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Improving Garden Production in Coastal Environments Using Raised Garden Beds

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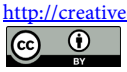


Abstract

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 rec-

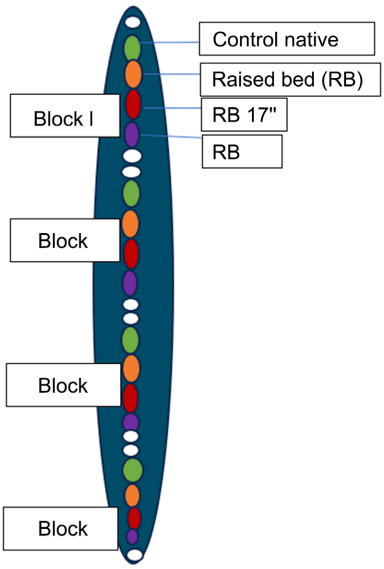
ommended by the U.S. Dietary Guidelines [2]. Additionally, vegetable gardeners produced substantial cost savings and improved nutrition in diets of low-income families [3]. Not only do gardeners save money but benefit from the physical activity of gardening and the health benefits of being outside. Research 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.

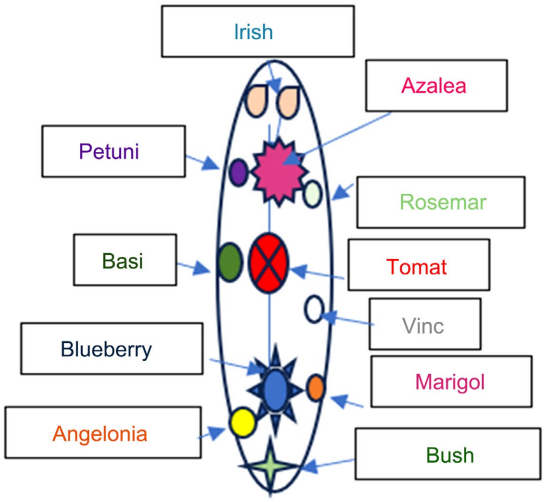
2. Materials and Methods

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.



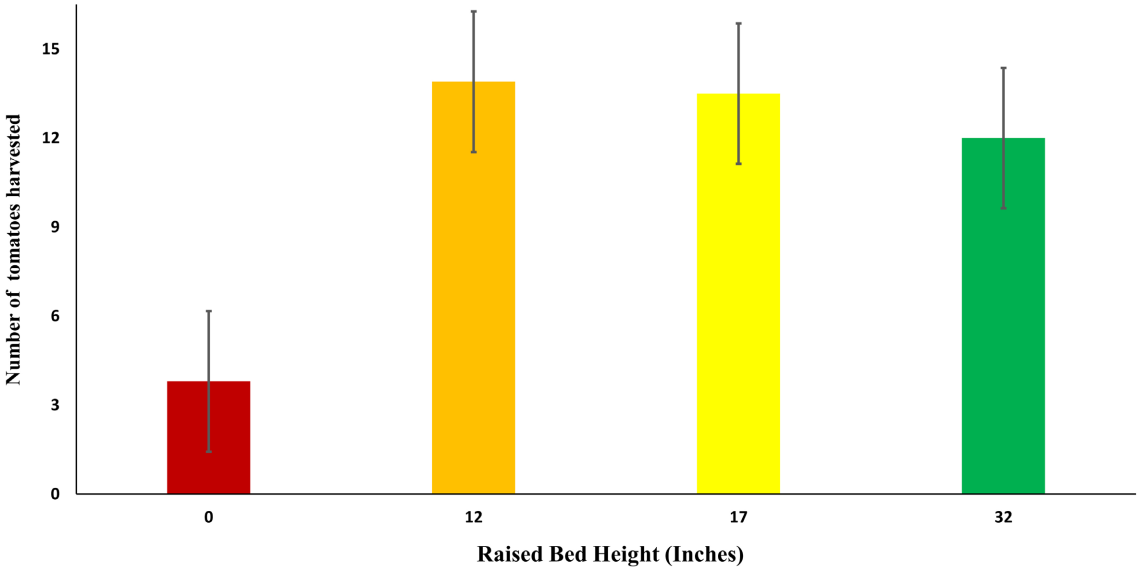
Planting Design 1. Moody research farm planting design.

3. Results and Discussion

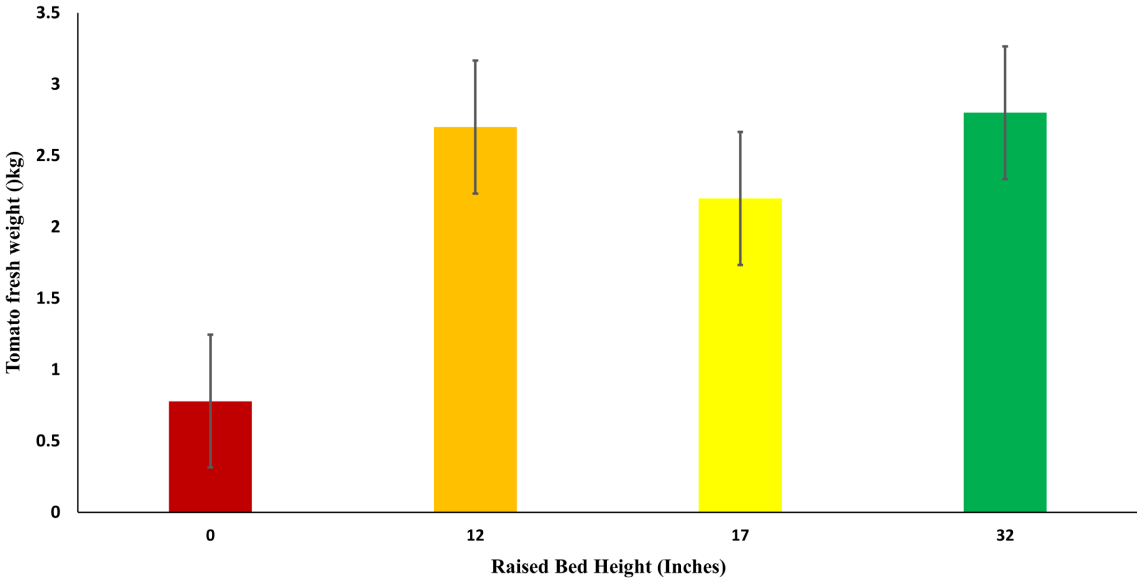
3.1. "Cherokee Purple" Heirloom Tomatoes

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

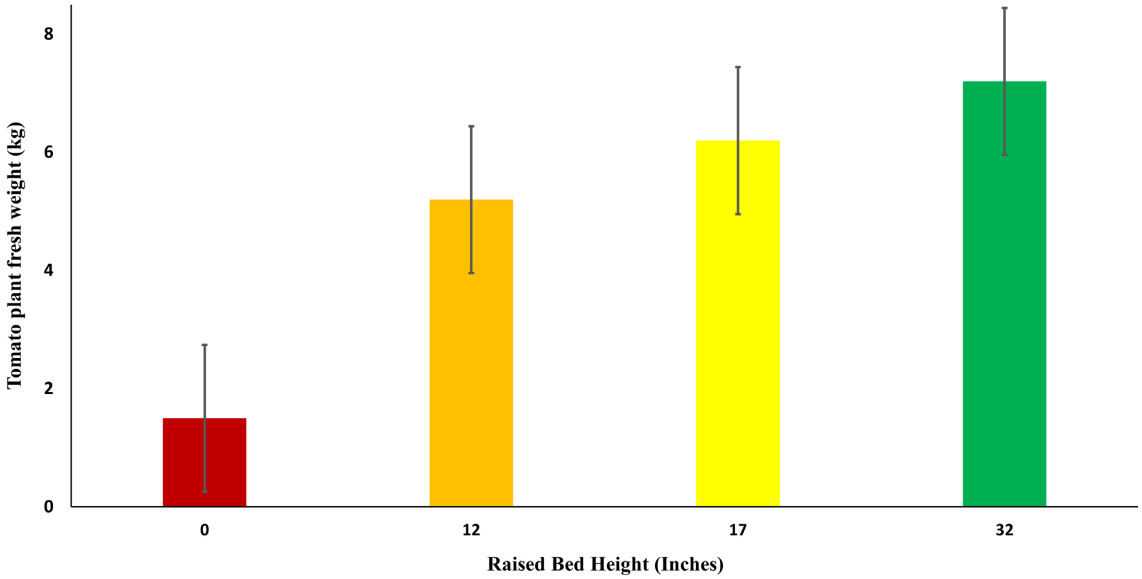
kg), and 32" (2.8 kg)] (Graph 2). Tomato plant biomass was also greater in all raised bed treatments compared to the native soil control yield (0") [Bed heights: 0" (1.5 kg), 12" (5.2 kg), 17" (6.2 kg), and 32" (7.2 kg)] (Graph 3). All raised bed treatments produced similar plant biomass weight statistically 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.



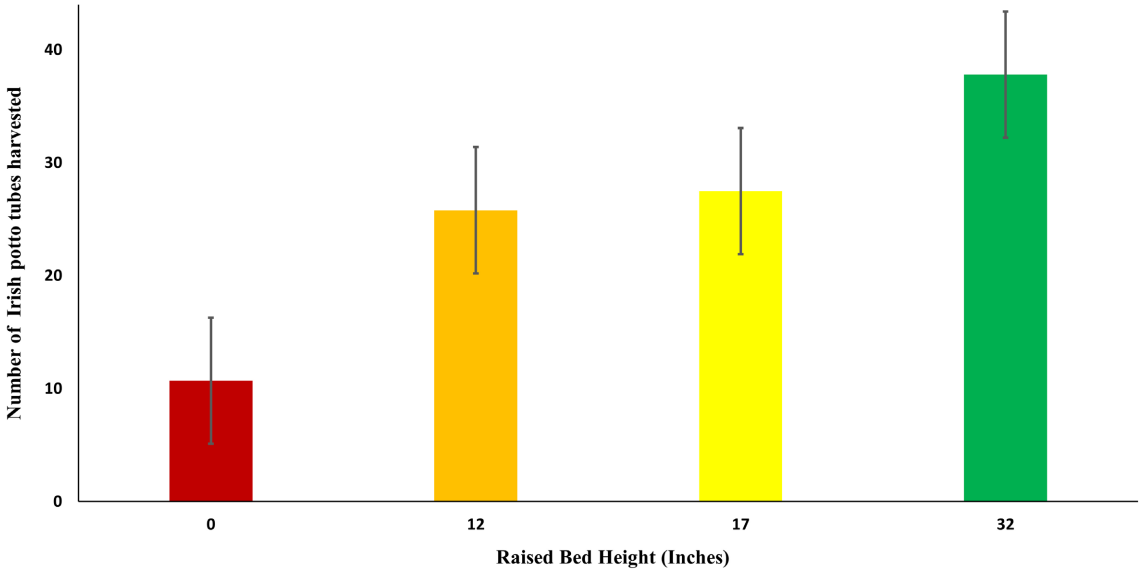
Graph 2. Raised bed height tomato production harvest on Galveston Island at Moody Gardens Research Farm.



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

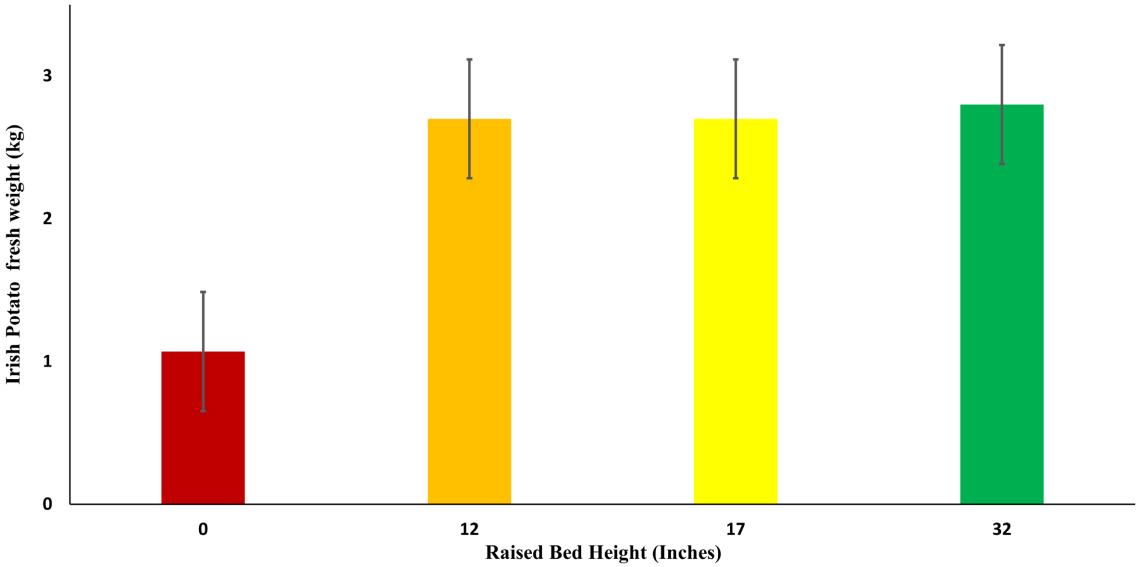
3.2. "Red La Soda" Irish Potatoes

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

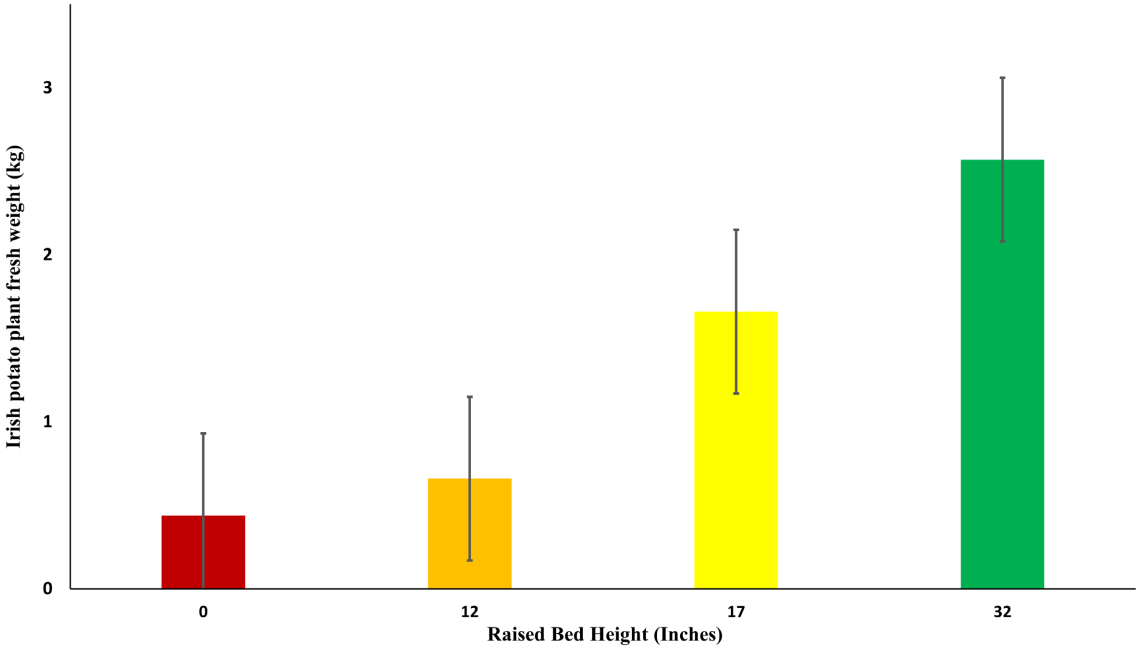


Graph 4. Raised bed height Irish potato production harvest on Galveston lsland on Moody Gardens Research Farm.

[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.



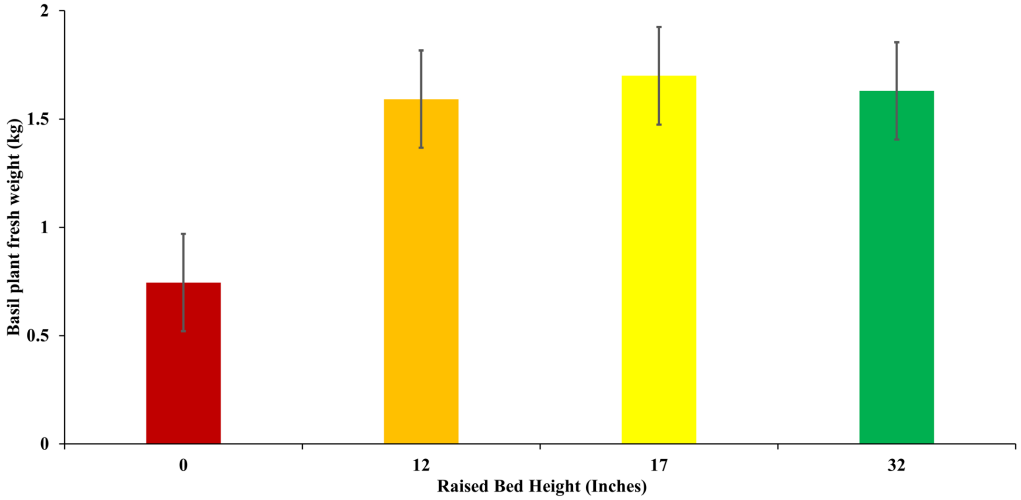
Graph 5. Raised bed height potato production harvest on Galveston lsland at Moody Gardens Research Farm.



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

3.3. Basil Production

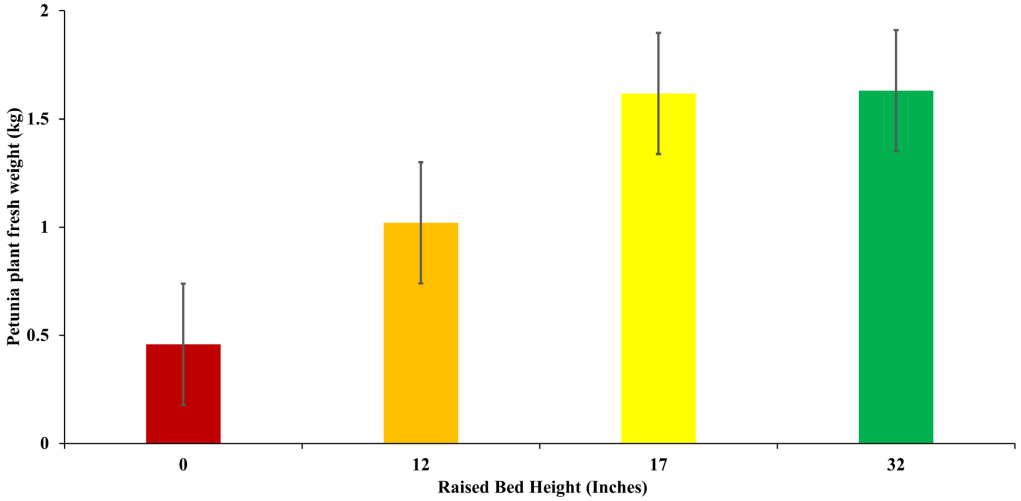
There was a greater than 2.5 times increase in total fresh weight of basil between the control treatment and raised beds [Bed heights: 0" (0.75 kg), 12" (1.6 kg), 17" (1.7 kg), and 32" (1.6 kg) per plant (Graph 7) (Image 10, **Appendix**). Plant biomass was similar among all raised bed treatment plants.



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**).

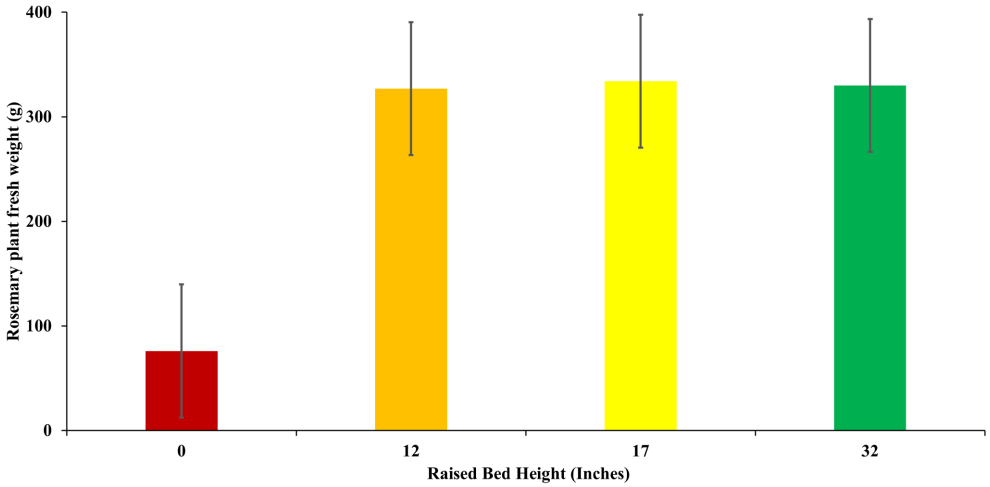


Graph 8. Raised bed height *petunia* biomass harvest on Galveston Island at Moody Gardens Research Farm.

3.5. Rosemary Harvest

All raised bed production (>300 g) of rosemary was significantly greater than the

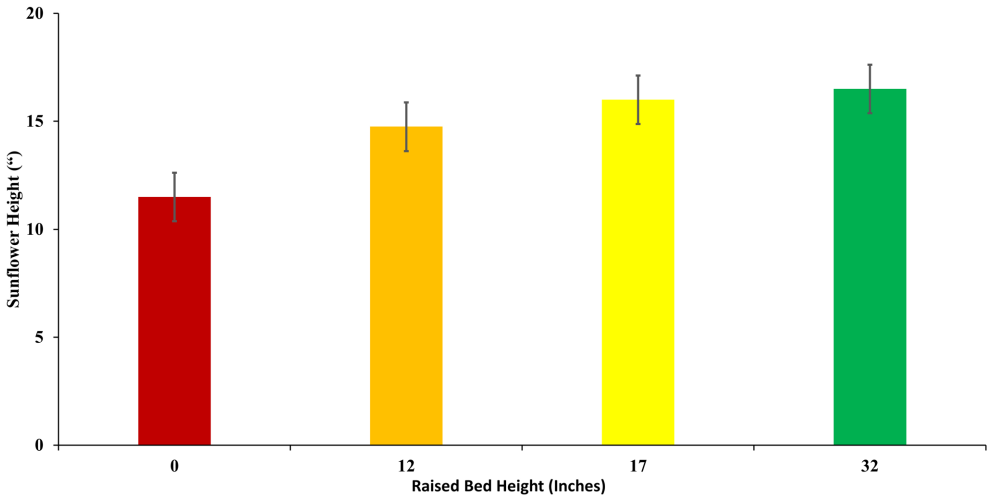
control plots (<100 g) resulting in 3 times greater biomass (Graph 9) (Image 9, Appendix). Foliage harvested was pruned to within one inch of the base of the plant and allowed to grow.



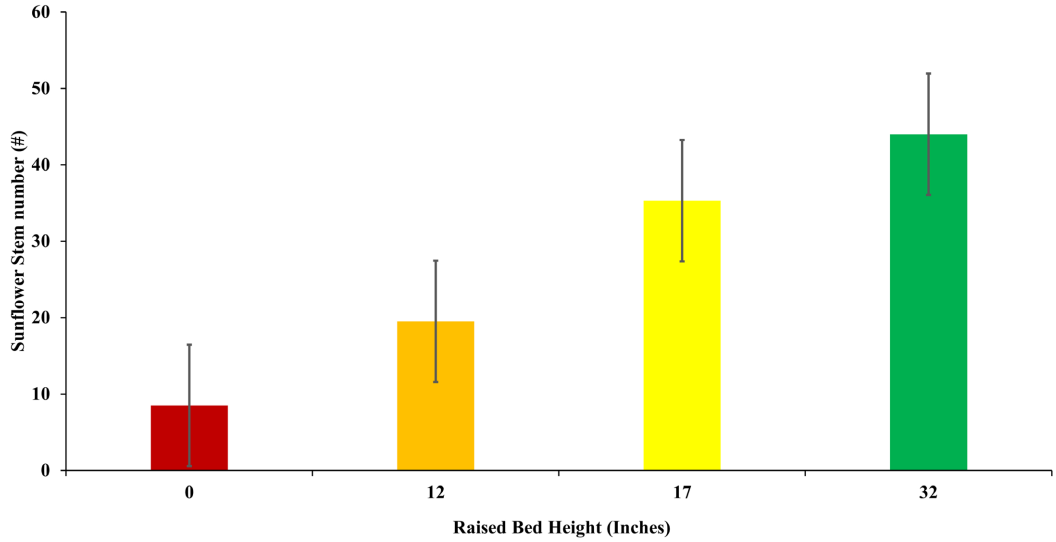
Graph 9. Raised bed height rosemary biomass harvest on Galveston Island at Moody Gardens Research Farm.

3.6. Sunflower Production

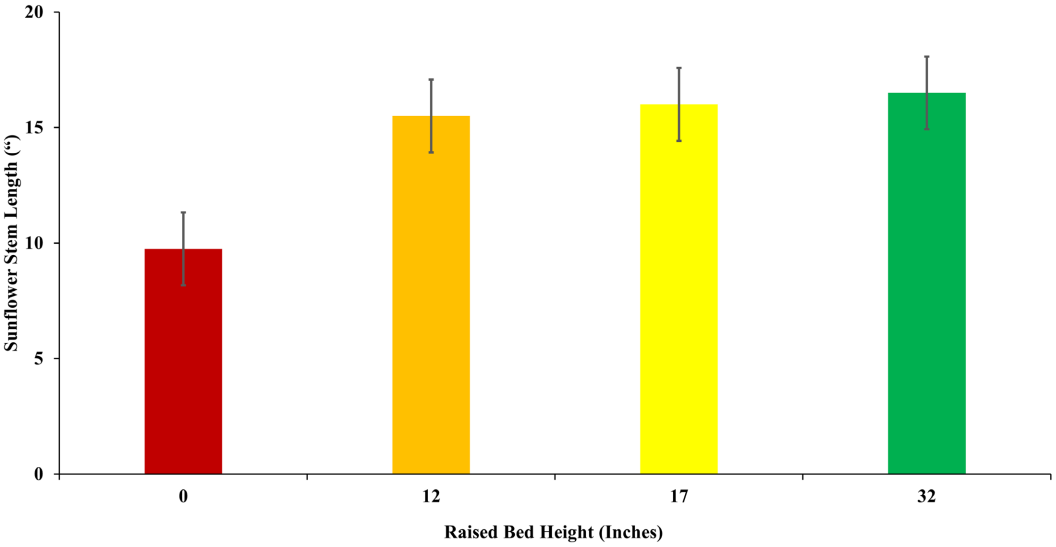
Suncredible® yellow sunflower plant height (12" bed-15", 17" - 16" and 32" bed-16.6") was greater for all raised beds compared to the control (0" bed 11.5") (Graph 10). All sunflower plants grown in raised beds were statistically similar. Number of flowers harvested were greater for plants grown in 17" (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.



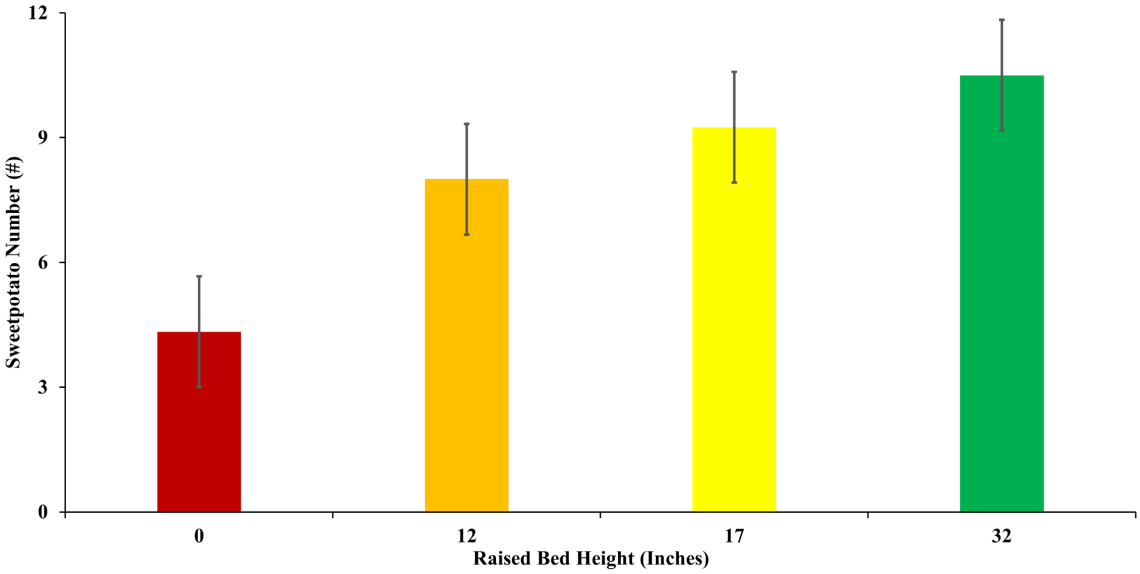
Graph 11. Raised bed height effect on number of sunflowers on Galveston Island at Moody Gardens Research Farm.



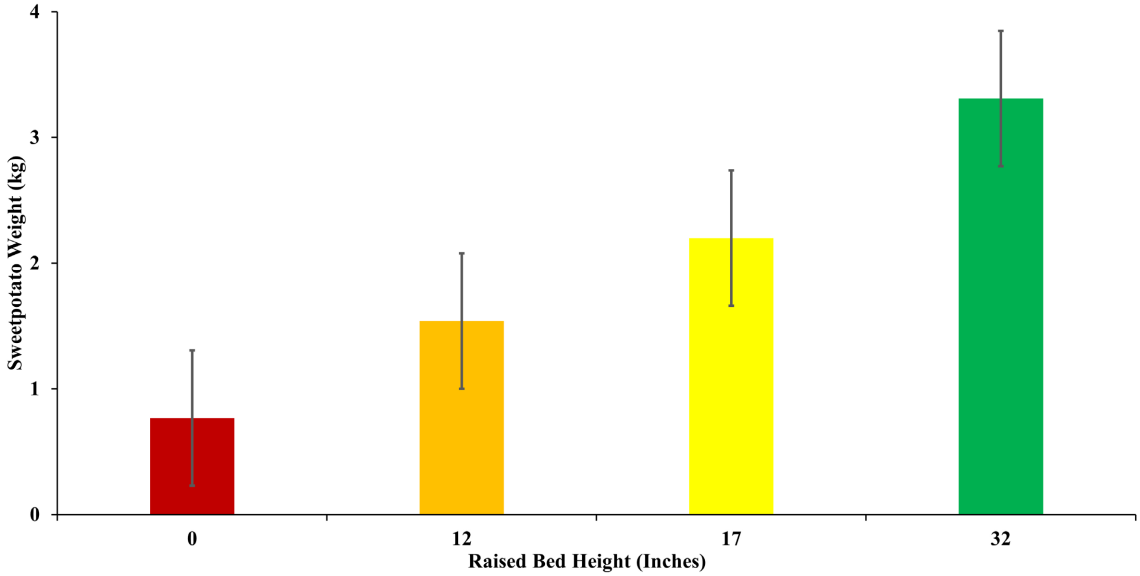
Graph 12. Raised bed height effect on Sunflower stem length on Galveston Island at Moody Gardens Research Farm.

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 im-

pact 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.

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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.

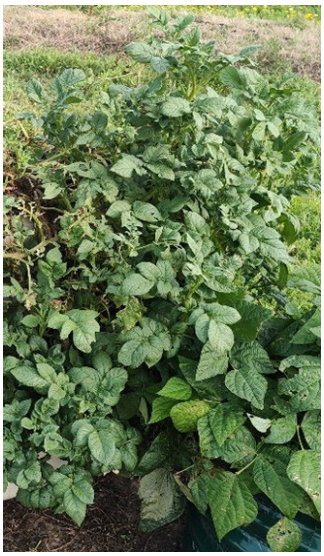

Image 6. Raised bed grown Irish potatoes plants at Moody Gardens research farm on May 21, 2024.

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.