve the tree height and the DBH."

Mycorrhizae MPN Study

Goal: Complete analyses and interpretation of greenhouse study that determined native mycorrhizae populations in Soil Amendments Study at Moody Gardens.

Project Team Members Involved: Olivia Plaza, Stephen Wagner, Josephine Taylor

Other SFASU Personnel Involved: Cassidy Owens

Progress Made: Olivia Plaza, undergraduate research assistant, completed collecting data on this study at the beginning of May, 2022. This data will be statistically analyzed to determine the effect of soil amendments on native mycorrhizae populations at the field site. We are hoping to include this data in a journal article manuscript to be submitted this coming Fall.

SOIL SALINITY AND SODICITY OF GALVESTON AND PELICAN ISLANDS, TEXAS

Rachel Murray, Master of Science, Environmental Science

I. Galveston Soil Salinity Mapping

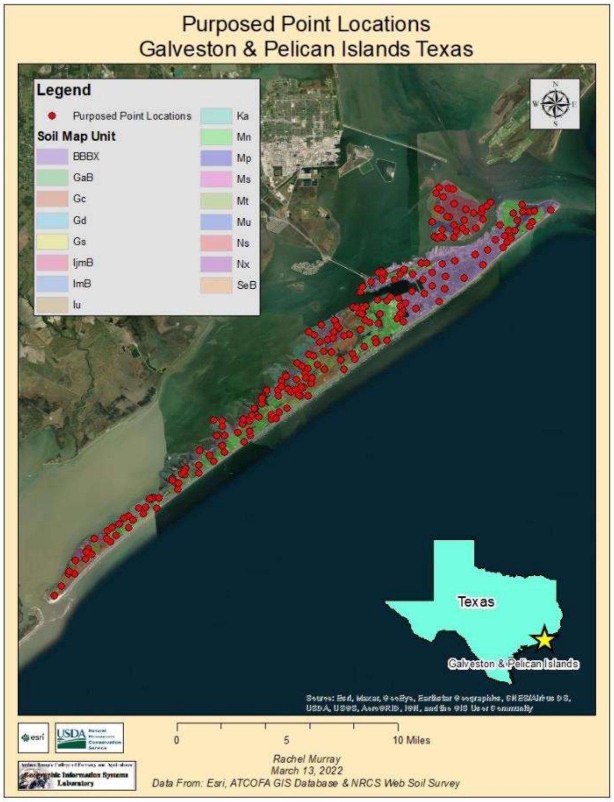
a. Goal: Finish work on completing the thesis project entitled “Soil Salinity

and Sodicity of Galveston and Pelican Islands, TX” – graduate Aug 2022.

b. Committee Members: Rachel Murray, Dr. Kenneth Farrish, Dr. IKuai Hung, Dr. Franta Majs and Dr. David Creech.

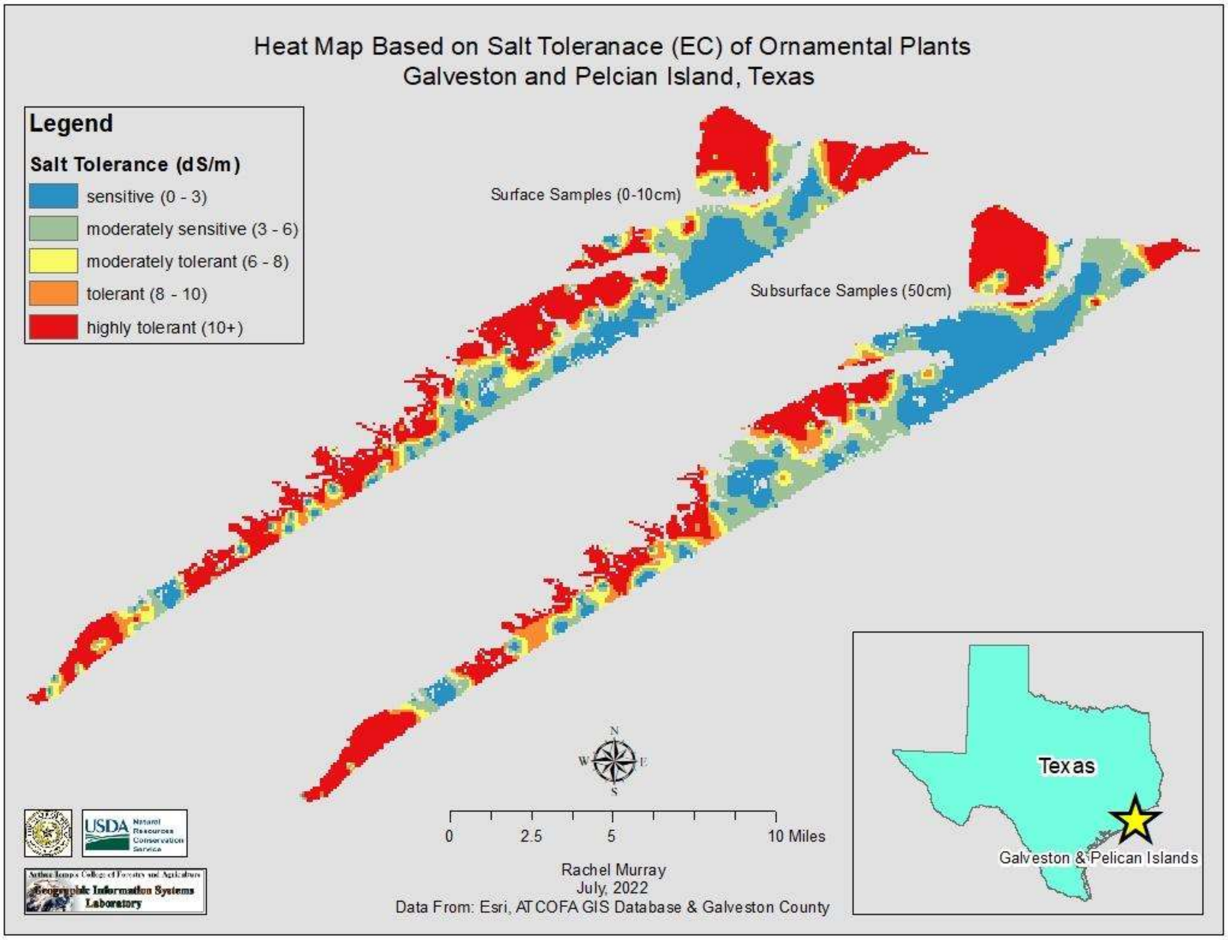
c. Current progress: In the summer of 2021, 328 soil samples were collected on Galveston and Pelican Island. As of June 2022, all soil samples have been tested at the Stephen F. Austin State University Soil, Plant & Water laboratory. The data has been statically analyzed, and interpolated surfaces have been created. I successfully defended my thesis July 15, 2022, and will be receiving the MS in Environmental Science this summer.

d. Summary: Galveston Island, Texas, is frequently affected by hurricanes. In 2008, Hurricane Ike inundated much of the island with seawater, causing elevated soil salinity levels that killed much of the vegetation on the island, including tens of thousands of trees. Residual salinity in soils and groundwater has hampered vegetation re-establishment in some areas. The existing USDA Natural Resource Conservation Service (NRCS) Galveston County Soil Survey map units were used as a base for the project. ArcGIS Desktop software was used to establish a sampling design with randomly located sampling points within each soil survey map unit. Samples were taken at 200 different soil samples across Pelican and Galveston Island. A total of 328 samples were collected, composed of 129 subsurface and 199 surface samples. The soil samples were tested in the laboratory for pH, macro-and micronutrients, sodium adsorption ratio (SAR), and electrical conductivity (EC). The data were entered into ArcGIS for analyses, and an IDW interpolated surface was created. The average salinity for all the soil samples was higher than normal levels. SAR and EC are correlate, meaning when there is high salinity, there is high sodicity. About half the samples were not classified as saline, sodic or saline-sodic. The other half was classified as saline, sodic, or saline-sodic soils. There is an increase in salinity and sodicity at Pelican island, near the tips of the island, the more industrial areas, and the coastal tidal flats along the Galveston Bay coastline. Pelican Island has an increased salinity due to being composed of dredge material. The areas with less salinity and sodicity are the heavily urbanized areas. The lower salinity and sodicity could be due to filler material being brought from the mainland.



Over 200 GIS-generated collection points for shallow and deep soil samples

Heat map below is only one of many visual representations of salinity on the island. Blue has lowest conductivity and has best conditions for plantings. Red has highest conductivity and will injure or kill most ornamentals except for the most salt tolerant types.



JUNE 1 2023 REPORT

Irrigation System Repaired.

The plot's irrigation system has been repaired and is back on line. The effort in the last year to tree spade and move the trees to Moody Gardens, parks and school yards left the irrigation system broken in the ground. The heavy truck tree spade created a repair headache but the SFA crew has brought the system back to its former glory. As the planting evolves in the future, the critical parts of the controller system and valves will be protected with steel t-posts to prevent future breaks when tractors, trucks work in the plots.

The drip lines have been replaced in the plots with new lines where needed and new emitters. Devin Stage, Peter Blanchette and Thomas Dimmitt (SFA Gardens Technicians) managed the repairs over the past few months. Undergraduate students Trevor Capper and Lee Hayden have been given valuable experience at the plots. Thanks given to Sabino Bilon for providing insight into how the original system was designed and the steps to bring it back on line.

Planting and mulching

The plots have received a transfusion of plant materials for trialing and they will provide a foundation for a number of research projects. Four dump trucks of off-island sand (60 cubic yards) have been moved into the rows to provide a good foundation for the beds. Two tractor trailer loads of pine bark fines (140 cubic yards) have been incorporated into the beds as in ground amendment and as a mulch. Weeds have been killed down the rows using Glyphosate on open rows and Glufosinate on rows with plant materials. Over half of the plots are planted and the remainder will be planted as the irrigation system proves itself reliable. The existing planting plan is included at the end of this document. The plot is divided into two sections called West end and East end. Rows run from south to north.

There are a good number of interesting plants in the ground in numbers that will allow an overlay of research projects for SFASU students. Selection material include genotypes of live oaks, burr oaks, Mexico oaks, hybrid baldcypress, Magnolia ‘Kay Parris’, and others are part of the new planting, each enjoying a reputation for salt tolerance. The heavy pressure of salt and wind will be a fine torture test for determining their worth on the island.

Moody Gardens planting of hybrid bald cypress.

A block of hybrid bald cypress has been located on the north side of the west parking lot at Moody Gardens and will be monitored in their first full year of establishment. The hybrid bald cypress are selections of a cross between bald cypress and Montezuma cypress, a product of the Taxodium Breeding and Improvement Program of the Nanjing botanical garden, selections made for salt tolerance and resistance to *Cercosporidium sequoiae* (Ellis and Everth.) W.A. Baker and Partridge. Aerial and soil salt, wind and needle blight can be very strong stressors on Galveston Island.

Plantings from the previous plot have been established at various locations on the island (city parks, school yards) and they too will be monitored as to their progress. The goal is to utilize the GIS strengths of the Arthur Temple College of Forestry and Agriculture, establish a database that provides long term documentation of salt and wind tolerance and long-term performance of the plant materials involved.

FUTURE WORK

As we gain confidence with the new irrigation system, we will finish the planting. We will be adding material from the University of Florida and various select nurseries we have made contact with. We have a new relationship with a nursery on the cutting edge of Nerium oleander genetics and will be planting a range of interesting clones in that arena. We are particularly excited about new clones of *Myrcianthes fragrans* which we feel has strong merit on the island as a small tree or shrub. From western Florida, it reaches 8-12' and features an evergreen nature, exfoliating bark, attractive white flowers, orange fruit and superior foliage.

STATUS OF ORNAMENTAL PLANT EVALUATION AT MOODY GARDENS

November 2024

Brittany Zwahr collected and turned in a new batch of soil samples, essentially collecting down the row and in the row middles.

SOIL ANALYSES FOR PLOTS AT MOODY GARDENS

Brittany Zwahr
Soil, Plant and Water Analysis Laboratory
Stephen F Austin State University
PO Box 13025, SFA Station
Nacogdoches, TX 75965
936.468.4500

1615 Terracewood St.
Nacogdoches, TX 75965

(832) 525-6461
zwahrbna@jacks.sfasu.edu

11/25/2024

Saturated Paste Analysis for Salt Affected Soil

Lab #	Sample ID	pH	Electrical Conductivity dS m–1	Sodium Na	Calcium Ca	Magnesium Mg	SAR
				--------- mg kg–1 soil ---------			[--]
R49176	Random Sample	7.97	12010	2012.02	256.62905	202.8278	22.78773
R49177	Row 1 West	8.32	523	21.97817	83.964475	14.04878	0.58472
R49178	Row 2 West	8.2	487	16.8965	81.412749	14.46201	0.4535
R49179	Row 3 West	8.32	596	21.05003	99.34668	16.89324	0.513945
R49180	Row 4 West	8.35	658	52.52221	83.126904	9.884781	1.450466
R49181	Row 5 West	7.88	531	52.42094	61.634021	7.250679	1.682716
R49182	Row 1 East	8.18	546	23.26243	103.6877	11.76079	0.577399
R49183	Row 2 East	8.08	431	9.939888	86.463687	8.930199	0.272102
R49184	Row 3 East	8.1	583	40.14529	91.829867	12.29549	1.044089
R49185	Row 4 East	8.37	668	27.69039	119.66792	14.27347	0.637187
R49186	Row 5 East	8.33	753	38.42011	116.59396	10.70346	0.913123
R49187	Walkway 1 East	8.44	609	37.9744	89.219967	14.81464	0.980893
R49188	Walkway 2 East	8.36	686	30.65256	106.99282	23.05284	0.700945
R49189	Walkway 3 East	8.48	820	70.17852	93.453562	26.11755	1.653914
R49190	Walkway 4 East	8.65	872	32.62339	128.28674	31.21337	0.670033
R49191	Walkway 5 East	8.44	859	55.23664	113.98737	30.87981	1.184447
R49192	Walkway 1 West	8.69	810	19.67259	131.58368	29.9621	0.402665
R49193	Walkway 2 West	8.15	777	23.7962	123.46931	27.18781	0.505097
R49194	Walkway 3 West	8.1	885	26.45494	133.53991	30.36803	0.537603
R49195	Walkway 4 West	8.09	623	14.37416	92.608495	23.87937	0.344532
R49196	Walkway 5 West	8.09	102.9	41.65962	149.97472	34.92856	0.796236

October-November 2024 imagery

Oct 18, 2024 – Taxodium X ‘T406’ – a hybrid of the Montezuma cypress and bald cypress shows great promise in this high wind, high salt environment

Simpson’s Stopper, *Myrcianthes fragrans*, shows great promise on Galveston Island

Jonathan Carrillo, SFA Gardens Technician, with *Lagerstroemia langkaiwensism,* a rare subtropical crape myrtle under evaluation.

Acca sellowiana, pineapple guava, is another strong landscape/fruit crop

IMPROVING GARDEN PRODUCTION IN COASTAL ENVIRONMENTS USING RAISED GARDEN BEDS

Ed Bush[1] and David Creech[2]

[1]Louisiana State University AgCenter and [2]Stephen F. Austin University

[1]137 J. C. Miller Hall, Baton Rouge, LA 70803; [2]2900 Raquet St., Nacogdoches, TX 75965

Key Words: Sodic Soils, Food Insecurity, Vegetable Production, Home Gardens

Abstract

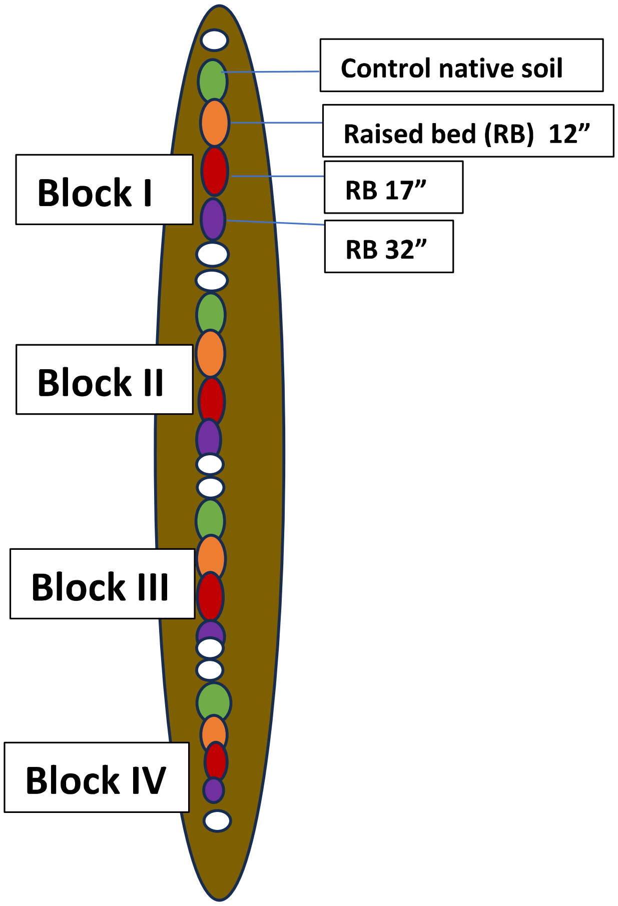
Food insecurity is particularly prevalent in coastal areas where sodic soils can make it difficult to successfully produce home gardens that supplement dietary needs of low-income gardeners. The objective of this study was to evaluate raised bed substrate depth needed to successfully produce several ornamental and garden species not typically adapted to a coastal environment. Raised beds of 12”, 17”, and 32” depth filled with an amended substrate successfully increased tomato and Irish potato yields. Tomato fruit count, yield and plant biomass were also increased by at least 2.8-fold compared to growing in the indigenous soil. Similarly, Irish potato count and yield were increased by 2.4-fold and plant biomass by as much as 3.5 times. Basil and rosemary harvest was increased by at least 2.5 times greater than the control. Sunflower and petunia count data was at least 3 times greater for 17” and 32” raised beds. Sweetpotato ‘Murasaki’ yields were increased 2 to 3 times yield when grown in 17” and 32” raised beds. Basil and rosemary harvest was increased by at least 2.5 times greater than the control. Raised beds can provide a substantial cost savings and improved nutrition in diets of low-income families.

Introduction

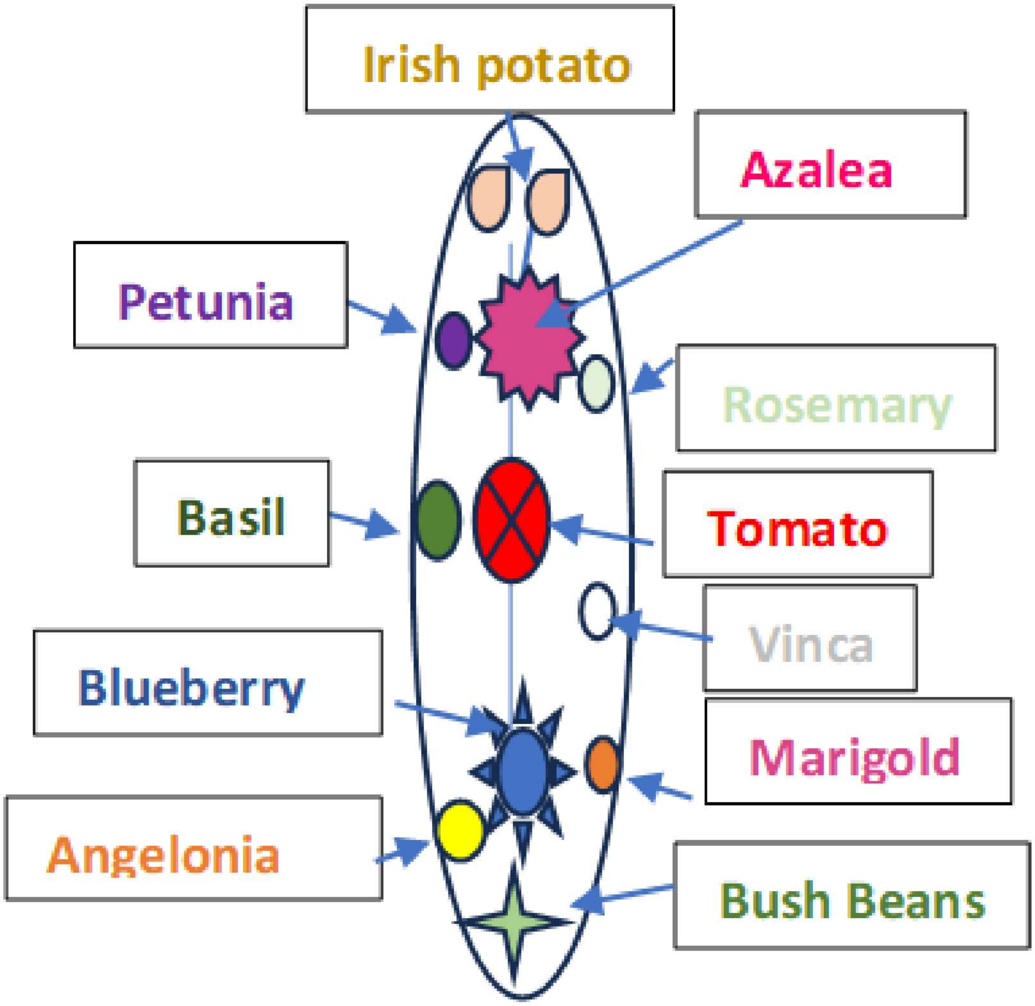
Raised garden beds are an economical and environmentally friendly way to improve access to fresh vegetables, thus benefiting the community’s nutrition status [1]. In a study focusing on an ethnically diverse group of 50 low-income family gardeners, participants produced 60% or more of the total cups of vegetables recommended by the U.S. Dietary Guidelines [2]. Additionally, gardeners produced a substantial cost savings and improved nutrition in diets of low-income families. Growing horticultural landscapes and crops in coastal environments can be challenging due to extreme winds, temperatures, sea spray, and sodic soils. Better crop performance was noticed with less salinization of the raised beds and a salt free root zone before leaching events [3]. An effective method of managing saline soils would be good use of raised beds in salt-affected irrigated arid regions. Homeowners in coastal environments are often restricted to plant species adapted to the environmental constraints. Raised beds filled with amended organic substrates can alleviate impediments to producing a successful garden in sodic soils. The objective of this study was to evaluate raised bed substrate depth needed to successfully produce several ornamental and garden species not typically adapted to a coastal environment.

Materials and Methods

A study was initiated in Galveston, Texas at the Moody Gardens research farm located adjacent to Scholes International Airport and Offats Bayou (29º6'31"N94º51'32"W). Soil sample results showed the native soil was high in Na and Cl. The native soil beds (0" control treatment) were tilled and amended with a 13-6-6 granular fertilizer at the rate of 1lb N/1000 square feet and irrigated with deionized water (0.8 EC, pH 7.0) generated on Moody Gardens property daily using a node timer adjusted to the seasonal watering requirements (0.25-to-0.5-acre inches per day). Raised bed treatments were constructed and positioned at their respective heights (12", 17", and 32") and arranged into a randomized complete block design (RCBD) with 4 blocks. Raised beds [12" metal raised beds (12" MRB), 17" metal raised beds (17" MRB), and 32" metal raised beds (32" MRB)] were filled to within 1" of the top of each container with Tiger Greaux bagged potting soil. A drip irrigation system was installed into each bed using Rainbird in-line drip pipe with 12" emitter spacing and an irrigation output of 0.5 gallons/hour. 'Cherokee Purple' tomato plants and 'Red La Soda' Irish pieces of seed potato tubers were planted into prepared, irrigated beds on February 28, 2024. On May 23, 2024, tomato fruit, Irish potato tubers and above ground plants (plant biomass) were harvested, counted, weighed, and data were statistically analyzed by species using SAS at the 0.05 level.



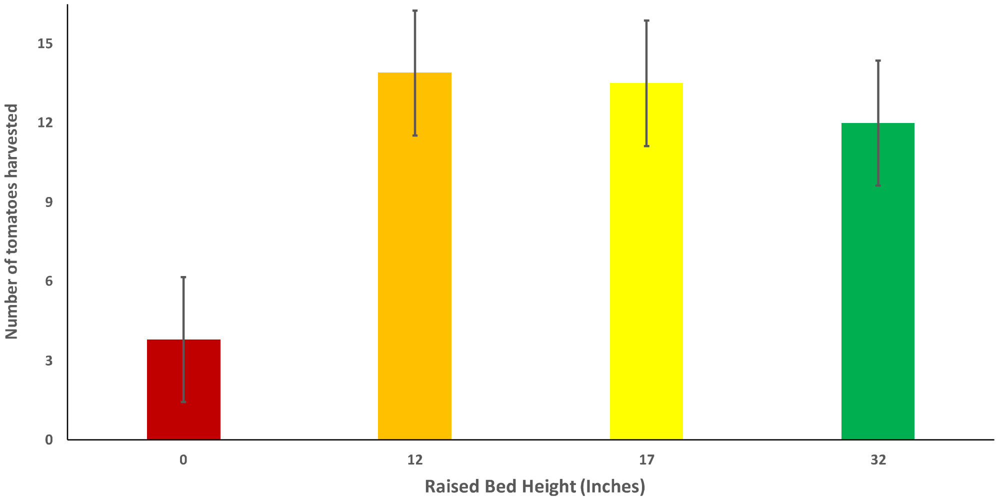
Plot Design1. Moody research farm design layout.



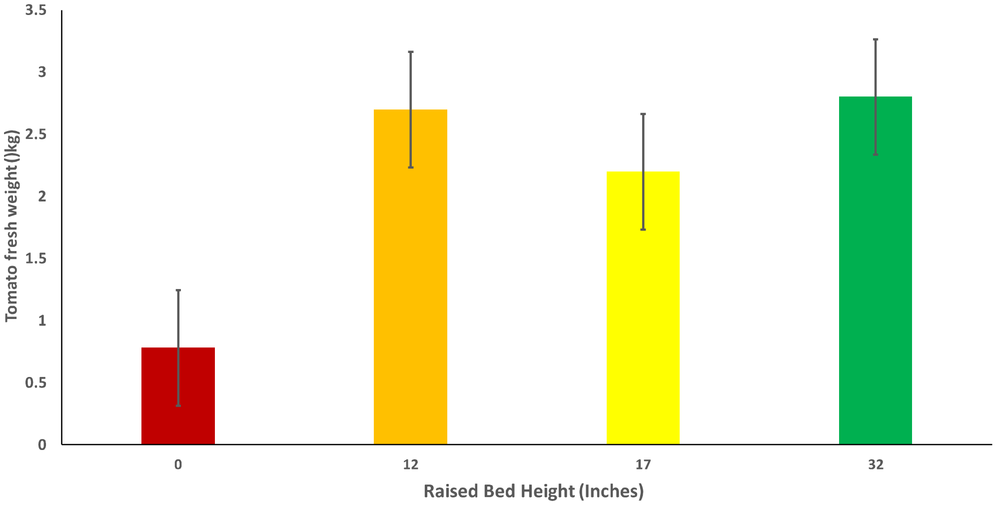
Planting Design 1. Moody research farm planting design.

Results and Discussion

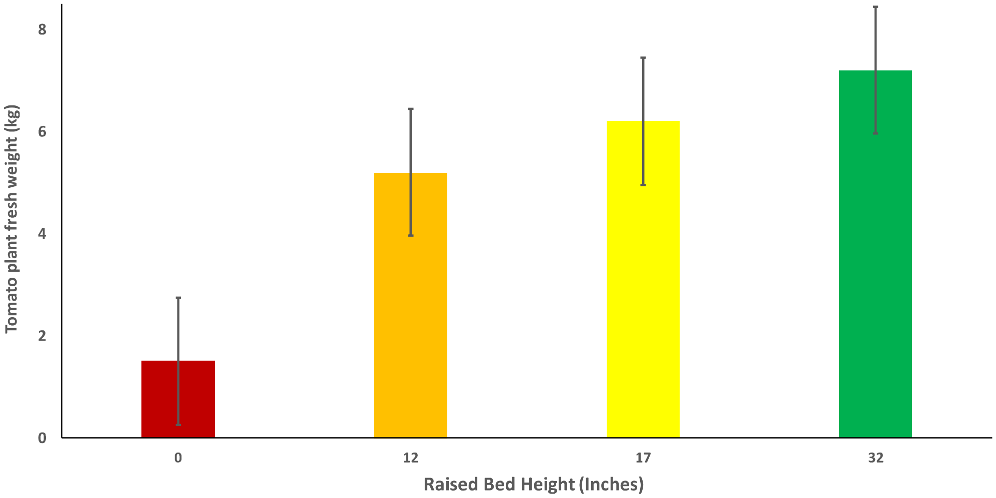
'Cherokee Purple' Heirloom Tomatoes: Statistical differences resulted for number (#) of harvested tomatoes, tomato yield (kg) and plant biomass (kg) between bed treatments. There was a 3-fold increase in number of tomatoes harvested for all raised bed treatments compared to the native soil control [Bed heights 0" control treatment (#3.8), 12" (#13.9), 17" (#13.8) and 32" (#12)] (Graph 1). Additionally, there was a greater than 2.8 times increase in total fresh tomato fruit yield [Bed heights: 0" (0.78 kg), 12" (2.7 kg), 17" (2.2 kg), and 32" (2.8 kg)] (Graph 2). Tomato plant biomass was also greater in all raised bed treatments compared to the native soil control yield (0") [Bed heights: 0" (1.5 kg), 12" (5.2 kg), 17" (6.2 kg), and 32" (7.2 kg)] (Graph 3). All raised bed treatments produced similar plant biomass weight statistically and were nearly 3.5 times greater than the control (0") beds. There were no significant differences between treatments for the average individual tomato weight harvested at the 0.05 level. There were three tomatoes damaged by worms and birds, but there was no disease present. Tomatoes were harvested at the green ripe stage. Overall results showed that raised beds (12", 17", and 32") increased tomato number, fruit yield and tomato plant biomass compared to the native soil control.



Graph 1. Raised bed height tomato production harvest on Galveston Island on Moody Gardens Research Farm.

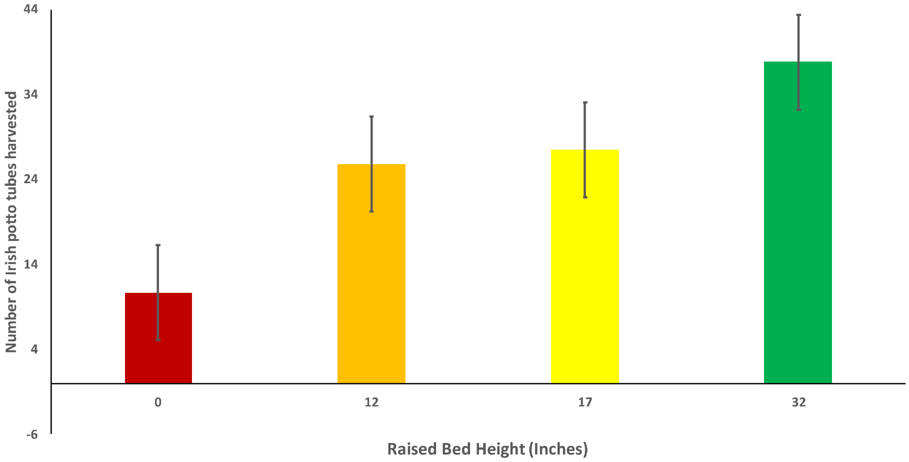


Graph 2. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.

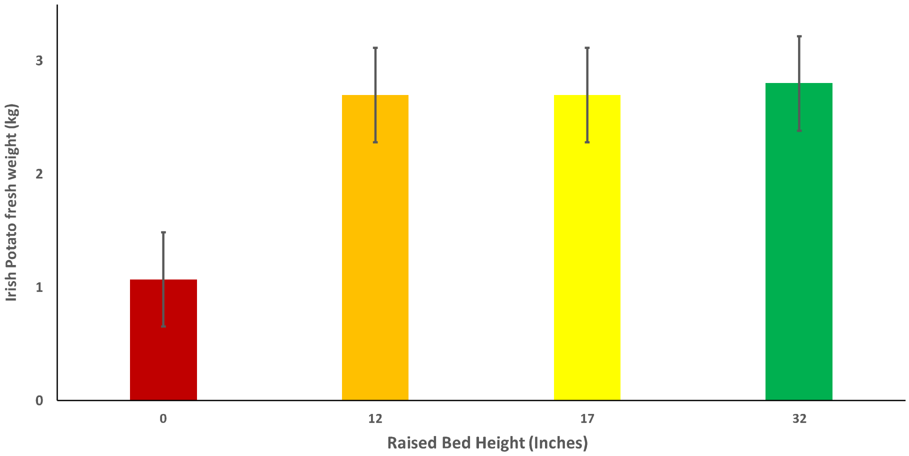


Graph 3. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.

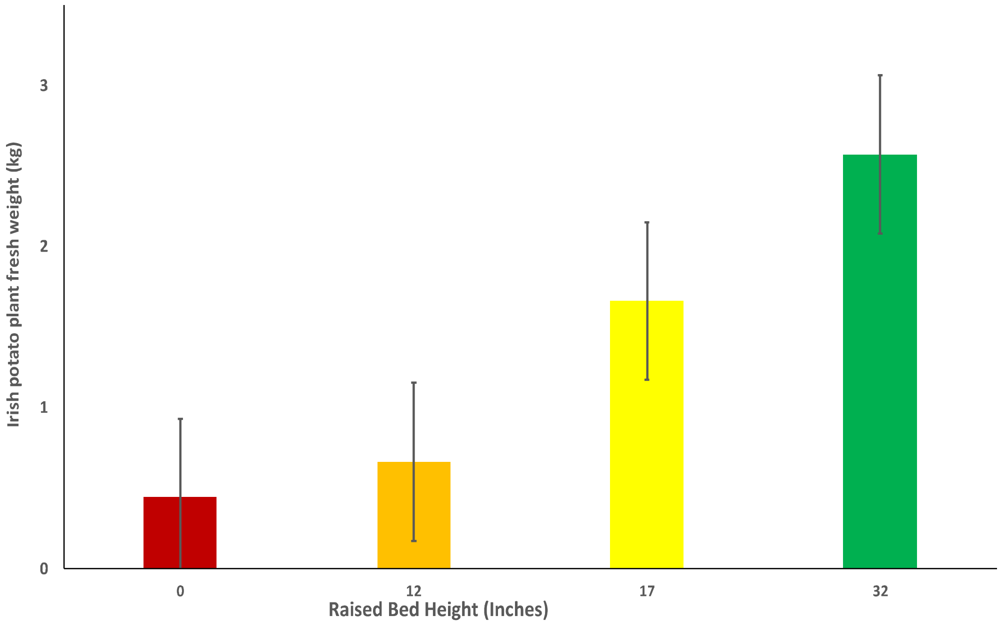
'Red La Soda' Irish Potatoes: Statistical differences resulted for number of Irish potato number, yield, and plant biomass between bed treatments at the 0.05 level. There was at least 2.4 times increase in number of Irish potato yield for all raised beds compared to the native soil control [Bed heights 0" (#10.7), 12" (#25.8), 17" (#27.5) and 32" (#37.8)] (Graph 4). Additionally, there was a greater than 2.5 times increase in total fresh weight of Irish potato tubers between the control treatment and raised beds [Bed heights: 0" (1.07 kg), 12" (2.7 kg), 17" (2.7 kg), and 32" (2.8 kg) (Graph 5). Irish potato plant biomass was also greater in the 17" and 24" raised bed treatments statistically compared to the native soil control yield [Bed heights: 0" (0.44 kg), 12" (0.66 kg), 17" (1.66 kg), and 32" (2.57 kg)] (Graph 6). The 17" and 32" raised bed treatment plant biomass was statistically similar and at least 3.5 times greater than the control (0") and 12" raised beds. There was no significant difference between the control and raised bed treatments for the average individual Irish potato weight harvested at the 0.05 level (data not shown). All Irish potatoes harvested and weighed were commercially acceptable. There was no insect damage or disease presence noticed on the plants or potatoes. For all parameters 17" and 32" raised beds resulted in significantly increased counts, produce weight, and plant biomass.



Graph 4. Raised bed height Irish potato production harvest on Galveston Island on Moody Gardens Research Farm.

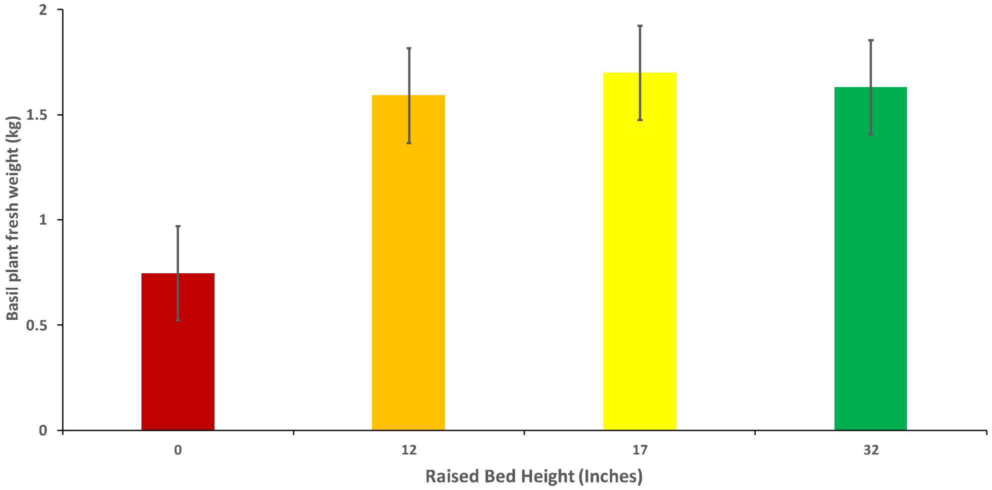


Graph 5. Raised bed height potato production harvest on Galveston Island at Moody Gardens Research Farm.



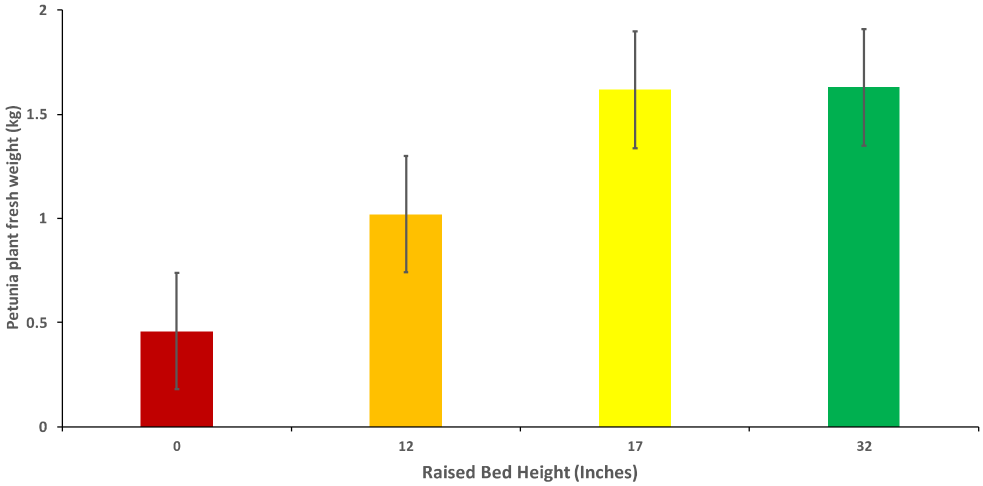
Graph 6. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.

Basil Production: There was a greater than 2.5 times increase in total fresh weight of basil between the control treatment and raised beds [Bed heights: 0” (0.75 kg), 12” (1.6 kg), 17” (1.7 kg), and 32” (1.6 kg) per plant (Graph 7). Plant biomass was similar among all raised bed treatment plants.



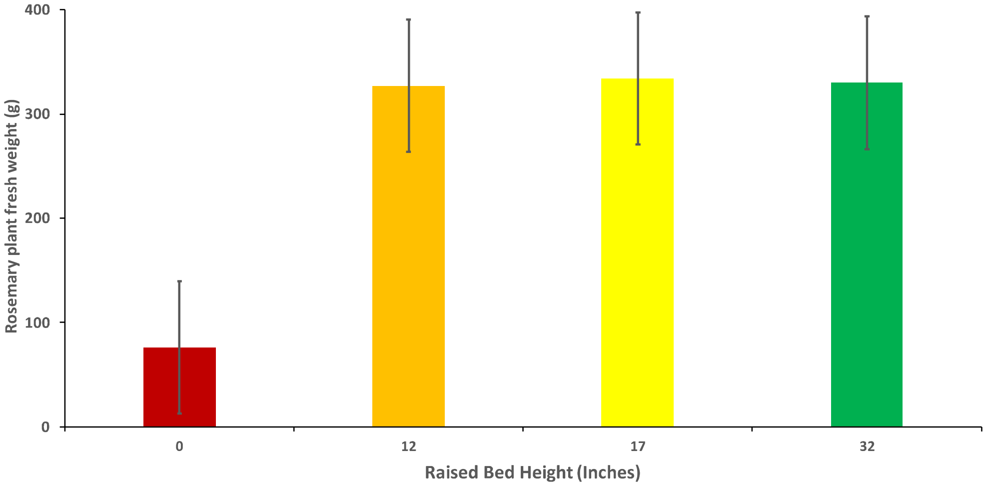
Graph 7. Raised bed height basil production harvest on Galveston Island at Moody Gardens Research Farm.

Petunia: Plant growth was good for all treatments, but exceptional for raised beds. ‘Plum Madness’ petunia biomass was greater for all raised beds (12”-1.02 kg, 17”-1.6 kg, and 32-1.7 kg) compared to the control (0.50 kg) (Graph 7).



Graph 8. Raised bed height petunia biomass harvest on Galveston Island at Moody Gardens Research Farm.

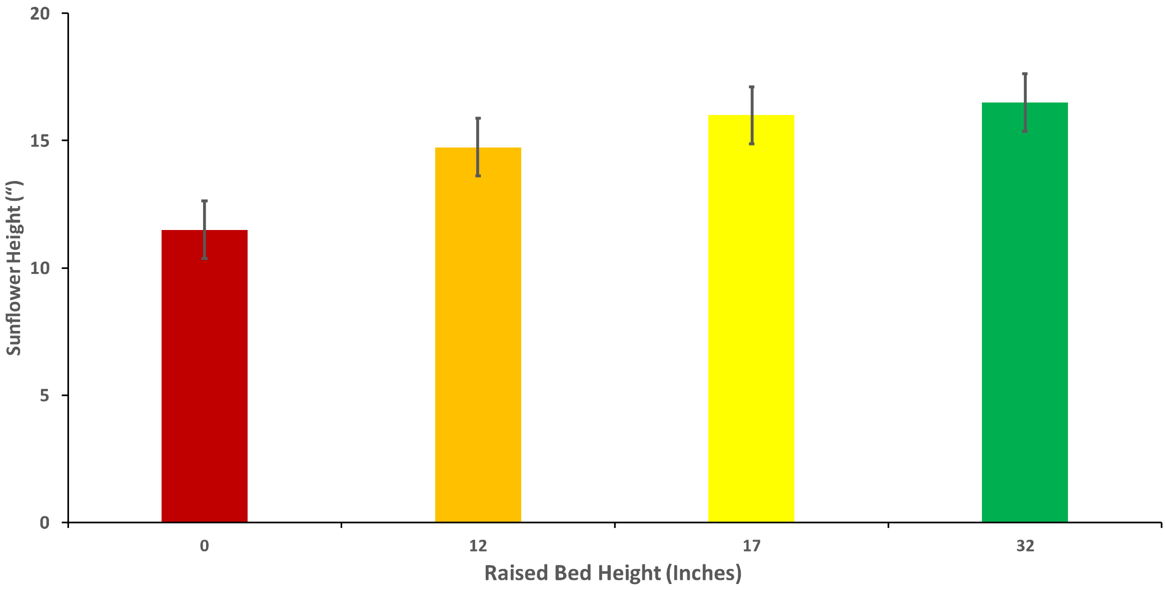
Rosemary Harvest: All raised bed production (>300g) of rosemary was significantly greater than the control plots (<100g) resulting in 3 times greater biomass (Graph 9). Foliage harvested was pruned to within one inch of the base of the plant and allowed to grow.



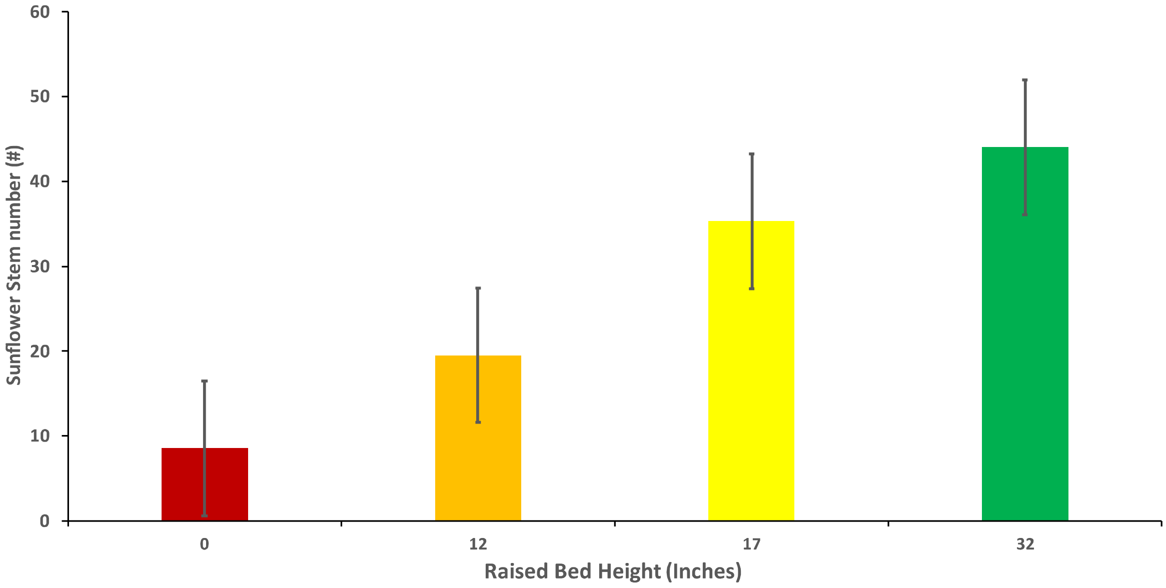
Graph 9. Raised bed height rosemary biomass harvest on Galveston Island at Moody Gardens Research Farm.

Sunflower

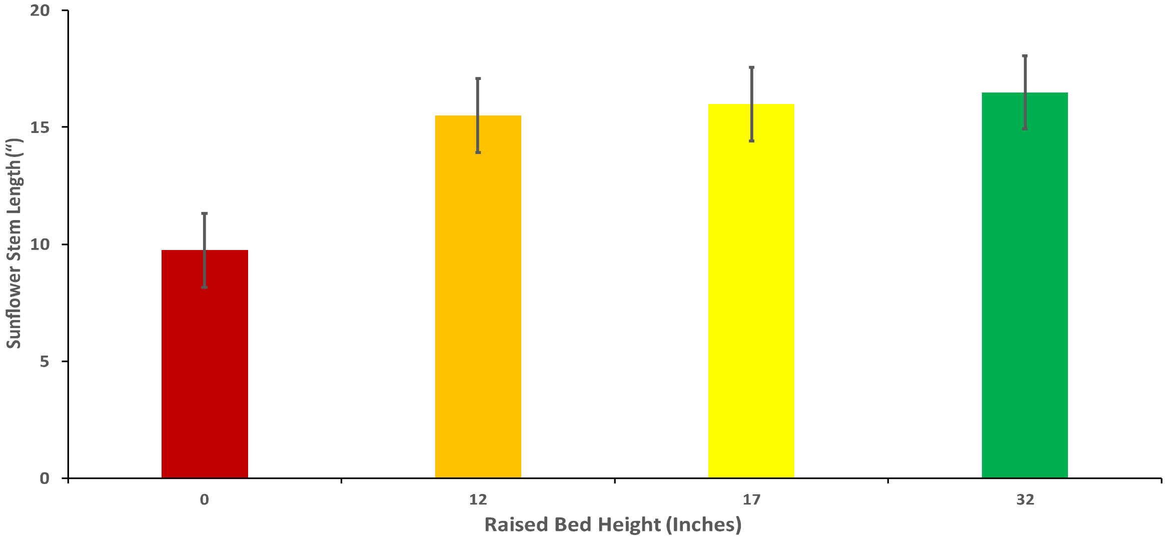
Production: Suncredible® yellow sunflower plant height (12” bed-15”, 17”-16” and 32” bed-16.6”) was greater for all raised beds compared to the control (0“ bed 11.5”) (Graph 10). All sunflower plants grown in raised beds were statistically similar. Number of flowers harvested were greater for plants grown in 17” (35.3”) and 32” (44.0”) raised beds (Graph 11). The control (8.5”), and 12” raised beds (19.5”) were statistically similar for flowers harvested. Flower stem length (12” beds-15.5”, 17” beds-16” , 32 ” beds-16.5”) was greater for all plants grown in raised beds compared to the control (9.75”) (Graph 12).



Graph 10. Raised bed height effect on Sunflower plant height on Galveston Island at Moody Gardens Research Farm.



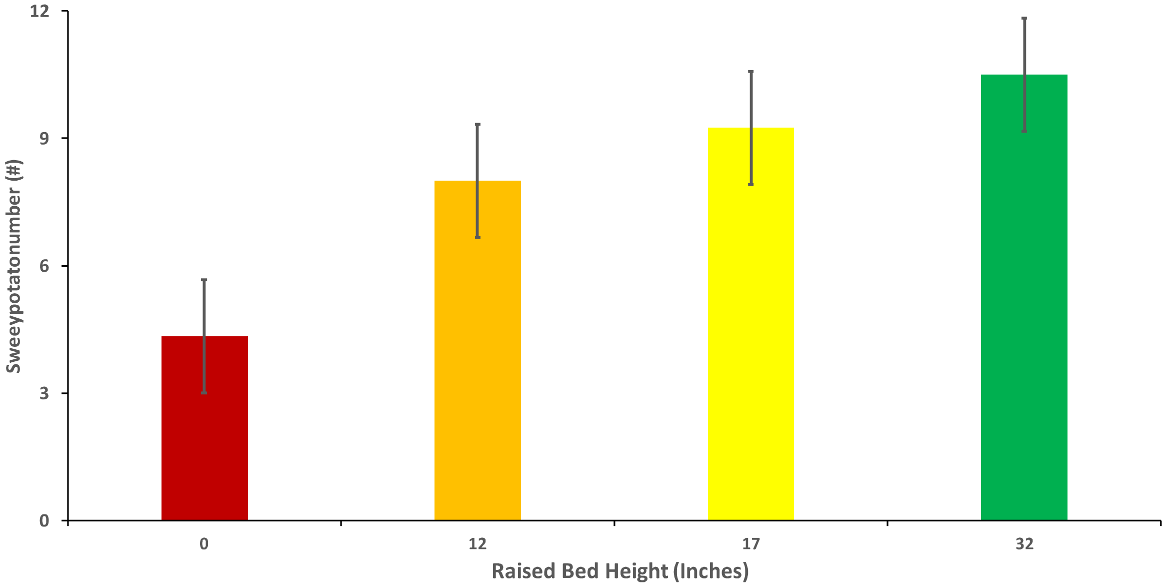
Graph 11. Raised bed height effect on number of sunflowers on Galveston Island at Moody Gardens Research Farm.



Graph 12. Raised bed height effect on Sunflower stem length on Galveston Island at Moody Gardens Research Farm.

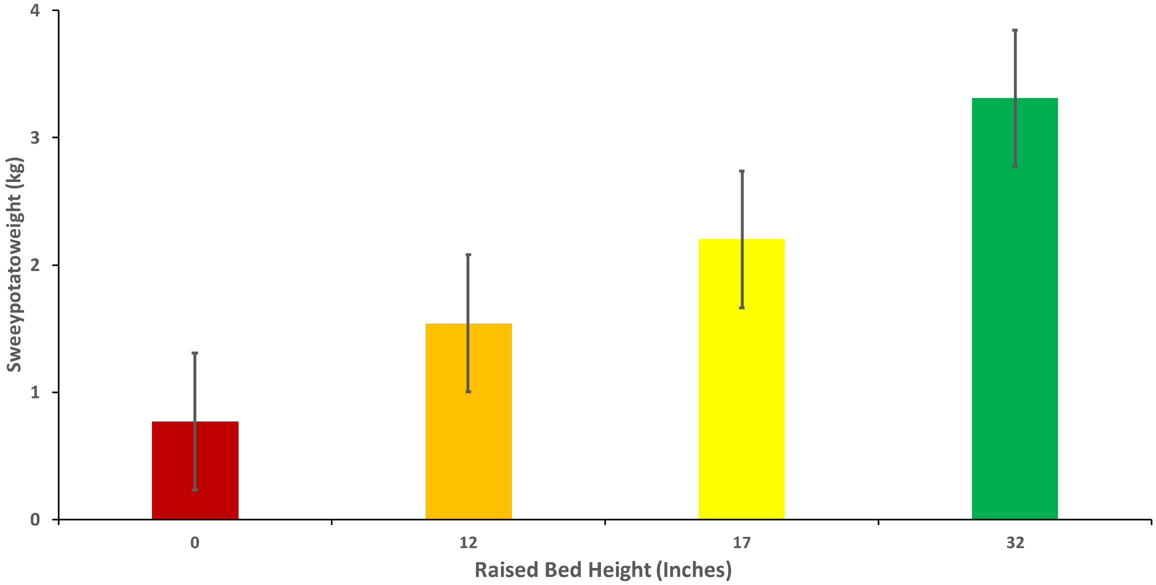
Sweetpotato Production: Number of 'Murasaki' sweetpotatoes produced in raised beds were greater compared to the control (Graph 13). There were at least twice as many sweetpotatoes

in the 17" and 32" than the control plots. Sweetpotato count for 17" (9.3) plots was twice that of the control (4.3) and for 32" plots (10.5) greater than three times tuber count yield.



Graph 13. Raised bed height effect on Sweetpotato number on Galveston Island at Moody Gardens Research Farm.

Sweetpotato yield weight was greatest for plants grown in 32" raised beds (3.3 kg), followed by the 17" raised bed (2.2 kg) (Graph 14). Yield was similar for 12" and the control (0.8 kg). Surprisingly, yields for control plots produced acceptable quality tubers, but with lower yield than raised beds.



Graph 14. Raised bed height effect on Sweetpotato weight on Galveston Island at Moody Gardens Research Farm.

Conclusions

This study supports using raised beds to maximize crop yield where coastal ecosystems typically limit healthy plant production and availability. Raised beds filled with the bagged substrate increased produce counts and produce weight for both tomatoes and Irish potatoes. Raised bed depths of 17” and 32” also increased plant biomass for Irish potatoes when compared to the native soil control beds. Raised bed production was both statistically and observably increased after harvest. Raised beds did improve harvested vegetable counts and yields. Further research on remaining plant species will continue to evaluate the effect of raised bed depth on production of other horticulture crops. These results can have positive local impact in Galveston, Texas where coastal and socioeconomic factors impede access to fresh produce. Plants grown in 17” and 32” raised beds maintained greater biomass compared to the 12” raised beds and native soils impacted by salinity.

Literature Citations

[1] Fruge, Andrew Dandridge, Sylvia H. Byrd, Pete Melby, and David Nagel. 2014. "The Economic and Nutritive Value of the Raised Bed Home Vegetable Garden: A Model for the Southeastern United States." *Food Studies: An Interdisciplinary Journal* 3 (2): 1-9. doi:10.18848/2160-1933/CGP/v03i02/40567.

[2] Algert, Susan J., Aziz Baameur, Lucy O. Diekmann, Leslie Gray & Diego Ortiz. 2016. Vegetable Output, Cost Savings, and Nutritional Value of Low-Income Families’ Home Gardens in San Jose, CA, Journal of Hunger & Environmental Nutrition, 11:(3):328-336. DOI: 10.1080/19320248.2015.1128866

[3] Velmurugan, A., T. P. Swarnam, S. K. Ambast, and N. Kumar. 2016. Managing waterlogging and soil salinity with a permanent raised bed and furrow system in coastal lowlands of humid tropics. *Agricultural Water Management*. *168*:56-67.

Images

Image 1. Native soil plots established at Moody Gardens research farm on February 28, 2024.

Image 2. Raised beds 12" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 3. Raised beds 17" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 4. Raised beds 12" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 5. Native soil grown Irish potato plants harvested at Moody Gardens research farm on May 21, 2024.

Image 6. Raised bed grown Irish potatoes plants at Moody Gardens research farm on May 21, 2024.

Image 7. Native soil grown Irish potato tubers harvested at Moody Gardens research farm on May 21, 2024.

Image 8. Raised bed Irish potato tubers harvested at Moody Gardens research farm on May 21, 2024.

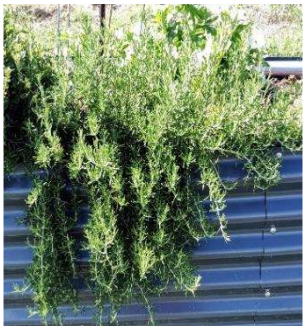
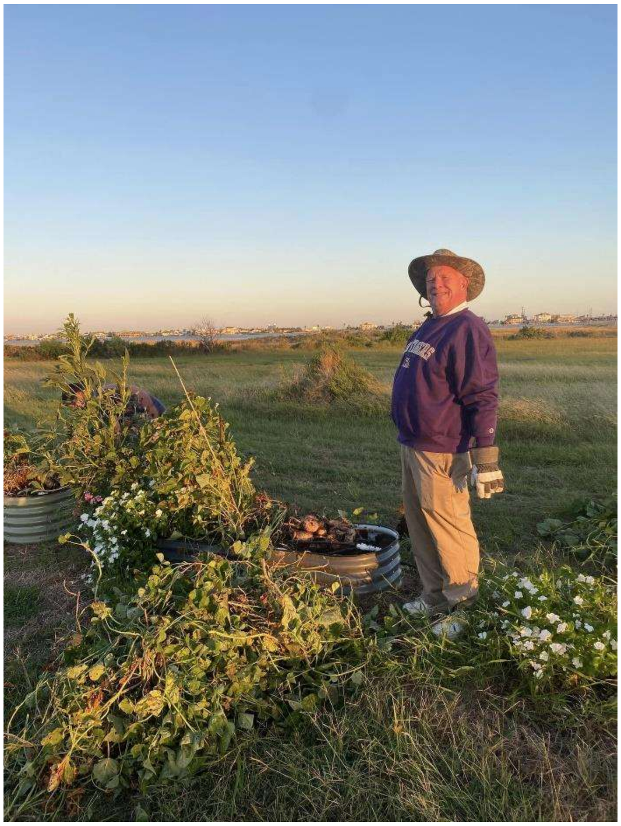


Image 9. Rosemary grown in a 32" bed harvested on June 21, 2024.

Image 10. Basil grown in a 32" raised raised bed harvested on June 21, 2024.

Image 11. Petunia plants grown in raised beds 32" raised beds and harvested on October 10, 2024.

Image 12. Sweetpotatoes grown in 17" raised bed on November 10, 2024



Dr. Ed Bush, LSU, cooperator on our Moody Gardens project and we're testing the influence of various depth Vego^{TM} containers on a range of ornamentals and vegetables. Andrea Gutierrez, SFA Gardens student assistant, is here helping with harvest and weights.

RESTORATION PLANT NURSERY PRODUCTION USING SALINE WATER INCREASES PLANT ACCLIMATION AND CONSERVES DESALINATED WATER RESOURCES

Ed Bush[1] and David Creech[2]

[1]Louisiana State University AgCenter and [2]Stephen F. Austin University

[1]137 J. C. Miller Hall, Baton Rouge, LA 70803; [2]Pineywoods Native Plant Center, 2900 Raguet Street, Nacogdoches, TX 75965

Keywords: Ecosystems, halophytes, ionic toxicity, sodic soils

Abstract

Coastal reclamation nursery production is essential for replanting coastal ecosystems damaged by construction, storms and disasters. Nursery management includes both growing and adapting plants to their final planting conditions. The objective of this study was to determine the best acclimation procedure to acclimate coastal plants to 32 ppt salinity. Most plant production was best at either 0, 8 and 16 ppt. Gradually ramping up salinity is a common practice to acclimate plants being planted in saline conditions. The tolerance of these plants will allow for better survivability in high salinity planting sites.

Introduction

Water resources are under extreme demand considering high summer temperatures and increasing population usage. Studying the use of saline water sources would reduce the cost of water treatment and possibly improve plant survivability. Many coastal plants thrive in brackish water where halophytes are adapted to grow. Some coastal plant nursery production is produced using fresh water and then gradually acclimated to increasing salinity concentrations. The objective of this study is to determine the feasibility of producing nursery plants in restoration nurseries.

Determining the amelioration benefits of different coastal plants and grasses or the absence of vegetation on marshes will provide an improved understanding of marsh grass selection and the overall costal environment. Erosion, subsidence, and salt-water intrusion, serious problems not only in Louisiana, but across the globe, continuously take a toll on land, vegetation, and habitats. With erosion comes loss of land and with land-loss comes habitat damage and economic decline. Marsh grasses and trees continuously protect vulnerable islands from dangerous storms and inauspicious saltwater intrusion. These grasses can lessen the force of strong winds and saltwater intrusion by tolerating some salinity. Without these crucial plants, environments continue to decline due to lack of protection. Even with plants, many marshes are deteriorating due to hypoxia, or lack of oxygen. An environment without oxygen cannot support life which is needed to prolong the lives of marshes. No oxygen means vegetation and habitat loss which then leads to vulnerability and later open-water areas. An effective way to combat these noxious forces is marsh grasses because they provide shelter, protect inward land against the daily ebb and flow of water, commonly reduce saltwater intrusion, prevent subsidence, and produce oxygen. This oxygen supplies organisms with necessary nutrients, and plants produce it as a biproduct of photosynthesis. There seemed to be a relationship between species and the adaptation of plants sodic waterlogged soils, as well as penetration force of the soil surface and subsidence. This valuable information can be used to effectively select marsh grasses that resist erosion and sinking and protect the marshes as well as possible. The barrier islands and marshes are essential to main-shore protection. Vegetation can slow forces of erosion, subsidence, and hypoxia on the Gulf coast. The management of coastline will require a balance between economic demands and preservation of sensitive coastal environmental resources. Coastal erosion is a serious problem in Louisiana causing significant economic and land loss. Louisiana's coastal infrastructure is worth more than $150 billion in value. The commercial fisheries in Louisiana provide 25% to 35% of the nation's entire catch. These southern fishermen are first in the yearly harvest of shrimp (*Penaeus sp.*), crabs (*Callinectes sapidus*), oysters (*Crassostrea virginica*), red snapper (*Lutjanus campechanus*), crawfish (*Procambarus clarkii*), wild catfish (*Siluriformes*), mullet (*Mugilidae*), and sea trout (*Salmotrutta*). Fisheries account for an estimated 3.1-billion-dollar impact to Louisiana in 2009. By 2050, it is predicted that the commercial fish industry will decrease by $ 550 million and the loss for recreational fisheries will be about $ 200 million a year [1]. Twenty-five percent of the energy supply in the United States is dependent on facilities in Louisiana. The oil and gas companies in Louisiana have a net value over $ 16 billion a year. Twenty thousand miles of pipes run through federal lands offshore and many more are inland. The wetlands serve as protection for pipes from waves and secure the pipelines in place. As wave action deteriorates land, more pipelines are exposed increasing the risk of shipping traffic being disrupted. Louisiana is the first in the nation for total shipping weight, so channeling occurs often to allow the large cargo to pass through successfully. Saltwater intrusion because of channelization destroys wetland plants, contributing to the loss of habitats for wildlife. It is estimated that at the current rate of land loss more than 155 miles of waterways and several of the ports will be exposed to open water within fifty years [1]. Erosion is defined as land loss caused by natural forces including water, waves, ice, wind, or tide [2]. If erosion continues at the current rate, approximately 640,000 more acres of Louisiana's land will be submerged by the year 2050 [3]. The impacted land area is approximately the size of the state of Rhode Island. Land subsidence, erosion, and sea level rise are the major contributing factors to land loss. The coast supports important infrastructure like ports, pipelines, navigational waterways, and highways which all hold financial significance. The importance of Louisiana's coast has worldwide ecological significance affecting the abundance of fisheries, wildlife, and waterfowl, and impacting a critical migratory flyway [3]. If current rates of erosion and subsidence continue, the wetland loss in Louisiana alone can cost the nation $ 36 billion in the next 50 years [3].

Researchers have established the importance of coastal and coastal plains vegetation. Bush, et al. [4] determined that after six months of flooded conditions in vegetated marshland, penetration and subsidence required the greatest penetration forces and subsided the least. Oxygen diffusion into the waterlogged soils was dependent on plant species and temperature. The penetration and subsidence results also support the conclusion that plants can reduce land loss and preserve the coast [4]. The objective of this study was to determine the best acclimation procedure to acclimate coastal plants to 32 ppt salinity.

Materials and Methods

Rooted cuttings of bitter panicum (*Panicum amarum*), marsh haygrass (*Spartina patens*), sea oats (*Uniola paniculata*) and seashore paspalum (*Paspalum vaginatum*) were planted into tree cones filled with an amended nursery potting soil. Each species was arranged into a RCBD with 15 replications. Plants were watered with salinity treatments: 0 ppt, control, 8 ppt NaCl, 16 ppt NaCl and 32 ppt NaCl. After 4 weeks plants grown with 8 ppt were watered with + 32 ppt NaCl and the 16 ppt treatment was exposed to 32 ppt. Plant species will be planted on Galveston Bay and evaluated.

Results and Discussion

On May 29, 2024, plants were arranged into each tray to be watered by their respective NaCl treatment. Plants were acclimated for 2 weeks prior to being exposed to their NaCl concentration. Lower salinity levels (0ppt, 8ppt, and 16ppt) promoted better growth in all coastal seagrasses during the early nursery stages (Figures 1, 2, 3, and 4). Specifically, when looking at the growth of plants grown in 8ppt watering regime in figure 2 for seashore paspalum there was consistent growth. Additionally, those plants were the tallest plants by the Week 6. Higher salinity regardless of the plant species maintained slower growth rate, in some cases, diminished vigor.

Conclusions

Results indicated that bitter panicum and spartina plants grew in 8ppt water. Marsh haygrass and sea oat plants preferred 0 ppt water. This data proves that lower salinities promote the growth of coastal grasses, and that preconditioning will promote the health of the ecosystems in Louisiana. Also, it would be more beneficial if preconditioning was done using lower salinities to promote coastal grass restoration.

Literature Cited

[1] Coastal Protection and Restoration Authority (CPRA). 2013. Fiscal Year 2012 Annual Plan: Integrated Ecosystem Restoration and Hurricane Protection in Coastal Louisiana. Coastal Protection and Restoration Authority of Louisiana, Baton Rouge.

[2] Spearing, D. 1995. Roadside Geology. Mountain Press Publishing Company, Missoula, 1-202.

[3] Coastal Erosion: Facts and Figures. 2012. Restore or Retreat, Inc., Thibodaux. http://www.restoreorretreat.org/la_erosion_facts.php.

[4] Bush, N., Bush, E., Blanchard, P., Bush, N. and Conover, J. 2015. Studying the Ecological Benefits of Spartina Grass Species and Use of a Mathematical Model (Pick’s Theorem) for Historical Documentation and Future Restoration of Hypoxic Marshlands. Journal of Water Resource and Protection, 7:1363-1374. http://dx.doi.org/10.4236/jwarp.2015.716110,

Images

Image 1. Four restoration grasses planted for (Seashore paspalum, bitter panicum, marsh haygrass, and Sea Oats) for the Galveston Island restoration. Six saline water regimes were established using instant ocean salt. Plants were acclimated to their trays for 2 weeks before treatments were initiated. Post-production saline acclimatization to 32 ppt salt concentrations for all species over a 4-week period.

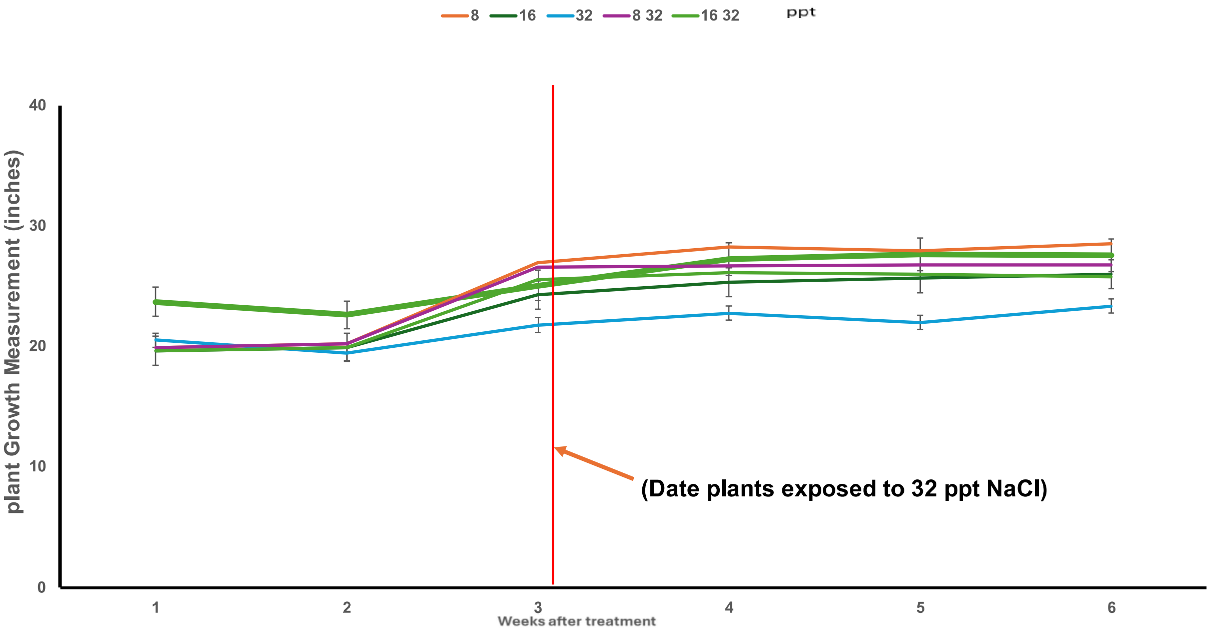


Table 1. Growth of Bitter Panicum as Effected by NaCl regimes over time

Figure 1. Growth of bitter panicum as effected by NaCl regimes over time

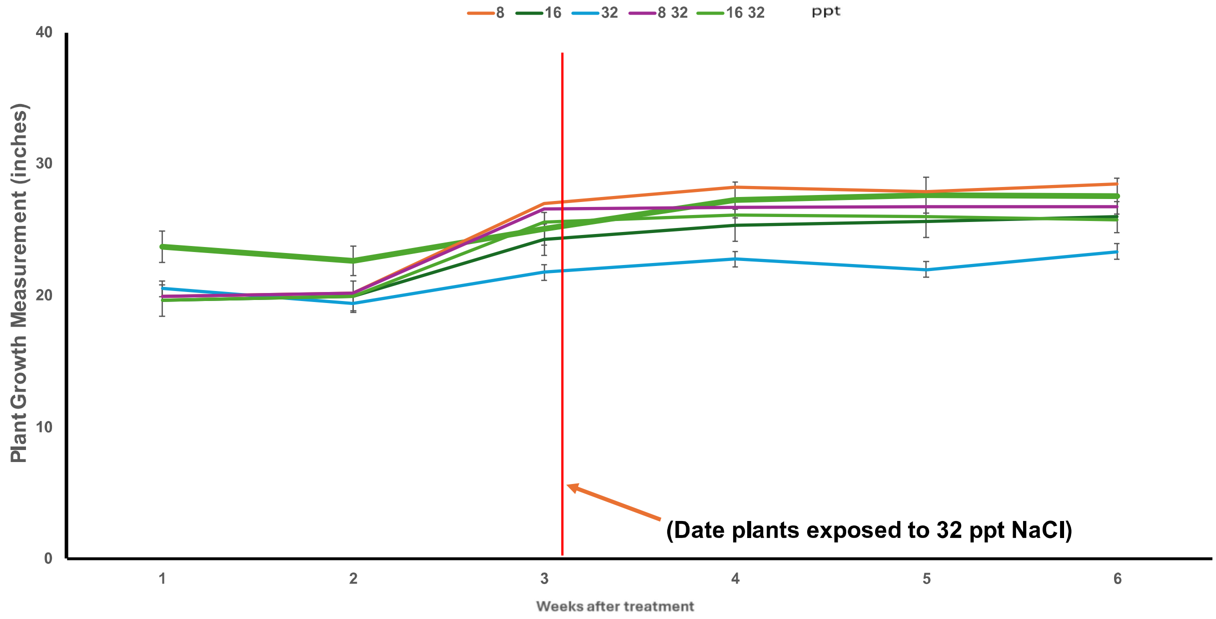


Figure 2. Growth of spartina as effected by NaCl regimes over time

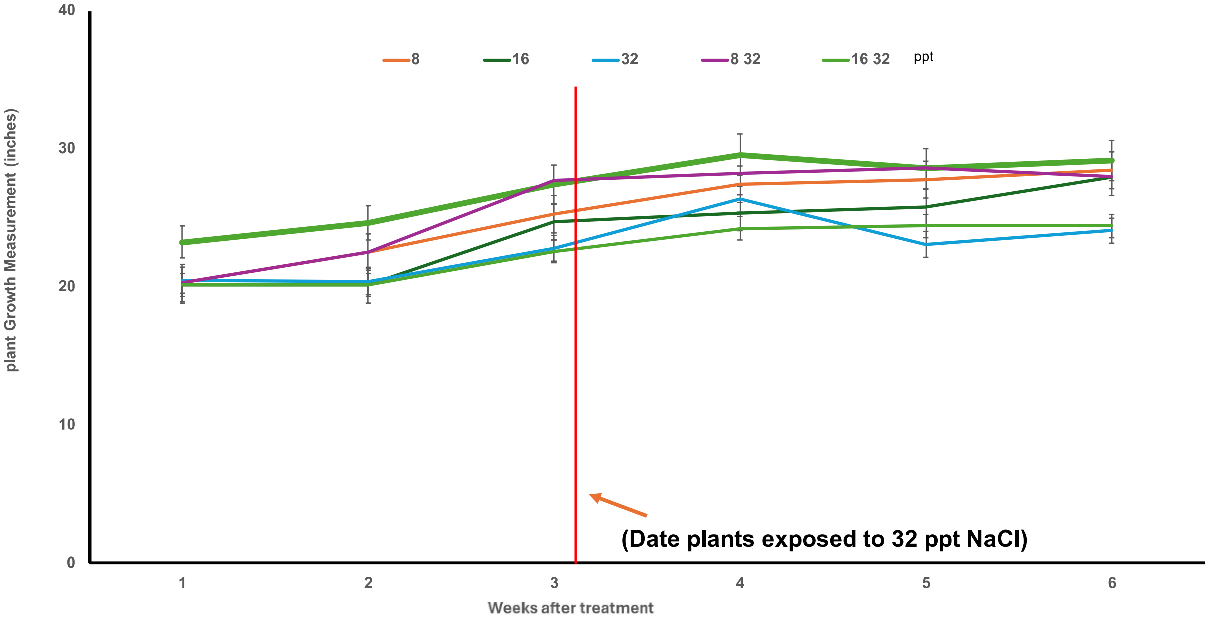


Figure 3. Growth of sea oats as effected by NaCl regimes over time

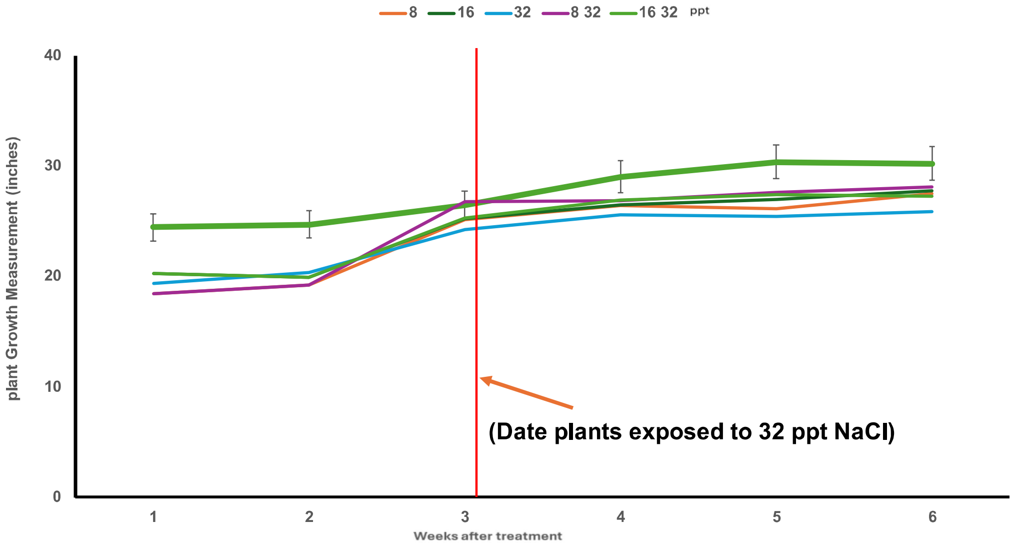


Figure 4. Growth of marsh haygrass as effected by NaCl regimes over time

CONSTRUCTION OF A SCHOOL NURSERY PRODUCTION YARD: MOODY GARDENS PLANT MATERIAL NURSERY FOR GALVESTON ISLAND RESTORATION, PRODUCTION AND PLANTING ACTIVITIES

Ed Bush[1] and David Creech[2]

[1]Louisiana State University AgCenter and [2]Stephen F. Austin University

[1]137 J. C. Miller Hall, Baton Rouge, LA 70803; [2]2900 Raquet Rd Nacogdoches, TX 75965

Key Words: Nursery production, asexual and sexual plant production, science education

Abstract

Construction of a Coastal Roots restoration nursery was accomplished adjacent to the Moody Garden Education Center on Galveston Island during the summer of 2024. The purpose of the nursery was educational and to provide teachers and students the opportunity to grow restoration trees for Moody Garden restoration efforts. Additionally, the nursery provided schools to become familiar with the restoration program. There are plans to host educational programs for schools to participate in our program and plant restoration material for Galveston Island restoration efforts. This nursery allows Moody Garden educators the option of intermittent programing for visitors.

Introduction

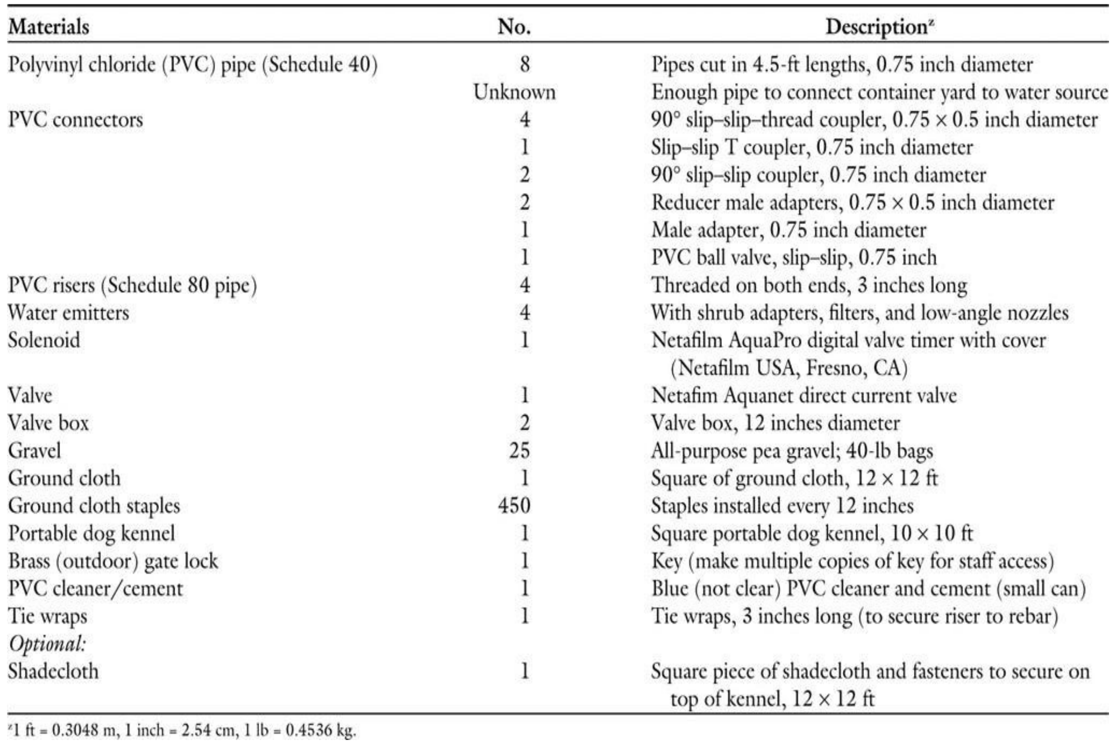
When the LSU Coastal Roots Program was initiated, teachers were planting their seeds in peat pots set out under grow lights in their classrooms. The plants from this first effort were often spindly and fragile, and the surviving seedling count was very low, usually 100 to 150 seedlings per year. To assure student success in germinating their seeds and raising healthy seedlings, several steps were taken. First, the plants were moved outside where they could receive sufficient light and adequate air movement. Second, seeds were planted in plastic seedling cells that fit neatly into a plastic plant stand, making seedling maintenance (watering, fertilizing, culling, and so on) much easier. Third, a protected container yard was devised to provide automatic irrigation, shade (if needed), and protection from vandals. These three steps helped improve the successful germination rate, on average, 50% for these initial schools. Available classroom space was at a premium and thus, moving the project outside was an idea welcomed by all the teachers in the project. Another serious problem was solved by the installation of the container yards: maintenance of the seedlings over summer vacation. Most teachers were unwilling to move the nine plant trays to their home over the summer. Thus, already overburdened facility maintenance personnel were asked to water and control the seedlings, which, sadly, meant that students returned to mostly dead plants in the fall. The container yard described in this article, with its automatic battery-operated irrigation system, meant that the teachers could control their seedlings over the summer every couple of days and that no one had to be asked to water the seedlings daily.

Container Yard Installation: The container yard used in the LSU Coastal Roots Program was designed to fit within a 10 × 10-ft square portable dog kennel (Picture 1). Dog kennels were purchased from vendors near the school. With permission of the school administration, a location was established that has ready access to water and was in a protected area of the school grounds to reduce vandalism. Under the direction of LSU Coastal Roots Program staff, students provided the installation labor for their container yard. A 9 × 9-ft square was painted on the ground to mark where a 6-inch-deep trench was to be dug. Students dig the trench while other students lay out, cut, and glue polyvinyl chloride (PVC) pipe (Schedule 40) to construct the irrigation system (Picture 1). Risers were installed at the four corners of the square and the valve and solenoid timer were installed on a side near the door. The valve and solenoid timer used in the container yard were a Netafilm DC valve (Netafilm USA, Fresno, CA) and a Netafim Node timer, respectively.

Picture 1. Coastal Roots Plant Nursery for restoration and educational plants.

The irrigation pipes were flushed, and the trenches backfilled approximately halfway to cover the pipes. Pea gravel was raked level on the ground inside the container yard to a depth of at least 3 inches. The pea gravel layer improves drainage and acts as a weed barrier for the interior of the yard. A square of ground cloth measuring 12 × 12 ft was cut and secured over the interior of the yard. Ground cloth staples were placed every 12 inches to secure the ground cloth. The ground cloth acted as a weed barrier and made the yard easier to keep clean of plant debris. The ends of the ground cloth were buried in the trenches with the remaining soil, and this was covered with pea gravel so that it was even with the interior of the container yard. The portable dog kennel was erected around the area being careful not to break the irrigation risers and to place the door nearest the solenoid timer. The timer was programed, and the emitters adjusted to reach the entire area of the enclosure. The kennel door was locked so that unwanted visitors could not enter the yard. A complete list of materials is provided in Table 1.

Table 1. Materials and parts list for a container yard installation for a school participating in the Louisiana State University Coastal Roots Program: A School Seedling Nursery Program.



Materials	No.	Description[z]
Polyvinyl chloride (PVC) pipe (Schedule 40)	8	Pipes cut in 4.5-ft lengths, 0.75 inch diameter
	Unknown	Enough pipe to connect container yard to water source
PVC connectors	4	90° slip–slip–thread coupler, 0.75 × 0.5 inch diameter
	1	Slip–slip T coupler, 0.75 inch diameter
	2	90° slip–slip coupler, 0.75 inch diameter
	2	Reducer male adapters, 0.75 × 0.5 inch diameter
	1	Male adapter, 0.75 inch diameter
	1	PVC ball valve, slip–slip, 0.75 inch
PVC risers (Schedule 80 pipe)	4	Threaded on both ends, 3 inches long
Water emitters	4	With shrub adapters, filters, and low-angle nozzles
Solenoid	1	Netafilm AquaPro digital valve timer with cover (Netafilm USA, Fresno, CA)
Valve	1	Netafim Aquanet direct current valve
Valve box	2	Valve box, 12 inches diameter
Gravel	25	All-purpose pea gravel; 40-lb bags
Ground cloth	1	Square of ground cloth, 12 × 12 ft
Ground cloth staples	450	Staples installed every 12 inches
Portable dog kennel	1	Square portable dog kennel, 10 × 10 ft
Brass (outdoor) gate lock	1	Key (make multiple copies of key for staff access)
PVC cleaner/cement	1	Blue (not clear) PVC cleaner and cement (small can)
Tie wraps	1	Tie wraps, 3 inches long (to secure riser to rebar)
Optional:		
Shadecloth	1	Square piece of shadecloth and fasteners to secure on top of kennel, 12 × 12 ft

[z] 1 ft = 0.3048 m, 1 inch = 2.54 cm, 1 lb = 0.4536 kg.

Results

Nursery construction began on April 20, 2024, near the educational Center. The yard was finished and was used on May 20, 2024, and Moody Garden staff were trained to plant bald cypress seed and make bitter panicum cuttings. Instruction was provided on filling the tray, watering and planting seed and sticking cuttings. These activities can occur with a single individual or large groups. Following maturity of these plants, groups can plant on Moody Garden property or offsite. On May 21, 2024, volunteers and staff were given a tour of the research plots. Volunteers were shown the coastal plant plots and were encouraged to include this site for educational tours and field trips. Seedlings began to sprout by June 4, 2024. Seedlings were thinned and fertilized on June 17, 2024. Bitter panicum was also healthy and growing and will be fertilized at the same time as the bald cypress trees. Cuttings and seedlings will be propagated through early fall by the Moody Garden educators on demand for client participants.

Conclusions

A simple automated, functional container yard design for the LSU Coastal Roots Program has helped students managing school-based plant nurseries be successful producers of wetland plants. These schools are working toward the goal of *Coast 2050: Toward a Sustainable Coastal* Louisiana Coastal Wetlands Conservation and Restoration Authority [7]: to create and sustain habitats, to maintain habitat diversity, and to maintain the exchange of energy and organisms within our coastal environments. By building hands-on experiences, students can become active participants in wetland conservation and become more aware of the environment in which they live [8]. Prepared nursery production guides provide guidance to produce restoration plants for restorative projects. Future research planned for this program includes a survey of how teachers integrate the use of the container yard into their lessons and school activities, what students gain from 1) growing the plants and 2) transplanting their plants into the environment at their partner restoration site. Research on students' attitudes toward the environment is also planned as is research on the stewardship aspects of the program. It is hoped that this research will help form and guide the program so that students will realize that small actions can have a major impact and that their efforts, both now and in the future, can help shape a positive future for our coastal wetlands. Using this yard as part of the Moody Garden Education Center has the potential to expand on-demand hands-on activities that teach stewardship and community service. Grasses and trees can be used to restore the Galveston shoreline.

Literature Cited

[1] Emekauwa, E. 2004. They remember what they touch: The impact of place-based learning in East Feliciana Parish. Place-based education collaborative 1 Aug. 2004 <http://www.peecworks.org/peec/peec_research/S0009d4fb-0084fe88>.

[2] Lieberman, G.A. & Hoody, L.L. 1998. Closing the achievement gap: Using the environment as an integrating context for learning 17 Feb. 2009 <http://www.seer.org/pages/gap.html>.

[3] Karsh, K.L. 2005. Integrating horticulture biology and coastal environmental issues into the middle school science curriculum MS thesis, Louisiana State Univ Baton Rouge, LA 18 Feb. 2008. <http://etd.lsu.edu/docs/available/etd-03282005-124326/>.

[4] Louv, R. 2006. Last child in the woods: Saving our children from nature-deficit disorder Algonquin Books Chapel Hill, NC.

[5] Blair, D. 2009. The child in the garden: An evaluative review of the benefits of school gardening *J. Environ. Educ.* 40:15-38.

[6] Roth, C.E. 1992. Environmental literacy: Its roots, evolution, and directions in the 1990s Environmental Education Columbus, OH.

[7] Coastal Protection and Restoration Authority (CPRA). 2013. Fiscal Year 2012 Annual Plan: Integrated Ecosystem Restoration and Hurricane Protection in Coastal Louisiana. Coastal Protection and Restoration Authority of Louisiana, Baton Rouge.

[8] Blanchard, P.B. 2009. LSU Coastal Roots: Seedling nursery program for wetland restoration 16 Feb. 2009 <5http://coastalroots.lsu.edu>.

[9] Coleman, E.B. and Bush, E.W. 2002. Putting down roots: Starting a seedling nursery for wetland replanting 25 May 2007 <http://nsgl.gso.uri.edu/lsu/lsuh02002.pdf>.

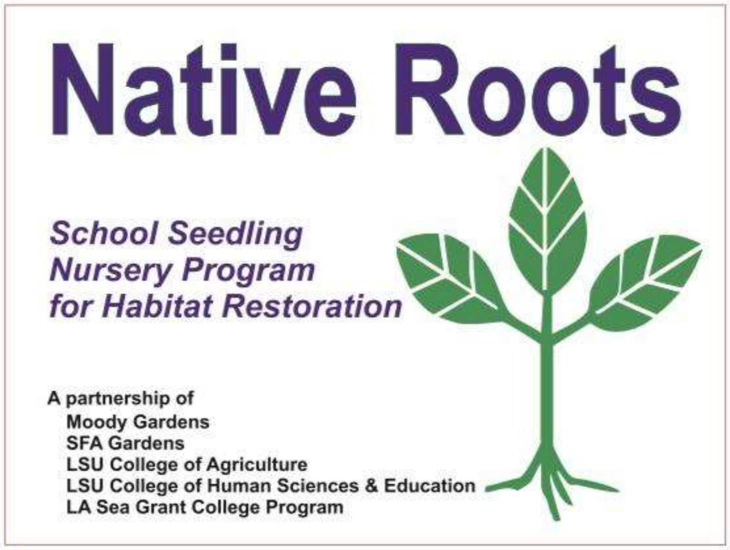
BRINGING A NATIVE ROOTS PROGRAM TO TEXAS SCHOOLS

Ed Bush[1] and David Creech[2]

[1]Louisiana State University AgCenter and [2]Stephen F. Austin University

[1]137 J. C. Miller Hall, Baton Rouge, LA 70803; [2]2900 Raquet Rd Nacogdoches, TX 75965

SFA Gardens is attempting to bring a modification of LSU's "Coastal Roots" program to Texas Schools. This 25-year-old program has touched the lives of thousands of school kids and hundreds of teachers in Louisiana. It has been an award-winning program that has made a difference in ecological restoration projects that involves our youngest citizens. As 2024 comes to an end, we have two propagation yards in Texas as prototypes; one is at Moody Gardens, Galveston, TX and one is at Chireno, Texas.



As a prototype for future installations, the first school installation is at Chireno, Texas, under the supervision of teacher Ryan Johnston. The installation from start to finish takes less than one day and that includes connecting the propagation yard to a source of water, installing the controllers and minisprinkler system, gravel base, weed barrier and securing the propagation yard (chain link dog kennel) to the ground. SFA Gardens provides starter media, flats, trays and seed

.

CONSTRUCTION OF RAISED BEDS AND ESTABLISHMENT OF PLANT PROPAGATION STOCK FOR TEACHING NURSERIES AND RESTORATION PROJECTS

Ed Bush[1] and David Creech[2]

[1]Louisiana State University AgCenter and [2]Stephen F. Austin University

[1]137 J. C. Miller Hall, Baton Rouge, LA 70803; [2]2900 Raquet Rd Nacogdoches, TX 75965

Keywords: Asexual plant propagation, Stock plants, Restoration plants

Abstract

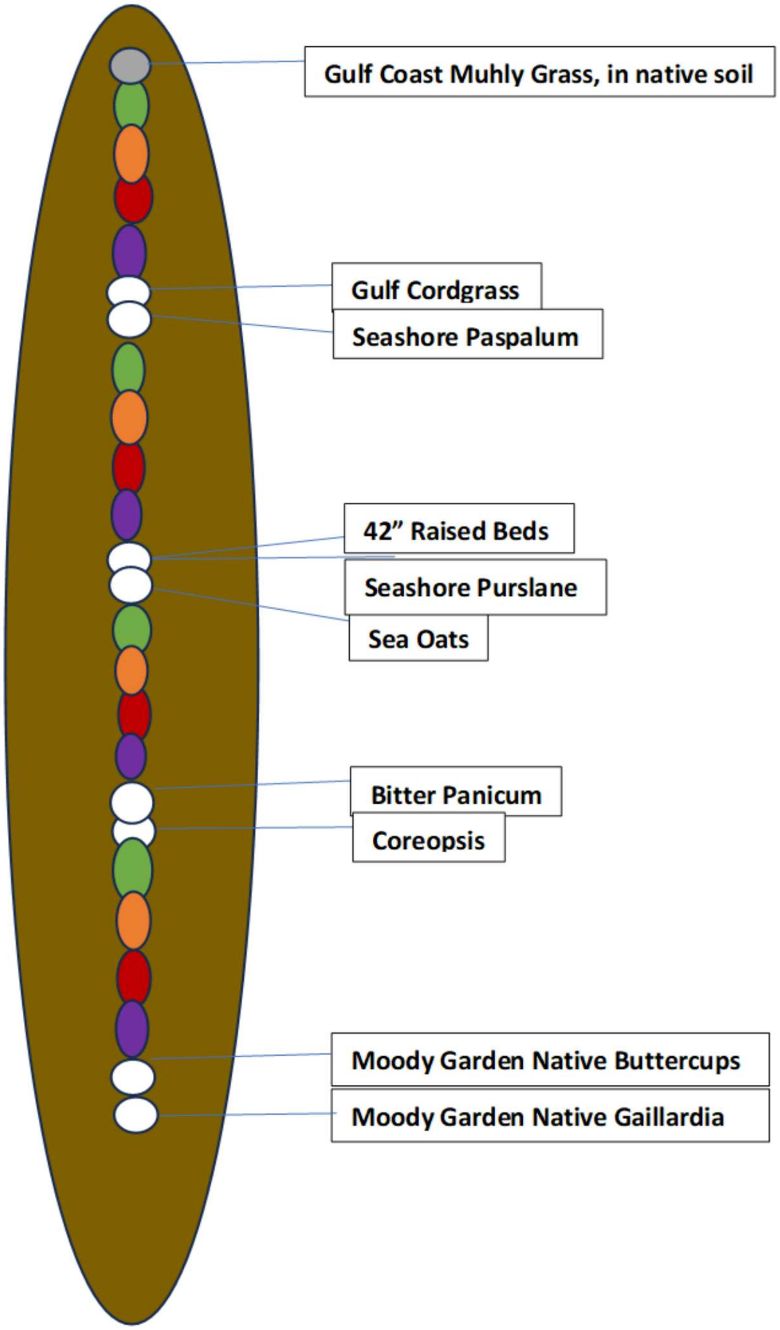
Establishment of educational restoration plots at Moody Gardens and plant propagation material was essential for the education program and school nursery programs. Several grass species (marsh hay grass, seashore paspalum, sea oats, coastal muhly grass) and dicots (seashore purslane, buttercups, coreopsis) were established for sexual and asexual reproduction efforts.

Introduction

Plant propagation is essential to produce restoration plants to restore lost coastline protection and remediation projects throughout the coast of the United States. The Gulf Coast is especially impacted by Petroleum industry, climate change and increasing frequencies of stronger hurricanes. Marine vegetated habitats occupy 0.2% of the ocean surface but sequester 50% of carbon burial in marine sediments [1]. Restoration efforts require stock plants that can provide healthy adapted plants [2]. Coastal plants adapted to the coast of Galveston can reduce erosion, sequester pollutants, uptake nutrients and reduce wave energy. The objective of this project was to build and establish these beds for future coastal restoration and education efforts.

Materials and Methods

On April 20, 2024, coastal plant liners of bitter panicum, seashore purslane, gaillardia, sand cordgrass, Gulf Coast muhly grass, sea oats, coreopsis, buttercups, and seashore paspalum were planted into 42" diameter round beds at a 17" depth Vego raised metal beds filled with an amended bag substrate (Tiger Greaux potting Soil, Phillips Bark Inc., Brookhaven, MS). Five-1" liners of bitter panicum, sea oats, seashore paspalum, and seashore purslane were spaced and planted into individual species irrigated beds. Gulf Coast Muhly grass was established using a 1-gallon nursery container plant. Gaillardia and buttercups were selected, harvested, and planted into the beds. Automated irrigation was delivered to each bed using rainbird in-line drip tube with emitters spaced every 12" delivering 0.5 gallons per minute.



Plot Design 2. Moody Garden research farm bed design layout.

Results and Discussion

Raised beds (42" diameter Vego round metal beds) were constructed on February 28, 2024, at the Moody Gardens research farm located adjacent to Scholes International Airport and Offats Bayou (29º6'31"N94º51'32"W). Raised beds were filled to within 1" of the top of each container with Tiger Greaux bagged potting soil. Plants were established throughout the year and pruned as needed. A drip irrigation system supplied deionized water (0.8 EC, pH 7.0) generated on Moody Gardens property daily using a node timer adjusted to the seasonal watering requirements (0.25 to 0.5" acre inches per day).

Conclusions

Raised beds were constructed, filled, planted, and established with 9 coastal restoration plants adapted to Galveston Island, Texas. Currently plants are growing and blooming to maturity to serve as stock plants for production in the Coastal nursery or directly on the beach or marsh. These beds were established for educational and restoration efforts.

Literature Cited

[1] Duarte, C.M., Losada, I.J., Hendriks, I.E., Mazarrasa, I. and Marbà, N., 2013. The role of coastal plant communities for climate change mitigation and adaptation. *Nature climate change*, *3*(11):961-968.

[2] Bush, N., Bush, E., Blanchard, P., Bush, N. and Conover, J. 2015. Studying the Ecological Benefits of Spartina Grass Species and Use of a Mathematical Model (Pick’s Theorem) for Historical Documentation and Future Restoration of Hypoxic Marshlands. Journal of Water Resource and Protection, 7:1363-1374. http://dx.doi.org/10.4236/jwarp.2015.716110.

Image 1. Construction and arrangement of experimental beds in progress on February 27, 2024 at the Moody Gardens Research farm.

Image 2. Bitter panicum beds at Moody beds at the Moody Gardens Research farm.

Image 3. Gaillardia beds at Moody beds at the Moody Gardens Research farm.

Image 6. Seashore purslane beds at Moody beds at the Moody Gardens Research farm.

Image 7. Coastal Muhly Grass beds at Moody beds at the Moody Gardens Research farm.

Image 8. Sand Cordgrass Grass beds at Moody beds at the Moody Gardens Research farm.

Image 9. Marsh Cordgrass Grass beds at Moody beds at the Moody Gardens Research farm.

APPENDIX

PLANTING PLAN DEC 2024

COASTAL ROOTS NEWSLETTER

PUBLICATION REPRINT ON FIRST PROJECT WITH VEGA CONTAINERS

MOODY GARDENS PLOT PLAN - DEC 2024

ROWS RUN S TO N, PLANTS IN ROW FRUN E TO W

Block	ROW	PLANT #	GENUS	SPECIES	VARIETY
EAST	1	1	*Quercus*	*virginiana*	Twinwood
EAST	1	2	*Quercus*	*virginiana*	Twinwood
EAST	1	3	*Quercus*	*virginiana*	Twinwood
EAST	1	4	*Quercus*	*virginiana*	Twinwood
EAST	1	5	*Quercus*	*virginiana*	Twinwood
EAST	1	6	*Quercus*	*virginiana*	Twinwood
EAST	1	7	*Quercus*	*virginiana*	Twinwood
EAST	1	8	*Quercus*	*virginiana*	Twinwood
EAST	1	9	*Quercus*	*rysophylla*	SFA tree
EAST	1	10	*Quercus*	*virginiana*	Twinwood
EAST	1	11	*Quercus*	*virginiana*	Twinwood
EAST	1	12	*Quercus*	*virginiana*	Twinwood
EAST	1	13	*Quercus*	*virginiana*	Twinwood
EAST	1	14	*Quercus*	*virginiana*	Twinwood
EAST	1	15	*Quercus*	*virginiana*	Twinwood
EAST	1	16	*Quercus*	*virginiana*	Twinwood
EAST	1	17	*Quercus*	*virginiana*	Twinwood
EAST	1	18	*Quercus*	*virginiana*	Twinwood
EAST	1	19	*Quercus*	*virginiana*	Twinwood
EAST	1	20	*Quercus*	*virginiana*	Twinwood
EAST	1	21	*Quercus*	*virginiana*	Twinwood
EAST	1	22	*Quercus*	*virginiana*	Twinwood
EAST	1	23	*Quercus*	*virginiana*	Twinwood
WEST	1	1	*Quercus*	*virginiana*	Twinwood
WEST	1	2	*Quercus*	*virginiana*	Twinwood
WEST	1	3	*Quercus*	*virginiana*	Twinwood
WEST	1	4	*Quercus*	*virginiana*	Twinwood
WEST	1	5	*Quercus*	*virginiana*	Twinwood
WEST	1	6	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	7	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	8	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	9	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	10	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	11	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	12	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	13	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	14	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	15	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	16	*x*	*x*	Twinwood

WEST	1	17	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	18	*Quercus*	*muehlenbergii*	Twinwood
WEST	1	19	*Lagerstroemia*	*indica*	Freedom'
EAST	2	1	Quercus	muehlenbergii	Twinwood
EAST	2	2	Quercus	San Carlos	Twinwood
EAST	2	3	Quercus	San Carlos	Twinwood
EAST	2	4	Quercus	muehlenbergii	Twinwood
EAST	2	5	Quercus	muehlenbergii	Twinwood
EAST	2	6	Quercus	muehlenbergii	Twinwood
EAST	2	7	Quercus	muehlenbergii	Twinwood
EAST	2	8	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	9	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	10	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	11	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	12	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	13	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	14	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	15	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	16	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	17	*Taxodium X*	*distichum x mexicanum*	T 406
EAST	2	18	*Ficus*	*carica*	Beall
EAST	2	19	*Ficus*	*carica*	Panachee
EAST	2	20	*Ficus*	*carica*	capiflia long
EAST	2	21	*Ficus*	*carica*	Celeste
EAST	2	22	*Quercus*	*San Carlos*	
EAST	2	23	*Quercus*	*San Carlos*	
WEST	2	1	*Callicarpa*	*longissima*	SFA CLONE
WEST	2	2	*Callicarpa*	*longissima*	SFA CLONE
WEST	2	3	*Callicarpa*	*longissima*	SFA CLONE
WEST	2	4	*Lagersroemia*	*indica*	Freedom
WEST	2	5	*Lagersroemia*	*speciosa*	prple flwr;
WEST	2	6	*Lagersroemia*	*indica*	Freedom
WEST	2	7	*Lagersroemia*	*indica*	Freedom
WEST	2	8	*Lagersroemia*	*indica*	Freedom
WEST	2	9	*Lagersroemia*	*limii*	
WEST	2	10	*Lagersroemia*	*indica*	Freedom
WEST	2	11	*Lagersroemia*	*indica*	Freedom
WEST	2	12	*Lagersroemia*	*indica*	Freedom
WEST	2	13	*Lagersroemia*	*indica*	Freedom
WEST	2	14	*Lagersroemia*	*indica*	Freedom
WEST	2	15	*Lagersroemia*	*limii*	early flwr
WEST	2	16	*Lagersroemia*	*indica*	Freedom

WEST	2	17	*Lagersroemia*	*langkaiwiensis*	burgundy fol
WEST	2	18	*Lagersroemia*	*indica*	Freedom
EAST	3	1	*x*	*x*	SFA Gardens
EAST	3	2	*x*	*x*	SFA Gardens
EAST	3	3	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	4	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	5	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	6	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	7	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	8	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	9	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	10	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	11	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	12	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	13	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	14	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	15	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	16	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	17	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	18	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	19	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	20	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	21	*Quercus*	*San Carlos*	SFA Gardens
EAST	3	22	*Euronymus*	*japonicus*	Chollipo
EAST	3	23	*Amorpha*	*fruticosa*	SFA Gardens
WEST	3	1	*Acca*	*sellowiana*	Brock seedling
WEST	3	2	*Acca*	*sellowiana*	Brock seedling
WEST	3	3	*Acca*	*sellowiana*	Brock seedling
WEST	3	4	*Acca*	*sellowiana*	Brock seedling
WEST	3	5	*Acca*	*sellowiana*	Brock seedling
WEST	3	6	*Acca*	*sellowiana*	Brock seedling
WEST	3	7	*Acca*	*sellowiana*	Brock seedling
WEST	3	8	*Acca*	*sellowiana*	Brock seedling
WEST	3	9	*Acca*	*sellowiana*	Brock seedling
WEST	3	10	*Acca*	*sellowiana DEAD*	Brock seedling
WEST	3	11	*Quercus*	*virginiana*	Twinwood
WEST	3	12	*Quercus*	*virginiana*	Twinwood
WEST	3	13	*Quercus*	*virginiana*	Twinwood
WEST	3	14	*Myrcianthes*	*fragrans*	SFA SEEDLING
WEST	3	15	*Myrcianthes*	*fragrans*	SFA SEEDLING
WEST	3	16	*Myrcianthes*	*fragrans*	SFA SEEDLING
WEST	3	17	*Myrcianthes*	*fragrans*	SFA SEEDLING

WEST	3	18	*Myrcianthes*	*fragrans mexicana*	SFA Gardens
WEST	3	19	*Myrcianthes*	*fragrans mexicana*	SFA Gardens

EAST	4	1	*Agave*	*ovatifolia*	SFA Gardens
EAST	4	2	*Agave*	*ovatifolia*	SFA Gardens
EAST	4	3	*Agave*	*ovatifolia*	SFA Gardens
EAST	4	4	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	\5	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	6	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	7	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	8	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	9	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	10	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	11	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	12	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	13	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	14	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	15	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	16	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	17	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	18	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	19	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	20	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	21	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	22	*Magnolia*	*grandiflora*	Kay Parris
EAST	4	23	*Magnolia*	*grandiflora*	Kay Parris

WEST	4	1	*Psidium*	*guajava*	Everde
WEST	4	2	*Psidium*	*guajava*	Everde
WEST	4	3	*Psidium*	*guajava*	Everde
WEST	4	4	*Psidium*	*guajava*	Everde
WEST	4	5	*Psidium*	*guajava*	Everde
WEST	4	6	*Acca*	*sellowiana*	sfa
WEST	4	7	*Acca*	*sellowiana*	sfa
WEST	4	8	*Acca*	*sellowiana*	sfa
WEST	4	9	*Acca*	*sellowiana*	sfa
WEST	4	10	*Acca*	*sellowiana*	sfa
WEST	4	11	*Acca*	*sellowiana*	sfa
WEST	4	12	*Acca*	*sellowiana*	sfa
WEST	4	13	*Acca*	*sellowiana*	sfa
WEST	4	14	*Acca*	*sellowiana*	sfa
WEST	4	15	*Acca*	*sellowiana*	sfa
WEST	4	16	*Acca*	*sellowiana DEAD*	sfa
WEST	4	17	*Acca*	*sellowiana*	sfa

WEST	4	18	*Acca*	*sellowiana DEAD*	sfa
WEST	4	19	*Acca*	*sellowiana*	sfa
WEST	4	20	*Acca*	*sellowiana DEAD*	sfa
WEST	4	21	*Acca*	*sellowiana*	sfa

EAST	5	1	*Populus*	*X*	Purple Tower
EAST	5	2	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	3	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	4	*Populus*	*X*	Purple Tower
EAST	5	5	*Populus*	*X*	Purple Tower
EAST	5	6	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	7	*Populus*	*X*	Purple Tower
EAST	5	8	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	9	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	10	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	11	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	12	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	13	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	14	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	15	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	16	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	17	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	18	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	19	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	20	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	21	*Quercus*	*San Carlos*	JFG garden seed
EAST	5	22	*Acca*	*sellowiana*	Brock seedling
EAST	5	23	*Acca*	*sellowiana*	Brock seedling
EAST	5	24	*Acca*	*sellowiana*	Brock seedling

WEST	5	1	*Acca*	*sellowiana*	Brock seedling
WEST	5	2	*Acca*	*sellowiana*	Brock seedling
WEST	5	3	*Acca*	*sellowiana*	Brock seedling
WEST	5	4	*Acca*	*sellowiana*	Brock seedling
WEST	5	5	*Acca*	*sellowiana*	Brock seedling
WEST	5	6	*Acca*	*sellowiana*	Brock seedling
WEST	5	7	*Acca*	*sellowiana*	Brock seedling
WEST	5	8	*Acca*	*sellowiana*	Brock seedling
WEST	5	9	*Acca*	*sellowiana*	Brock seedling
WEST	5	10	*X*	*X*	X
WEST	5	11	*X*	*X*	X
WEST	5	12	*Acacia*	*maidenii*	cutting grown
WEST	5	13	HOLE	TREE SPACE	
WEST	5	14	*Quercus*	*muhlenbergii DEAD*	seedling

WEST	5	15	*Quercus*	*grisea DEAD*	seedling
WEST	5	16	*Quercus*	*laceyi DEAD*	seedling
WEST	5	17	*Quercus*	*virginiana*	seedling
WEST	5	18	*Quercus*	*mohriana*	seedling
WEST	5	19	*Querecus*	*muhlenbergii*	seeding
EAST	6	1	*Quercus*	*laceyi*	SFA Gardens
EAST	6	2	*Quercus*	*muhlenbergii*	SFA Gardens
EAST	6	3	*Querecus*	*mohriana DEAD*	SFA Gardens
EAST	6	4	*Quercus*	*muhlenbergii*	SFA Gardens
EAST	6	5	*Araucaria*	*araucana*	old planting
EAST	6	6	*Quercus*	*laceyi*	SFA Gardens
EAST	6	7	*Quercus*	*muhlenbergii*	SFA Gardens
EAST	6	8	*Quercus*	*San Carlos DEAD*	JFG garden seed
EAST	6	9	*Quercus*	*San Carlos*	JFG garden seed
EAST	6	10	*Quercus*	*San Carlos*	JFG garden seed
EAST	6	11	*Quercus*	*mohriana*	SFA Gardens
EAST	6	12	*Quercus*	*San Carlos*	JFG garden seed
EAST	6	13	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	14	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	15	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	16	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	17	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	18	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	19	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	20	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	21	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	22	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	23	*Grevillea*	*robusta Peaches n Cream*	Florida
EAST	6	24	*Myrcianthes*	*fragrans var mexicana*	Ogden
EAST	6	25	*Myrcianthes*	*fragrans var mexicana*	Ogden
EAST	6	26	*Myrcianthes*	*fragrans var mexicana*	Ogden
EAST	6	27	*Populus*	*X*	Purple Tower

Greauxing Roots

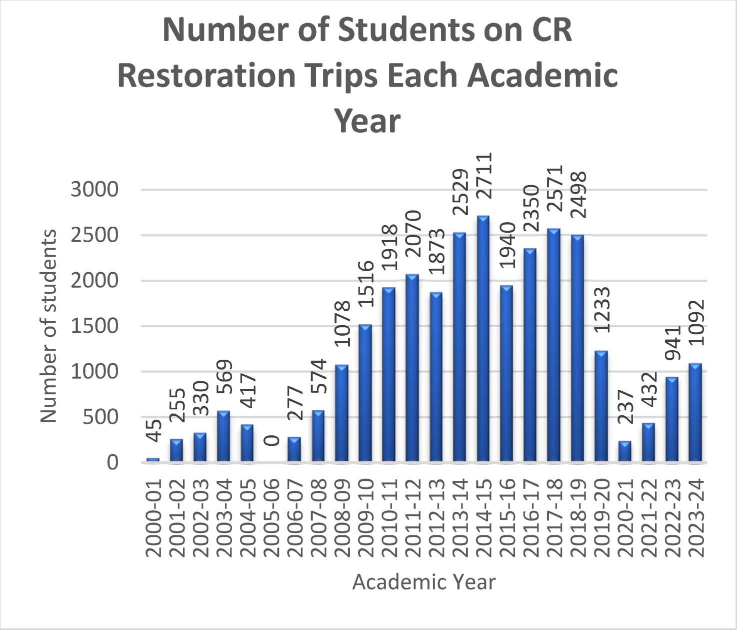
A newsletter of the LSU Coastal Roots Program www.lsu.edu/coastalroots April 2024

A partnership of
LSU Lutrill & Pearl Payne School of Education
LSU School of Plant, Environmental, & Soil Sciences
Louisiana Sea Grant College Program

Your students' legacy to our Louisiana coastal plain!

Restoration trip totals: 2000 - May 2024

★ **29,456 students** ★ **212,330 plants** ★ **561 trips**
★ **2,005 teachers** ★ **4,238 chaperones**



Effects of the COVID-19 Pandemic and Recent Hurricanes on the Coastal Roots Program

When the COVID-19 pandemic closed schools down on March 13, 2020, the immediate result was the cancellation of 13 of the 33 scheduled Coastal Roots trips scheduled at the end of the 2019-2020 school year. Another impact of the pandemic has been reduced maintenance of tree seedlings and innumerable instances of water being shut off in the nurseries. Many of our CR teachers no longer had access to the school grounds and all of us were on a steep learning curve to learn how to teach our normally hands-on subject via Zoom technology. Admittedly, many of us were exhausted and were worried about our collective health. With the passage of four hurricanes since 2020 (Laura, Delta, Zeta, and Ida) several schools were damaged as well has homes of the teachers.

As we know, it takes work and time to bring a dormant nursery back online. We've lost contact with more than 10 schools in the aftermath of the COVID-19 pandemic and recent hurricanes. Our latest school count is 46 schools (10 of these are dormant due to teacher turnover or hurricane damage) in 17 parishes. The good news is that we've heard from 6 new schools that are interested in joining (or rejoining) our program!

Survey for Winter Workshop Feedback, CREATE nominations, and Summer PD

We ask all our teachers in the Coastal Roots Program to please complete the survey that was emailed to them on April 23. This survey asks for Winter Workshop feedback, information on your ideas for summer professional development and allows you to nominate yourself to serve on the CR Educational Advisory Team (CREATE; see article on page 3). Please take 10 minutes to fill out the survey!

https://lsu.qualtrics.com/jfe/form/SV_6Io3GqrMRqT0Oh0

A new CR co-director joins Ed and Pam.

Mrs. Dani DiIullo, Director of Engagement and Outreach for the LA Sea Grant College Program, has joined Ed and Pam as co-directors of the CR Program. Dani is an expert at organizing professional development and running MWEEs (Meaningful Watershed Educational Experiences) and place-based educational experiences for all ages. She has worked in formal and informal education in over half a dozen states. She tries to drag her family outside as often as possible, with moderate success! Under Dani's leadership, LA Sea Grant's education and outreach program has truly become PreK-to-gray, as she works with youth, graduate students, faculty, teachers, and numerous community stakeholders. She received her BS from Davidson College, double majoring in biology and economics. After working for a number of years in the classroom and in the field she went back and got her master's degree from the Scripps Institute of Oceanography, focusing on environmental literacy. If Pam had her way, Dani would get herself a PhD! Dani will be taking on some of the responsibilities for the Winter Workshop programming, and we hope, in time, for the return of the CR Summer Institutes. She has already run several restoration trips for CR and has assisted with installations. Please reach out to Dani (ddiiullo@lsu.edu) and welcome her to CR!

Equipment for Your Nursery

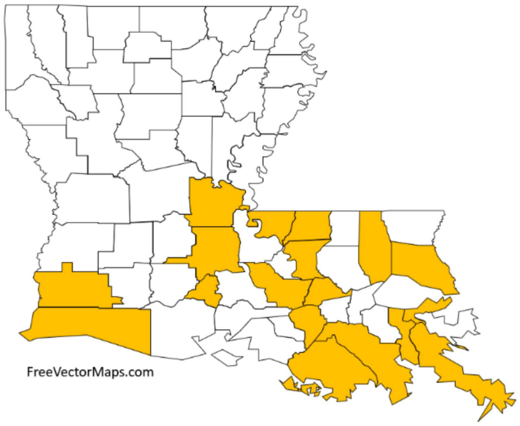
Items that are FREE!	Items that have a COST!
Nursery signs – FREE	**Planting template** – 1st free with nursery installation, then $70 for a new stainless-steel template.
Ground cloth replacements – FREE	**Rain gauge** – 1st free with nursery installation, then $10 each thereafter.
Black tray replacements – FREE	**Irrigation timer** - $125 each
Yellow cell replacements – FREE	**Large flow tray** - $125 each
Irrigation heads – FREE	

LSU Coastal Roots at a Glance

School type	# schools
Public	18
Public charter	6
Parochial	19
Private	3

Grade level	# schools
Elementary	9
Middle	22
High	17

Type of plant	# schools
Tree	37
Grass	8
Tree & grass	1



Distribution of CR Schools by Parish

Parishes with CR Schools

Parish	# Schools
Ascension	2
Assumption	1
Avoyelles	1
Calcasieu	1
Cameron	1
EBR	10

Parish	# Schools
E Feliciana	1
Iberville	1
Jefferson	6
Lafayette	4
Lafourche	1
Orleans	7

Parish	# Schools
Plaquemines	1
St. Landry	2
St. Tammany	3
Tangipahoa	1
Terrebonne	2
W. Feliciana	1

Join CREATE: CR Educational Advisory Team

To assist in making CR Program decisions, Pam, Ed and Dani are forming a CR Educational Advisory Team (CREATE) of teachers. The purpose of this group will be to provide advice on policies for the CR Program and make recommendations for the Winter Workshop and CR Handbook materials. This CR Advisory Team will be asked to meet 1-2 times a year (via ZOOM). We will ask for two members to serve 1 year and three members to serve two years. After this initial year another request will be sent out next August (2025) to ask for two additional applicants to serve a term of two years in place of the outgoing members.

To volunteer your talents and experience for the CR Educational Advisory Team (CREATE), you must meet the following specifications:

- available to meet 1-2 times a year (via ZOOM),
- interested in improving the CR Program in creative and meaningful ways.
- The CREATE team will consist of 1-2 experienced lead teachers (8+ years), 1-2 mid-experienced lead teachers (2-7 years), and 1-2 New CR lead teachers (0-2 years).

This is a self-nomination process. Members will be selected from self-nominations. ***A survey will be sent out at the beginning of May to solicit nominations***.
https://lsu.qualtrics.com/jfe/form/SV_6lo3GqrMRqT0Oh0 Deadline is **May 15, 2024**.

openclipart.com

Helping Hands!

Wannapik Studio

Help comes in all sizes and ages! We had a 300-foot roll of ground cloth that had to be cut into 15-foot lengths. This would have taken all day for Pam to do by herself. To the rescue… **Dani Dilullo** and her daughters, **Stella** and **Addie**. Cutting cloth isn't exactly a fun job, but Stella and Abby were real troopers. Before we knew it, we had the whole roll finished, folded and ready for new Coastal Roots nurseries! Thank you!

You know the saying, "Many hands make light work"? That was exactly the case when the **Louisiana Sea Grant Education and Outreach** Team at (at far left) joined in to help cut and plant bitter panicum nodes last September. Together we planted four trays of bitter panicum nodes. These grasses are destined to help restart some of the Coastal Roots' nurseries that grow these beach dune grasses.

Tommy Blanchard, Pam's husband, has helped her weigh our seeds the night before our Winter Workshop for more than 20 years. Yes, Pam loves AND appreciates him and his careful work!

There is nothing that brings on butterflies like a bus full of students excited about their planting trip. **Dani Dilullo** (far left laughing with Brian Pember, Bayou Teche National Wildlife Refuge, about having to push the CR van out of the mud) and **Ali McMillian** (near left) did just that this past January and February after Pam took a spill on some black ice that resulted in broken bones. They ran all the restoration trips in January and February and let Pam tag along once she was able to navigate on crutches. Kudos and thanks to these strong and capable women who are not afraid of a challenge.

Coastal Roots YouTube Channel.

Thanks to the talents and hard work of **Bridget Seghers**, an undergraduate honors college student interested in Louisiana's wetlands, we now have a Coastal Roots YouTube Channel! You can access the captioned videos we have: **https://www.youtube.com/channel/UCSGeKuY8KncRZ7Ud_7xL6Fw**. Right now, we have five videos available: cleaning riser heads, fertilizing your seedlings with Osmocote, using the GPS units for location information, how to use the green (or stainless steel) planting templates, and how to properly install a shade cloth. *Coming soon*: How to program your NODE timer!

Rutherford Beach, Cameron Parish (2020)

The beach in Cameron Parish that we plant on is Rutherford Beach. Hurricane Laura (Category 4) and Hurricane Delta (Category 2) devastated the area. The picture to the right shows what is left of the picnic pavilion after H. Laura – a slab of concrete, two picnic tables, a couple of grills and one pole that once held the roof. I took a screenshot from a drone video and is looking north. The waterway is where the paved road met the beach next to the pavilion. There is not much left of the cluster of homes west of where we planted. The screenshot is from https://www.youtube.com/watch?v=rSY4E3om1qg

*NOTE ON RUTHERFORD BEACH: This image is of damage done by H. Laura, which made landfall 12 miles west of this beach. I have not been able to find any footage or photographs of our planting area or S. Cameron High after H. Delta made landfall there in October, 2020. H. Delta came ashore on top of Rutherford Beach with winds of 101 mph & a storm surge of 9.3 feet (https://www.washingtonpost.com/weather/2020/10/12/hurricane-delta-winds-surge-rain/).*Additional drone footage of Rutherford Beach after H. Laura at https://www.theadvertiser.com/videos/news/2020/09/01/hurricane-laura-damage-drone-footage-shows-rutherford-beach-after-storm/5680613002/; Drone footage of South Cameron High School after H. Laura: https://www.theadvertiser.com/videos/news/2020/09/01/hurricane-laura-damage-drone-footage-shows-south-cameron-high-school-after-storm/5680658002/

Grand Isle State Park

I emailed the Grand Isle State Park manager to make restoration trip arrangements for St. Paul's Episcopal School (NOLA). I asked how the park faired in the storms, particularly H. Zeta. She said that park property at both ends of the island lost substantial amounts of sand. At least 3-4 feet of sand was eroded near the pier within the main park. All the park buildings (including her park manager's home) survived with varying degrees of damage. The levee (fake sand dune) that runs the length of the island was heavily damaged and breached in several places. Grand Isle was hit again when Hurricane Ida came ashore in 2021. Needless to say, that storm, a Category 4 at landfall with winds of up to 150 miles per hour, destroyed and damaged many vacation homes and wreaked havoc on the fake sand dunes and beaches.

At left: U.S. Army Corps of Engineers personnel survey levee damage Friday at Grand Isle, La, which was one of the areas hardest hit by Hurricane Zeta. More photos at arkansasonline.com/1031zeta/. (AP/Matthew Hinton). Additional photos at https://www.theadvertiser.com/picture-gallery/news/2020/10/30/photos-hurricane-zeta-damage-grand-isle-louisiana/6088609002/

Moving or Renewing Your Nursery

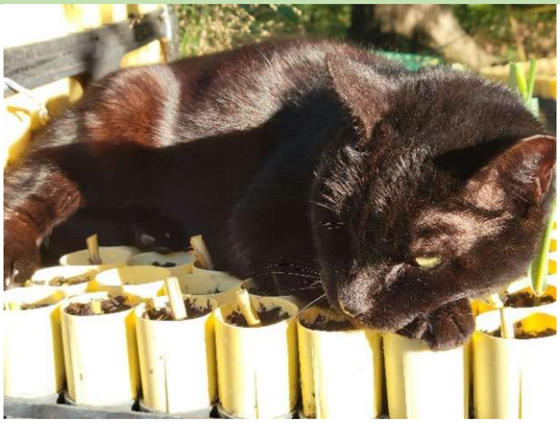
Moving or Renewal	COST*
Move with a reused kennel and a functioning timer.	$500
Move with a reused kennel and no timer	$650
Move with no kennel and no timer	$1,100

* Through May 2025.

Summary Nursery Maintenance

End of year and summer maintenance is super important for you to produce the largest and healthiest tree seedlings as possible. Therefore, please make sure to...

- **add Osmocote to EACH of your cells that have a seedling growing in them** in May AND August. This is not a task to leave until August. The rain and irrigation washes the nutrients from the soil and the plants are turning yellow - which means they are basically starving for nutrients. ***If you do not do this task in the by the end of May you will end up with STUNTED SEEDLINGS that may be alive but will have a tough time growing once transplanted in the fall and winter on our restoration trips***.
- **water with a liquid feed** (such as MiracleGro or similar brand) as often as is allowed on the package label.
- **change your timer batteries** before you leave for summer break.
- **check on your seedlings at least 1-2 times a week** to make sure the water is running!



Meet **Katniss Everdeen Blanchard**… another one of Pam's trusty helpers with the Coastal Roots Program. She's sitting on a tray of newly planted bitter panicum!

It Takes a Village!

Things can be complicated. For instance, where can an 18-wheeler off load Coastal Roots materials given all the Easy Gates and crazy parking lots at LSU? Certainly NOT at Peabody Hall. To the rescue... It turns out that the **College of the Coast and the Environment** has a wonderful loading dock… and they occasionally let me use it to have all our trays and cells from Stuewe and Sons off loaded. Thanks to CCE for helping out!

Another big thank you goes to my husband, **Tommy** (right in the picture) and my son, **Paul** (left in the picture). They help me move and ferry bulky and heavy things off that loading dock over to **Sea Grant**, which graciously allows us storage in their "dungeon" and one of their closets.

Coastal Roots Awarded a $5K Grant from Sam and Mary Lawrence Foundation's *Sea2Earth Fund*

In 2023, Coastal Roots was awarded a $5K grant from the Sam and Mary Lawrence Foundation's *Sea2Earth Fund.* The purpose of this fund is to connect "youth and adults to nature in ways that inspire stewardship and build community" (sea2earth.org). This grant will allow for the creation of 2-minute videos of each of our restoration site partners to help students understand the needs of the restoration site and how their restoration efforts will benefit the site. Louisiana Sea Grant College Program will be creating the videos over the next half year or so! We hope to have these videos published to the CR website by the end of the next academic year.

Recap of 2024 Winter Workshop

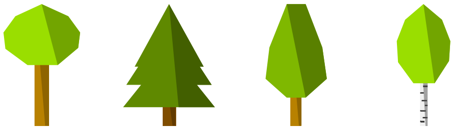
This past February 24, 2024, was our Winter Workshop. We had as our guest speaker **Ms. Maria Landrum** from the STEM Library Lab. She came to share the wonderful opportunity that is being offered by the Brown Foundation Service-Learning Grant Program. ***Coastal Roots has been selected as a "Ready-to-Go" partner for schools wishing to enter the Coastal Roots Program.***

A *Ready-to-Go* partner application is a streamlined process and provides for the affiliation fee as well as funds for other expenses such as bus transportation and other materials to ensure success of the program (e.g., water cans, MiracleGro, gloves, etc.). Any Coastal Roots school is invited to apply for the funding. The grant requires a reflective component that connects what the students learned from participating in the CR project with what they are learning as a part of their academic studies. To access the grant, go to https://stemlibrarylab.org/slp/. Ms. Landrum can be reached at Maria@StemLibraryLab.org or 504.517.3584, ext. 3. **Grants close on ~~April 26, 2024~~, May 17, 2024 (extended!) for the 2024-2025 academic year**. Awards are made in September 2024. Please take advantage of this amazing opportunity!

As a part of the day, **Dani DiIullo** presented an activity entitled, ***Coastal Master Plan Decision Making Activity***. Participating in the day were 36 Coastal Roots teachers (there were 8 no-shows) representing 27 schools! Ed, Dani, and I enjoyed seeing each and every one of you! ***We work with the MOST AMAZING teachers in Louisiana!***

New School Installations, Re-entering or Reinstalled Schools in the CR Program since 2020

 **West Feliciana Middle School (2021)** St. Francisville, LA [West Feliciana Parish]	 **St. Amant High School (2022)** St. Amant, LA [Ascension Parish]
 **Trinity Episcopal School (2023)** Baton Rouge, LA [East Baton Rouge Parish]	 **Haynes Academy (2023, 2024)** Metairie, LA [Jefferson Parish]
 **St. Mary's Dominican High School (2023)** New Orleans, LA [Orleans Parish]	 **Slaughter Community Charter School (2023)** Slaughter, LA [East Feliciana Parish]



openclipart.com

New School Installations, Re-entering or Reinstalled School in the CR Program since 2020 (continued)

Chateau Estates Elementary School (2023)
Kenner, LA [Jefferson Parish]

L. Leo Judice Elementary School (2023)
Scott, LA [Lafayette Parish] *

South Cameron High School (2023)
Grand Chenier, LA [Cameron Parish] **

Christ Episcopal School (2024)
Covington, LA [St. Tammany Parish] **

* Returning from Dormancy ** Reinstallation

Helping Hands!

Wannapik Studio

Help comes in all sizes and ages! We had a 300-foot roll of ground cloth that had to be cut into 15-foot lengths. That would have taken all day for Pam to do this by herself. To the rescue… **Dani Dilullo** and her daughters, **Stella** and **Addie**. Cutting cloth isn't exactly a fun job, but Stella and Abby were real troopers. Before we knew it, we had the whole roll finished, folded and ready for new Coastal Roots nurseries! Thank you!

Pam Moves to a New Role in LSU Payne School of Education.

After more than 5 years of being the only science education staff in the School of Education, Pam has been privileged to step away from all teaching and graduate student mentorship duties and is being allowed to focus solely on running CR. She will be exploring avenues to enhance our current program and hopefully secure more stable funding for the future of Coastal Roots.

Coastal Roots Restoration Trips for 2023-2024.

Academy of the Sacred Heart  **2023-11-03 @ Avery Island**	**Berchmans Academy**  **2023-11-03 @ Avery Island**
St. Amant High School  **2023-11-10 @ Bonnet Carré**	**Christ Episcopal School**  **2023-11-16 @ Fontainebleau State Park**
Trinity Episcopal School  **2023-11-28 @ BREC Manchac Park**	**St. Mary’s Dominican High School**  **2023-11-29 @ Bonnet Carré**
Chateau Estates Elementary  **2023-12-14 @ Bonnet Carré**	**The Brighton School**  **2024-01-18 @ BREC Parklawn Park**

Coastal Roots Restoration Trips for 2023-2024.

Pierre Part Middle School  **2024-01-19 @ Maple Bayou Hunting Club**	**St. Joseph’s Academy**  **2024-01-22 @ Fontainebleau State Park**
Lafayette Middle School  **2024-01-30 @ Bayou Teche Nat’l Wildlife Refuge**	**St. Aloysius School**  **2024-02-02 @ Bonnet Carré Spillway**
Isidore Newman School  **2024-02-23 @ Fontainebleau State Park**	**Bishop Noland Episcopal Day School**  **2024-02-26 @ Sam Houston Jones State Park**
Chapelle High School  **2024-02-29 @ Bonnet Carré Spillway**	**Dutchtown High School**  **2024-03-20 @ Bonnet Carré Spillway**

Coastal Roots Restoration Trips for 2023-2024.

Slaughter Community Charter School

2024-03-28 @ Airline Highway Community Park

St. Paul's Episcopal School

2024-04-09 @ Grand Isle State Park

Chapelle High School

2024-04-12 @ Bonnet Carré Spillway

Not pictured:
Mayfair Lab School -
2024-02-28 @ Bonnet Carré Spillway
Ponchatoula High School -
2024-03-06 @ Fontainebleau State Park

New or Returning Schools Planning on Entering CR in 2024-2025

- **New Orleans Military and Maritime Academy (N)**
- **St. Thomas More High School (Lafayette) (N)**
- **Belle Chasse Middle School (R)**
- **Montegut Middle School (R)**
- **Golden Meadow Middle School (R)**
- **Eva Legard Center for Coastal and Environmental Studies (N)**
- **Metairie Park Country Day School (R)**

Louisiana Sea Grant's *Ocean Commotion*!

Coastal Roots participated in **Louisiana Sea Grant's *Ocean Commotion***! We've been at every single Ocean Commotion except for the one(s) that went digital during COVID. By Pam's count that is 25 of the last 26 Ocean Commotion's! The very first one was in 1998 and celebrated the International Year of the Ocean. We've had a number of schools participate as exhibitors… **Westdale Heights Academic Magnet School, St. Joseph's Academy, St. Scholastic Academy** and **Harry Hurst Middle School** are the ones that come to mind. This event is one way in which we get help planting the extra trees we sometimes need to help with our restoration trips!

Moody Gardens' *Party for the Planet*

Pam and **Tommy Blanchard** brought the Coastal Roots exhibit to Moody Gardens to help celebrate Earth Day on April 21, 2024. **Lisa Stegman**, MG's Education Curator, (shown standing behind the two boys) and **Ed** installed a Coastal Roots nursery at Moody Gardens to grow trees and grasses with their student camps at the facility.

American Journal of Plant Sciences, 2025, 16(3), 419-433
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Improving Garden Production in Coastal Environments Using Raised Garden Beds

Alessandro Holzapfel[1], Edward Bush[1], David Creech[2]

[1]Louisiana State University Agricultural Center, Baton Rouge, USA
[2]Stephen F. Austin State University, Nacogdoches, USA
Email: aholzapfel@agcenter.lsu.edu

How to cite this paper: Holzapfel, A., Bush, E. and Creech, D. (2025) Improving Garden Production in Coastal Environments Using Raised Garden Beds. *American Journal of Plant Sciences*, **16**, 419-433.
https://doi.org/10.4236/ajps.2025.163032

Received: December 3, 2024
Accepted: March 23, 2025
Published: March 26, 2025

Abstract

Food insecurity is particularly prevalent in coastal areas where sodic soils can make it difficult to successfully produce home gardens that supplement dietary needs of low-income gardeners. The objective of this study was to evaluate raised bed substrate depth needed to successfully produce several ornamental and garden species not typically adapted to a coastal environment. Raised beds of 12", 17", and 32" depth filled with an amended substrate successfully increased tomato and Irish potato yields. Tomato fruit count, yield and plant biomass were also increased by at least 2.8-fold compared to growing in the indigenous soil. Similarly, Irish potato count and yield were increased by 2.4-fold and plant biomass by as much as 3.5 times. Basil and rosemary harvest was increased by at least 2.5 times greater than the control. Sunflower and *petunia* count data were at least 3 times greater for 17" and 32" raised beds. Sweetpotato "Murasaki" yields were increased 2 to 3 times yield when grown in 17" and 32" raised beds. Basil and rosemary harvest was increased by at least 2.5 times greater than the control. Raised beds can provide a substantial cost savings and improved nutrition in diets of low-income families.

Keywords

Sodic Soils, Food Insecurity, Vegetable Production, Home Gardens

1. Introduction

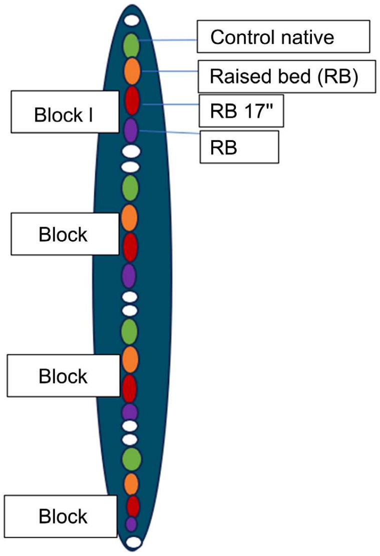
Raised garden beds are an economical and environmentally friendly way to improve access to fresh vegetables, thus benefiting the community's nutrition status [1]. In a study focusing on an ethnically diverse group of 50 low-income family gardeners, participants produced 60% or more of the total cups of vegetables recommended by the U.S. Dietary Guidelines [2]. Additionally, vegetable gardeners produced substantial cost savings and improved nutrition in diets of low-income families [3]. Not only do gardeners save money but benefit from the physical activity of gardening and the health benefits of being outside. Research results suggested that gardening can improve physical, psychological, and social health, as well as alleviating and prevent potential health issues facing today's sedentary population [4].

Growing horticultural landscapes and crops in coastal environments can be challenging due to environmental conditions such as extreme winds, temperatures, sea spray, and sodic soils. Wind and sea mist can be difficult to manage on the coast especially within 1000 feet from shore when combined with a salt spray and blowing sand [5]. Sea levels can increase soil salinity causing an accumulation of residual soil salts. Better crop performance was noticed with less salinization of the raised beds and a salt free root zone before leaching events [6]. An effective method of managing saline soils would be good use of raised beds in salt-affected irrigated arid regions. Homeowners in coastal environments are often restricted to plant species adapted to the environmental constraints. Raised beds filled with amended organic substrates can alleviate impediments to producing a successful garden in sodic soils. The objective of this study was to evaluate raised bed substrate depth needed to successfully produce several ornamental and garden species not typically adapted to a coastal environment.

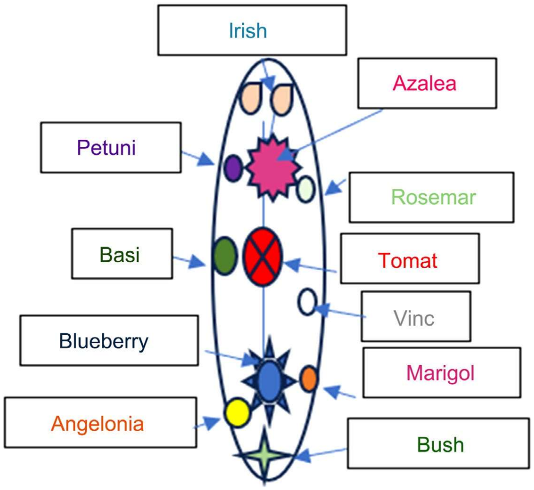
2. Materials and Methods

A study was initiated in Galveston, Texas at the Moody Gardens research farm located adjacent to Scholes International Airport and Offats Bayou (29˚6'31"N 94˚51'32"W). Soil sample results showed the native soil was high in Na (4500 ppm). The native soil beds (0" control treatment; fine sandy loam) were tilled and capped with a 12" sandy loam garden soil in 2022. The capped bed was tested (148 ppm Na, pH 6.8, fine sandy loam texture), amended with gypsum (1.5 T/A) and fertilized with a 13-6-6 granular fertilizer at the rate of 1lb N/1000 square feet. The plots were irrigated with deionized water (0.8 EC, pH 7.0) generated on Moody Gardens property daily using a node timer adjusted to the seasonal watering requirements (0.25-to-0.5-acre inches per day) (**Image 1**, **Appendix**). The raised bed treatments were constructed and positioned on top of the capped soil at their respective heights (12", 17", and 32") and arranged into a randomized complete block design (RCBD) with 4 blocks using random assignment. Raised beds [12" metal raised beds (12" MRB), 17" metal raised beds (17" MRB), and 32" metal raised beds (32" MRB)] were filled to within 1" of the top of each container with Tiger Greaux bagged potting soil (19 ppm Na, pH 5.9 sandy loam texture, organic substrate) (**Images 2-4**, **Appendix**). A drip irrigation system was installed into each bed. A drip irrigation system was installed into each bed using Rainbird inline drip pipe with 12" emitter spacing and an irrigation output of 0.5 gallons/hour. "Cherokee Purple" tomato plants and "Red La Soda" Irish pieces of seed potato tubers were planted into prepared, irrigated beds on February 28, 2024. On May

23, 2024, tomato fruit, Irish potato tubers and above ground plants (plant biomass) were harvested, counted, weighed, and data were statistically analyzed by species using SAS ANOVA at the 0.05 level (**Plot Design 1**, **Planting Design 1**).



Plot Design 1. Moody research farm design layout.



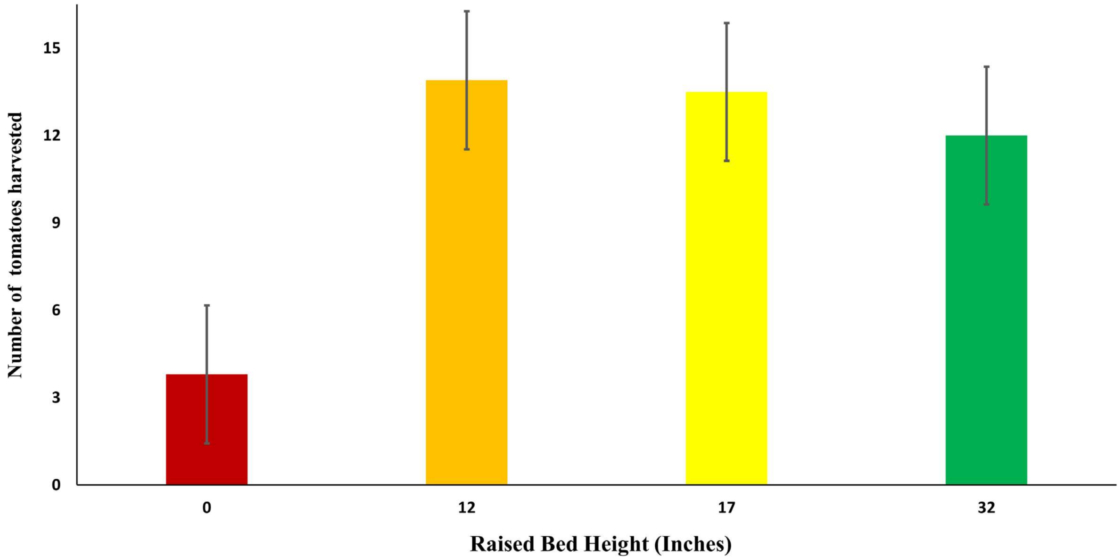
Planting Design 1. Moody research farm planting design.

3. Results and Discussion

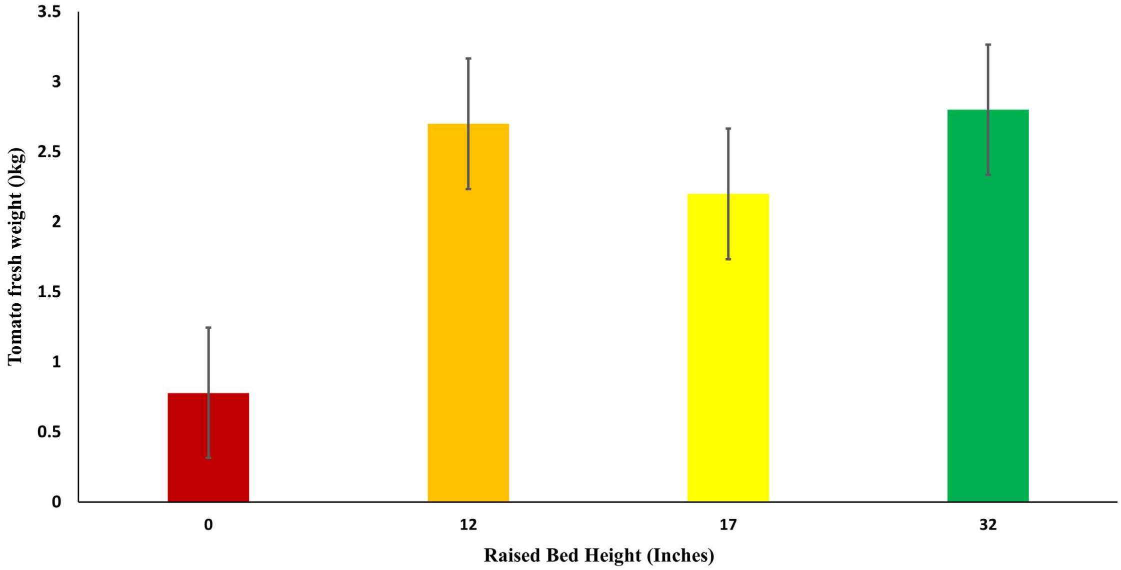
3.1. "Cherokee Purple" Heirloom Tomatoes

Statistical differences resulted for number (#) of harvested tomatoes, tomato yield (kg) and plant biomass (kg) between bed treatments. There was a 3-fold increase in number of tomatoes harvested for all raised bed treatments compared to the native soil control [Bed heights 0" control treatment (#3.8), 12" (#13.9), 17" (#13.8) and 32" (#12)] (**Graph 1**). Additionally, there was a greater than 2.8 times increase in total fresh tomato fruit yield [Bed heights: 0" (0.78 kg), 12" (2.7 kg), 17" (2.2

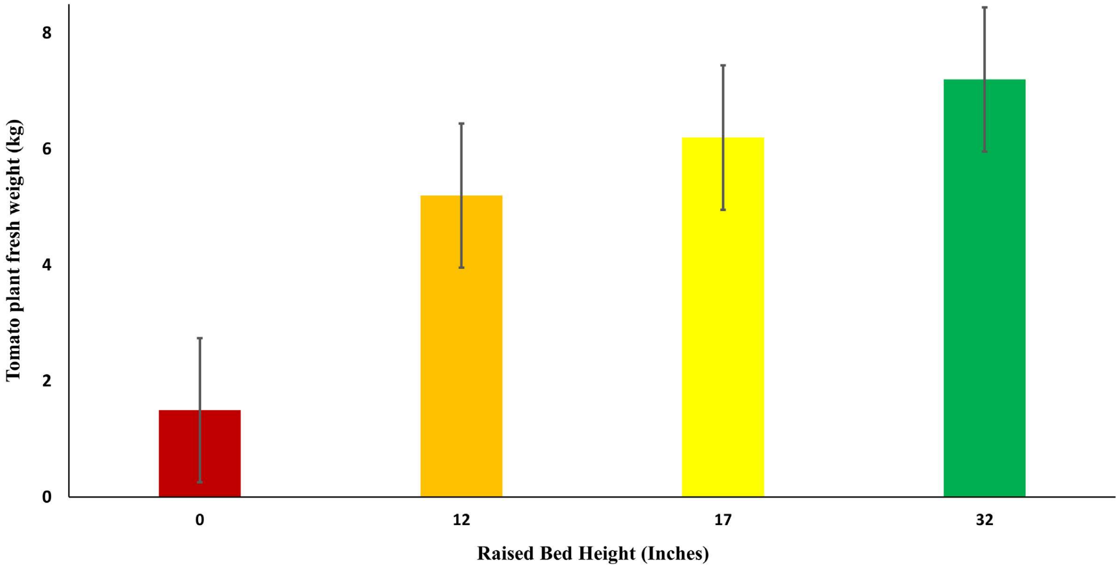
kg), and 32" (2.8 kg)] (**Graph 2**). Tomato plant biomass was also greater in all raised bed treatments compared to the native soil control yield (0") [Bed heights: 0" (1.5 kg), 12" (5.2 kg), 17" (6.2 kg), and 32" (7.2 kg)] (**Graph 3**). All raised bed treatments produced similar plant biomass weight statistically and were nearly 3.5 times greater than the control (0") beds. There were no significant differences between treatments for the average individual tomato weight harvested at the 0.05 level. There were three tomatoes damaged by worms and birds, but there was no disease present. Tomatoes were harvested at the green ripe stage. Overall results showed that raised beds (12", 17", and 32") increased tomato number, fruit yield and tomato plant biomass compared to the native soil control.



Graph 1. Raised bed height tomato production harvest on Galveston Island on Moody Gardens Research Farm.



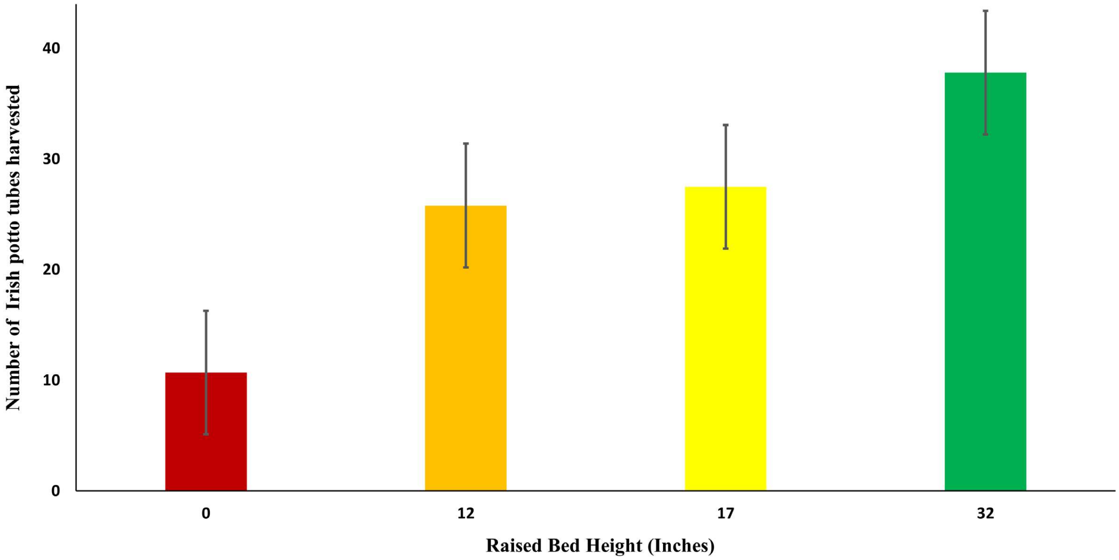
Graph 2. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.



Graph 3. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.

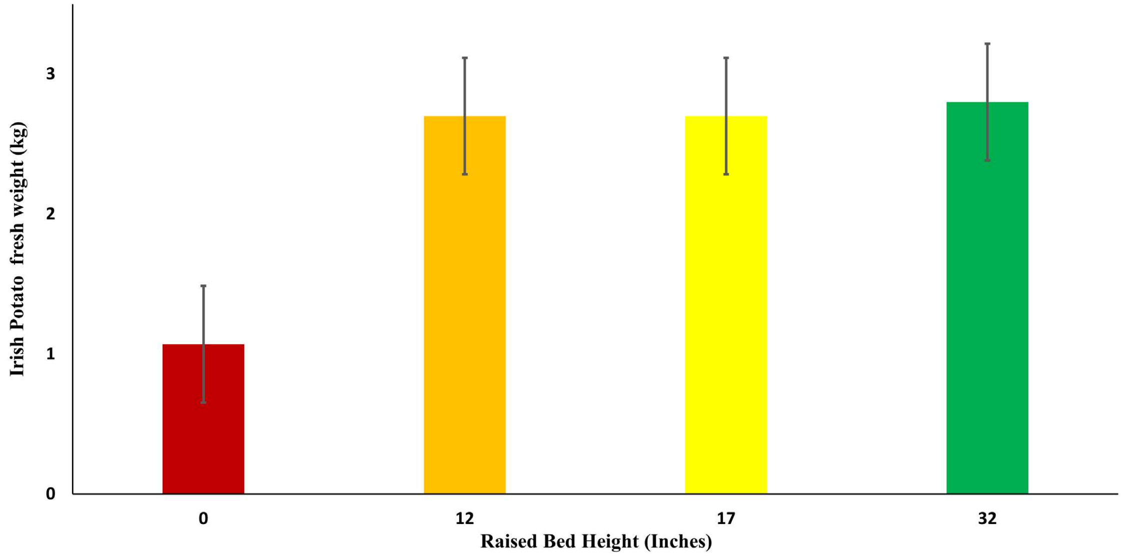
3.2. "Red La Soda" Irish Potatoes

Statistical differences resulted for number of Irish potato number, yield, and plant biomass between bed treatments at the 0.05 level. There was at least 2.4 times increase in number of Irish potato yield for all raised beds compared to the native soil control [Bed heights 0" (#10.7), 12" (#25.8), 17" (#27.5) and 32" (#37.8)] (Graph 4) (Image 5-8, **Appendix**). Additionally, there was a greater than 2.5 times increase in total fresh weight of Irish potato tubers between the control treatment and raised beds [Bed heights: 0" (1.07 kg), 12" (2.7 kg), 17" (2.7 kg), and 32" (2.8 kg) (Graph 5). Irish potato plant biomass was also greater in the 17" and 24" raised bed treatments statistically compared to the native soil control yield

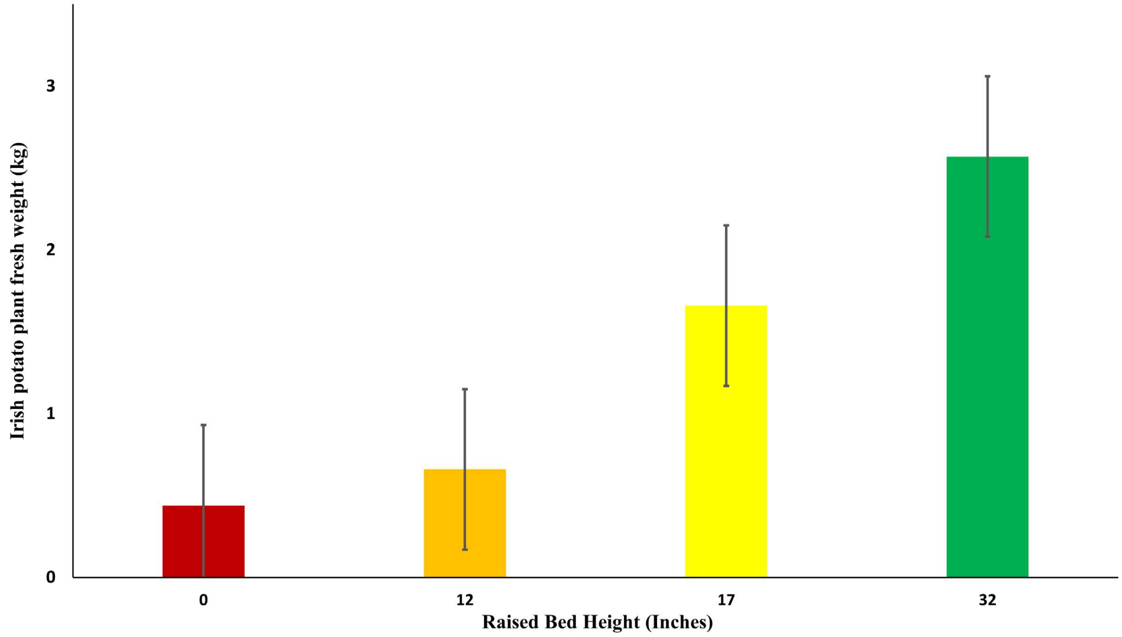


Graph 4. Raised bed height Irish potato production harvest on Galveston lsland on Moody Gardens Research Farm.

[Bed heights: 0" (0.44 kg), 12" (0.66 kg), 17" (1.66 kg), and 32" (2.57 kg)] (**Graph 6**). The 17" and 32" raised bed treatment plant biomass was statistically similar and at least 3.5 times greater than the control (0") and 12" raised beds. There was no significant difference between the control and raised bed treatments for the average individual Irish potato weight harvested at the 0.05 level (data not shown). All Irish potatoes harvested and weighed were commercially acceptable. There was no insect damage or disease presence noticed on the plants or potatoes. For all parameters 17" and 32" raised beds resulted in significantly increased counts, produce weight, and plant biomass.



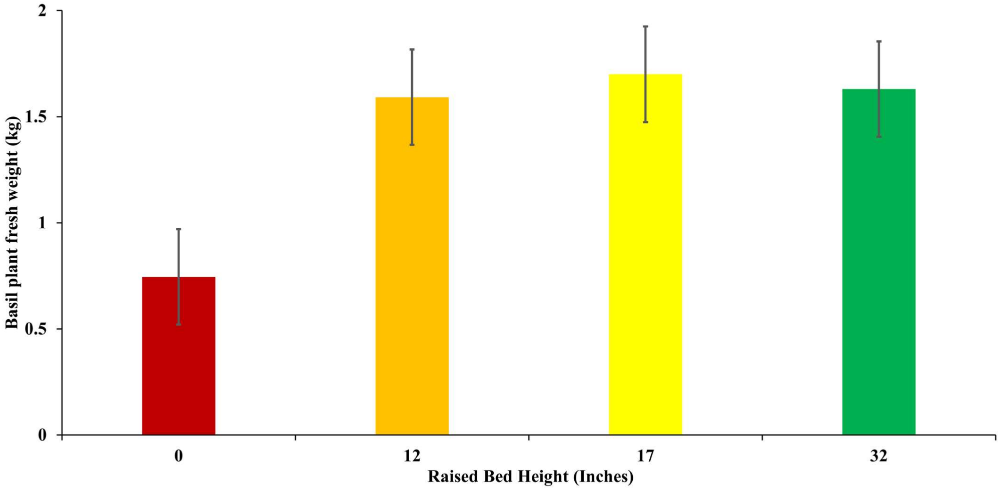
Graph 5. Raised bed height potato production harvest on Galveston lsland at Moody Gardens Research Farm.



Graph 6. Raised bed height tomato production harvest on Galveston lsland at Moody Gardens Research Farm.

3.3. Basil Production

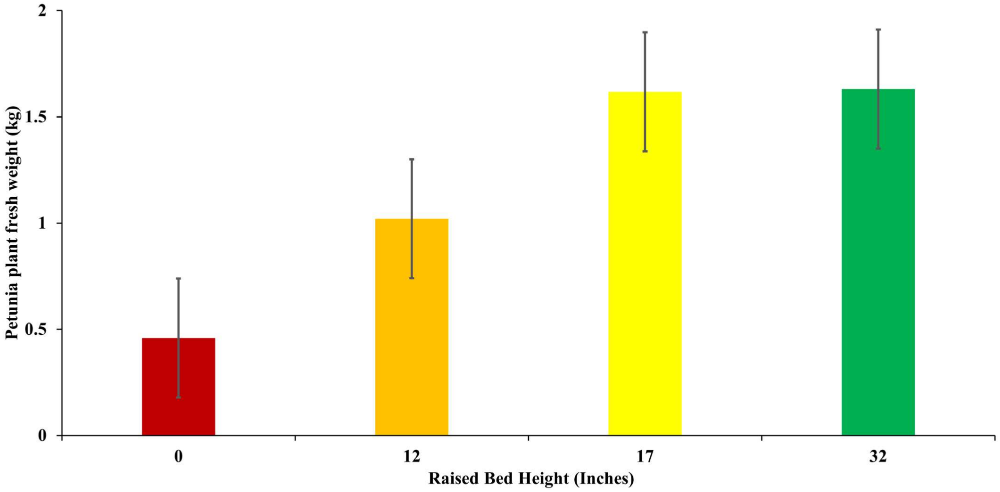
There was a greater than 2.5 times increase in total fresh weight of basil between the control treatment and raised beds [Bed heights: 0" (0.75 kg), 12" (1.6 kg), 17" (1.7 kg), and 32" (1.6 kg) per plant (**Graph 7**) (**Image 10**, **Appendix**). Plant biomass was similar among all raised bed treatment plants.



Graph 7. Raised bed height basil production harvest on Galveston Island at Moody Gardens Research Farm.

3.4. *Petunia*

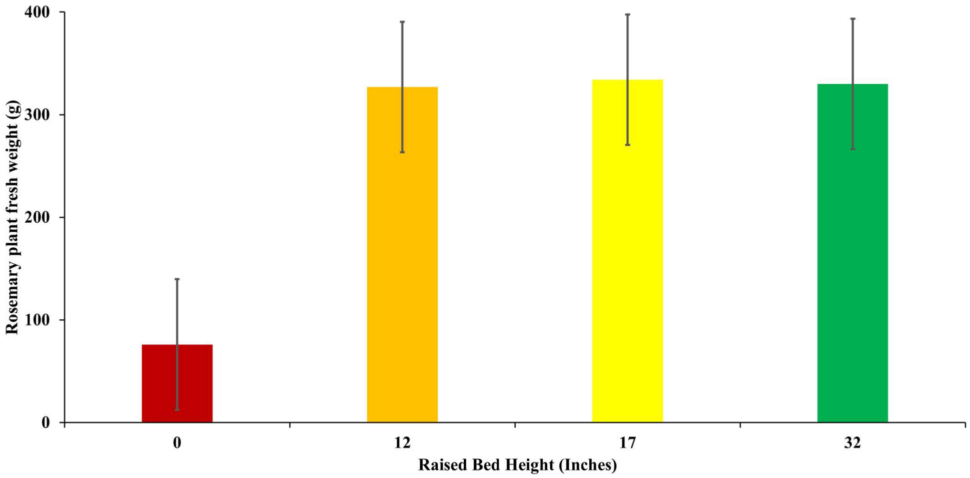
Plant growth was good for all treatments, but exceptional for raised beds. "Plum Madness" *petunia* biomass was greater for all raised beds (12" - 1.02 kg, 17" - 1.6 kg, and 32 - 1.7 kg) compared to the control (0.50 kg) (**Graph 8**) (**Image 11**, **Appendix**).



Graph 8. Raised bed height *petunia* biomass harvest on Galveston Island at Moody Gardens Research Farm.

3.5. Rosemary Harvest

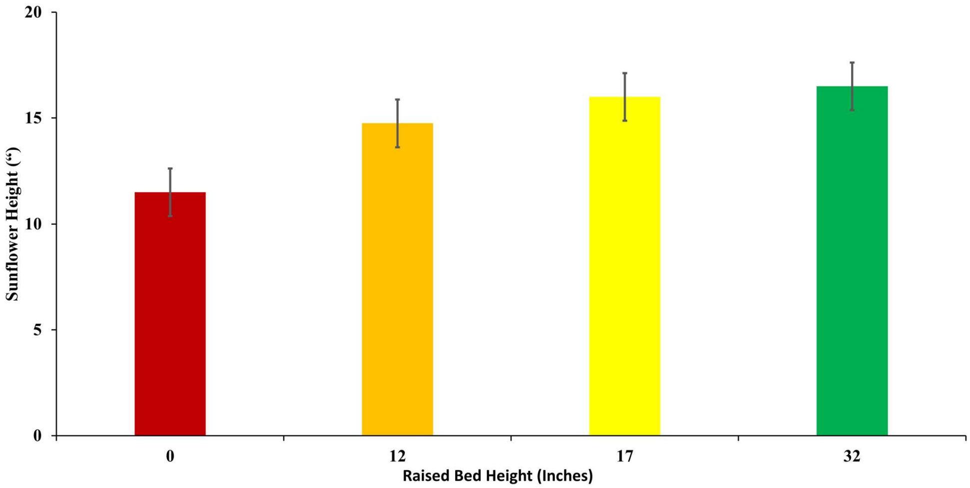
All raised bed production (>300 g) of rosemary was significantly greater than the control plots (<100 g) resulting in 3 times greater biomass (**Graph 9**) (**Image 9, Appendix**). Foliage harvested was pruned to within one inch of the base of the plant and allowed to grow.



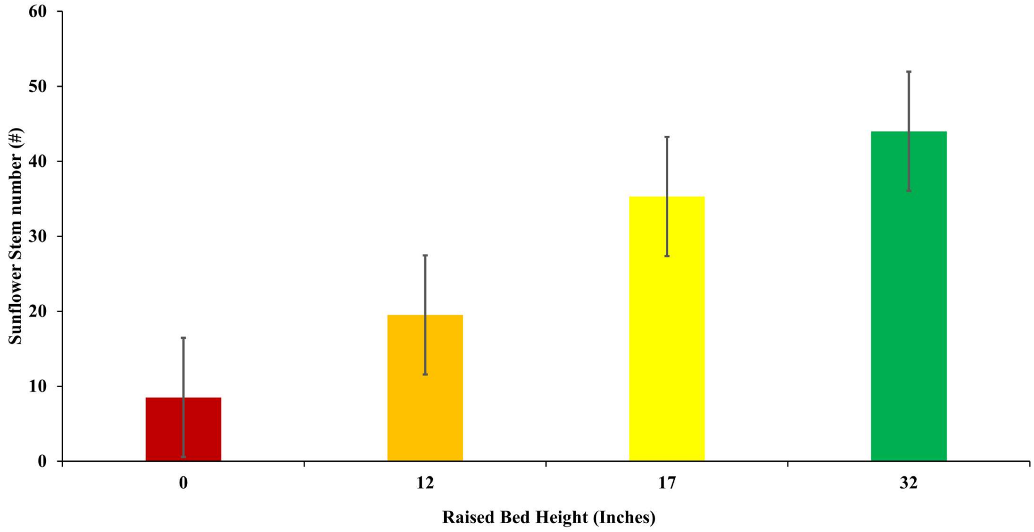
Graph 9. Raised bed height rosemary biomass harvest on Galveston Island at Moody Gardens Research Farm.

3.6. Sunflower Production

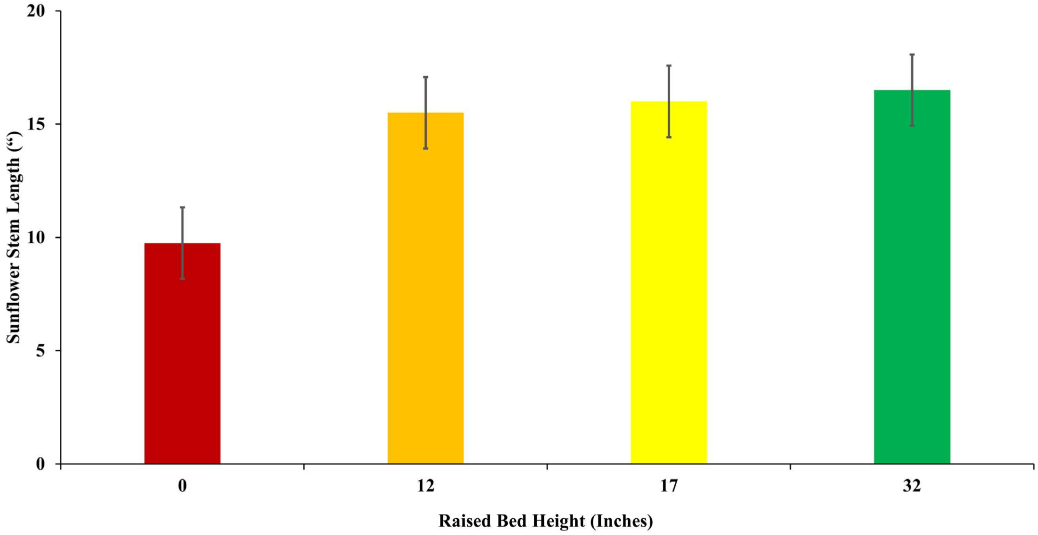
Suncredible® yellow sunflower plant height (12" bed-15", 17" - 16" and 32" bed-16.6") was greater for all raised beds compared to the control (0" bed 11.5") (**Graph 10**). All sunflower plants grown in raised beds were statistically similar. Number of flowers harvested were greater for plants grown in 17" (35.3") and 32" (44.0") raised beds (**Graph 11**). The control (8.5"), and 12" raised beds (19.5") were statistically similar for flowers harvested. Flower stem length (12" beds-15.5", 17" beds-16", 32" beds-16.5") was greater for all plants grown in raised beds compared to the control (9.75") (**Graph 12**).



Graph 10. Raised bed height effect on sunflower plant height on Galveston Island at Moody Gardens Research Farm.



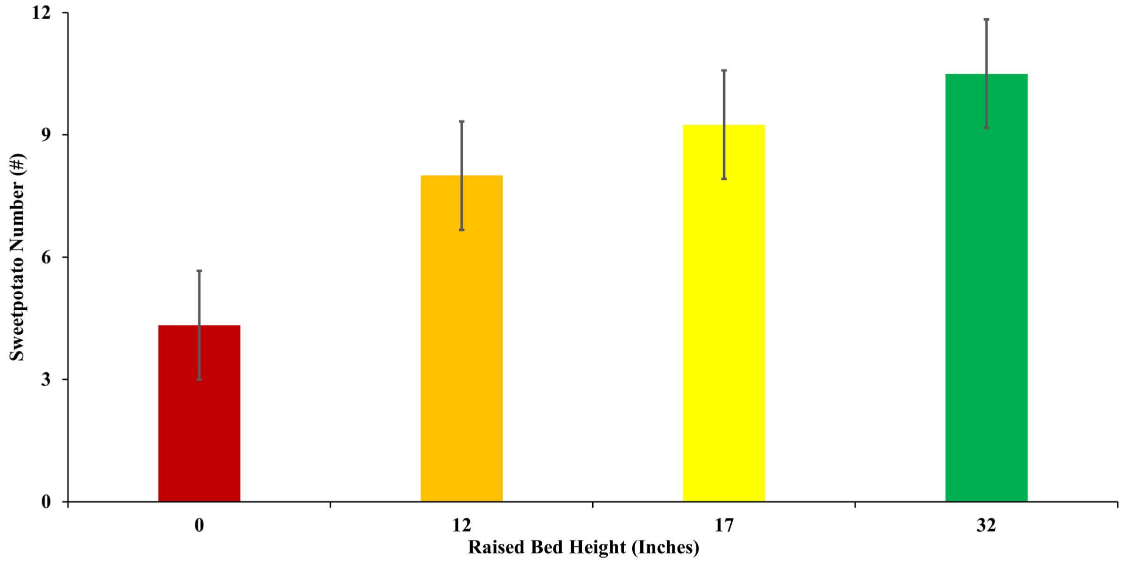
Graph 11. Raised bed height effect on number of sunflowers on Galveston Island at Moody Gardens Research Farm.



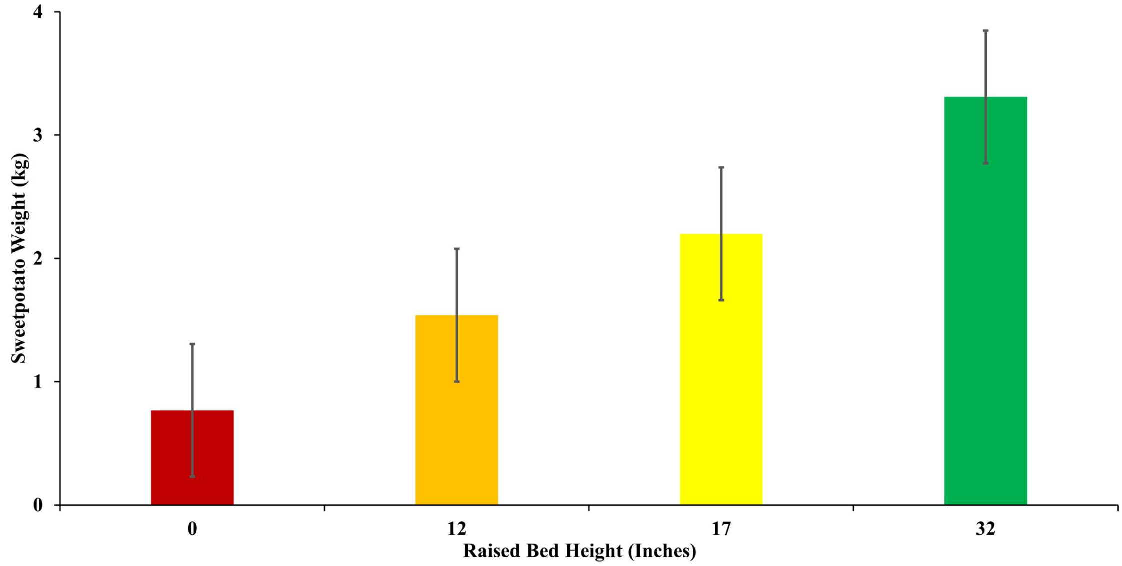
Graph 12. Raised bed height effect on Sunflower stem length on Galveston Island at Moody Gardens Research Farm.

3.7. Sweetpotato Production

Number of "Murasaki" sweetpotatoes produced in raised beds were greater compared to the control (**Graph 13**). There were at least twice as many sweetpotatoes in the 17" and 32" than the control plots. Sweetpotato count for 17" (9.3) plots were twice that of the control (4.3) and for 32" plots (10.5) greater than three times tuber count yield. Sweetpotato yield weight was greatest for plants grown in 32" raised beds (3.3 kg), followed by the 17" raised bed (2.2 kg) (**Graph 14**) (**Image 12**, **Appendix**). Yield was similar for 12" and the control (0.8 kg). Surprisingly, yields for control plots produced acceptable quality tubers, but with lower yield than raised beds.



Graph 13. Raised bed height effect on Sweetpotato number on Galveston Island at Moody Gardens Research Farm.



Graph 14. Raised bed height effect on Sweetpotato weight on Galveston Island at Moody Gardens Research Farm.

4. Conclusion

This study supports using raised beds to maximize crop yield where coastal ecosystems typically limit healthy plant production and availability. Raised beds filled with the bagged substrate increased produce counts and produce weight for both tomatoes and Irish potatoes. Raised bed depths of 17" and 32" also increased plant biomass for Irish potatoes when compared to the native soil control beds. Raised bed production was both statistically and observably increased after harvest. Raised beds did improve harvested vegetable counts and yields. Further research on remaining plant species will continue to evaluate the effect of raised bed depth on production of other horticulture crops. These results can have positive local impact in Galveston, Texas where coastal and socioeconomic factors impede access to fresh produce. Clearly increasing crop yields by using raised beds reduced the effects of soil salinity reducing the cost of production while maintaining the same inputs. In some cases, crop yields doubled or even tripled. Plants grown in 17" and 32" raised beds maintained greater biomass compared to the 12" raised beds and native soils impacted by salinity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Fruge, A.D., Byrd, S.H., Melby, P. and Nagel, D. (2014) The Economic and Nutritive Value of the Raised Bed Home Vegetable Garden: A Model for the Southeastern United States. *Food Studies*: *An Interdisciplinary Journal*, **3**, 1-9. https://doi.org/10.18848/2160-1933/CGP/v03i02/40567

[2] Algert, S.J., Baameur, A., Diekmann, L.O., Gray, L. and Ortiz, D. (2016) Vegetable Output, Cost Savings, and Nutritional Value of Low-Income Families' Home Gardens in San Jose, CA. *Journal of Hunger & Environmental Nutrition*, **11**, 328-336. https://doi.org/10.1080/19320248.2015.1128866

[3] Langellotto, G.A. (2014) What Are the Economic Costs and Benefits of Home Vegetable Gardens? *Journal of Extension*, **52**, 1-7. https://www.researchgate.net/publication/306223401_What_Are_the_Economic_Costs_and_Benefits_of_Home_Vegetable_Gardens https://doi.org/10.34068/joe.52.02.14

[4] Masashi, S., Gaston, K.J. and Yamaura, Y. (2017) Gardening Is Beneficial for Health: A Meta-Analysis. *Preventive Medicine Reports*, **5**, 92-99. https://www.sciencedirect.com/science/article/pii/S2211335516301401 https://doi.org/10.1016/j.pmedr.2016.11.007

[5] Bickerton, J. and Clark, G. (2010) A Book: Coastal Gardening. 1-192.

[6] Velmurugan, A., Swarnam, T.P., Ambast, S.K. and Kumar, N. (2016) Managing Waterlogging and Soil Salinity with a Permanent Raised Bed and Furrow System in Coastal Lowlands of Humid Tropics. *Agricultural Water Management*, **168**, 56-67. https://doi.org/10.1016/j.agwat.2016.01.020

Appendix

Image 1. Native soil plots established at Moody Gardens research farm on February 28, 2024.

Image 2. Raised beds 12" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 3. Raised beds 17" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 4. Raised beds 12" deep filled with Tiger Greaux potting soil established at Moody Gardens research farm on February 28, 2024.

Image 5. Native soil grown Irish potato plants harvested at Moody Gardens research farm on May 21, 2024.

Image 6. Raised bed grown Irish potatoes plants at Moody Gardens research farm on May 21, 2024.

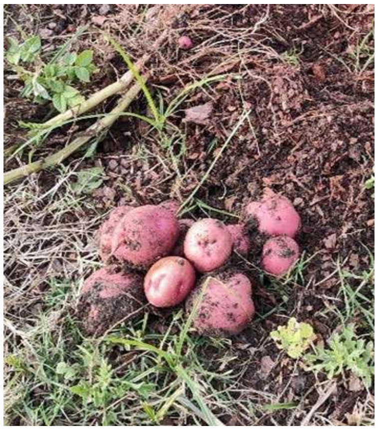


Image 7. Native soil grown Irish potato plants harvested at Moody Gardens research farm on May 21, 2024.

Image 8. Raised bed Irish potato tubers harvested at Moody Gardens research farm on May 21, 2024.

Image 9. Rosemary grown in a 32" raised bed harvested on June 21, 2024.

Image 10. Basil grown in a 32" raised bed harvested on June 21, 2024.

Image 11. *Petunia* plants grown in a 32" raised bed harvested on October 10, 2024.

Image 12. Sweetpotatoes grown in a 17" raised bed harvested on November 10, 2024.