Assessment and Characterization of Microbial Communities in Salt Affected Soils on Galveston Island

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♦ Abstract

In 2008, Hurricane Ike devastated Galveston Island and left behind elevated salt concentrations in the soils and groundwater, killing 80% of the live oak trees. In an effort to alleviate this situation, a project has been initiated to evaluate, introduce, and promote a wide range of salt- and hurricane- tolerant plants for Galveston Island. A research site has been established at Galveston's Moody Gardens to study the growth of *Hibiscus hamabo*, and *Quercus virginiana*, and *Taxidium distichum* in salt-impacted soils. Because microbial species play an intricate role in the success of these plants, research included assessing indigenous microbial populations and activity at this site. 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. Soil samples were collected in July and October 2016 to estimate total bacteria and fungi populations. These were determined by serial dilution plating on selective media using a spiral plating system. Soil respiration rates were determined using a Model EGM-4 Environmental Gas Monitor for CO_2 evolution. Bacteria populations ranged from 4.07 to 5.12 and 3.73 to 4.26 log CFU g^{-1} in soils collected in July and October, respectively. Fungi ranged from 3.27 to 3.58 and 3.09 to 3.71 log CFU g^{-1}. Fungal populations were not significantly different between treatments. Bacteria populations were significantly higher only in control bedded and mulch flat treatments. Likewise soil respiration rates ranged from 0.873 to 3.07 g CO2 m^{-2} hr $^{-2}$ but showed little response to soil amendments. These results indicate that there are relatively large and active soil microbial communities inhabiting soils at the field site. However, soil amendments had little effect on microbial populations and activities.

♦ Introduction

With the loss of nearly 80% of live oak trees on Galveston Island due to the inundation of salt water from Hurricane Ike came a desire to reestablish live oak and/or other plant species that could tolerate future weather events. To that end, SFASU is conducting a three-year project at Moody Gardens to evaluate, introduce, and promote a wide range of salt- and hurricane- tolerant landscape trees, shrubs, groundcovers and herbaceous perennials for Galveston Island. In support of this work, we initiated several research projects to consider the importance of microorganisms on the growth of these plants. Research has focused on assessing indigenous fungal and bacterial populations and activity at the field research site at Moody Gardens.

♦ Objectives

- ❖ Ascertain effect of soil conditioning practices on microbial populations at Moody Gardens research plots
- ❖ Determine effect of soil conditioning practices on in situ soil respiration rates at Moody Gardens research plots
- ❖ Screen for Pseudomonads able to grow and respond to high salt conditions.

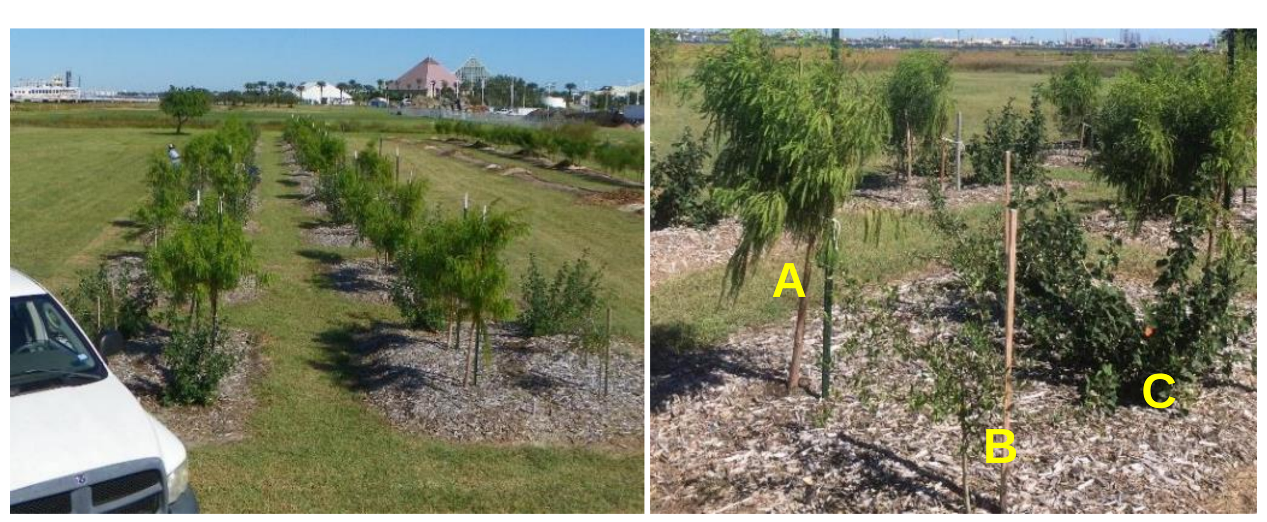
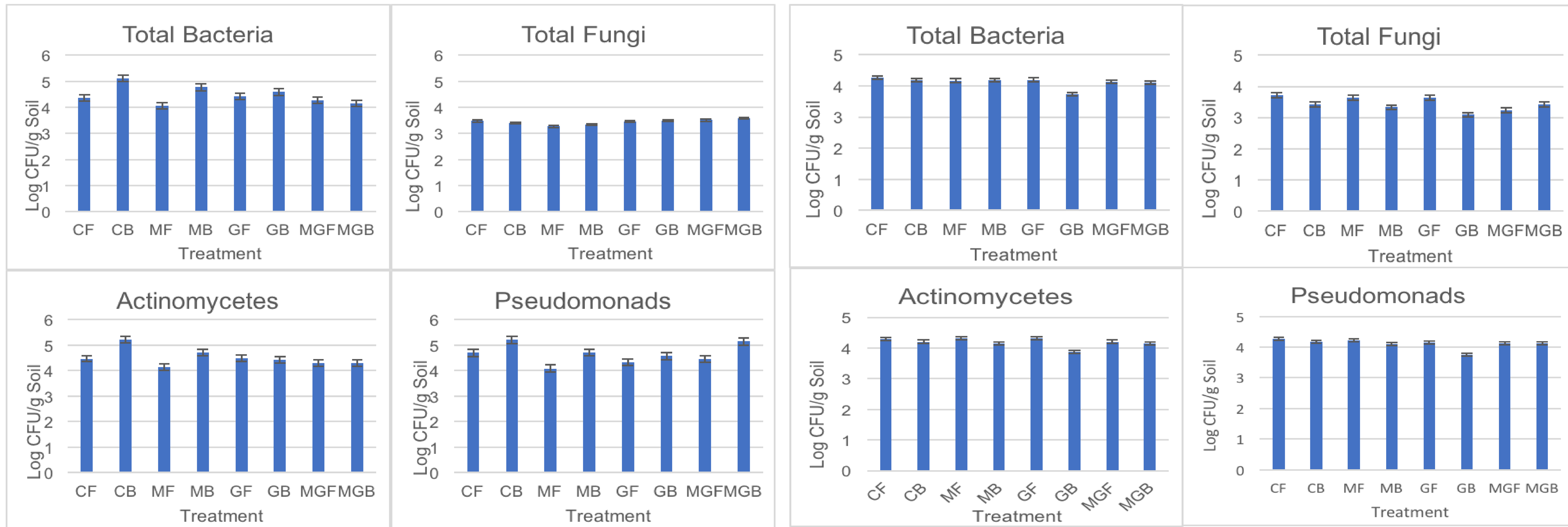


Figure 1. Study plots containing *Taxodium* X 'T406' (Montezuma/Bald Cypress hybrid, A), *Quercus virginiana* (Live Oak, B), and *Hibiscus hamabo* (C).

♦ Results A. Microbial Population Response to Soil Amendments



July, 2016 Sample Period **October, 2016 Sample Period**

Figure 2. Effect of Soil Amendments of Microbial Populations in Bedded and Fallow Soils

♦ Materials and Methods

A. **Field Research Plots.** A research site has been established at Moody Gardens to test the efficacy of *Hibiscus hamabo*, and *Quercus virginiana*, and *Taxidium distichum* grown in soils impacted by salt deposition. The site contains 48 plots (Figure 1), half of which are bedded with nonnative bank sand soil. Either the bedded plots or bare ground plots were then treated with one of the following to ameliorate the salt concentrations: 1) Control (no additives) (CF & CB); 2) Gypsum (5 kg per plot) (GF & GB); 3) Pine Bark Mulch (MF & MB); 4) Gypsum + Pine Bark Mulch (MGF & MGB). Each treatment was replicated 6 times for the 48-plot total. After the amendments had been added , 2 plants of each of the 3 different plant species were planted in each plot.

B. Microbial Populations. Soil samples were collected from each research plot in July and October 2016 to estimate total bacteria, total fungi, pseudomonad, and actinomycete numbers in each soil. These were determined by serial dilution plating on selective media using a spiral plating system.

C. Soil Respiration. Soil respiration rates in the field were determined using a Model EGM-4 Environmental Gas Monitor for CO_2 (PP Systems). This instrument measures CO_2 evolved over time compared to levels in ambient air after being placed directly in contact with the soil surface. This difference in CO_2 concentration over time was plotted in real time during sampling.

C. Salt Tolerant Pseudomonads. Soils from control plots (CF and CB) were assessed for salt tolerant fluorescent pseudomonads. Soils were serial diluted and spiral plated on pseudomonas isolation agar containing 0, 5, and 10% NaCl.

D. Statistical Analyses. A single classification analysis of variance (ANOVA) was performed used SAS version 9.2 statistical software (2017) comparing microbial populations as well as soil respiration data between treatments.

♦ Results B. Soil Respiration Rates

Table 1. Effect of Soil Amendments on Soil Respiration Rates

Treatment	Respiration Means[1]	SNK Grouping[2]
Mulch Bedded	3.07	A
Mulch Flat	2.56	A, B
Gypsum Flat	2.56	A, B
Control Flat	2.25	A, B
Mulch Gypsum Flat	2.13	A, B
Gypsum Bedded	1.84	A, B
Control Bedded	1.63	A, B
Mulch Gypsum Bedded	0.87	B

[1]g CO_2 m^{-2} hr^{-1}
[2]means with the same letter are not significantly different

♦ Results C. Pseudomonad Salt Response

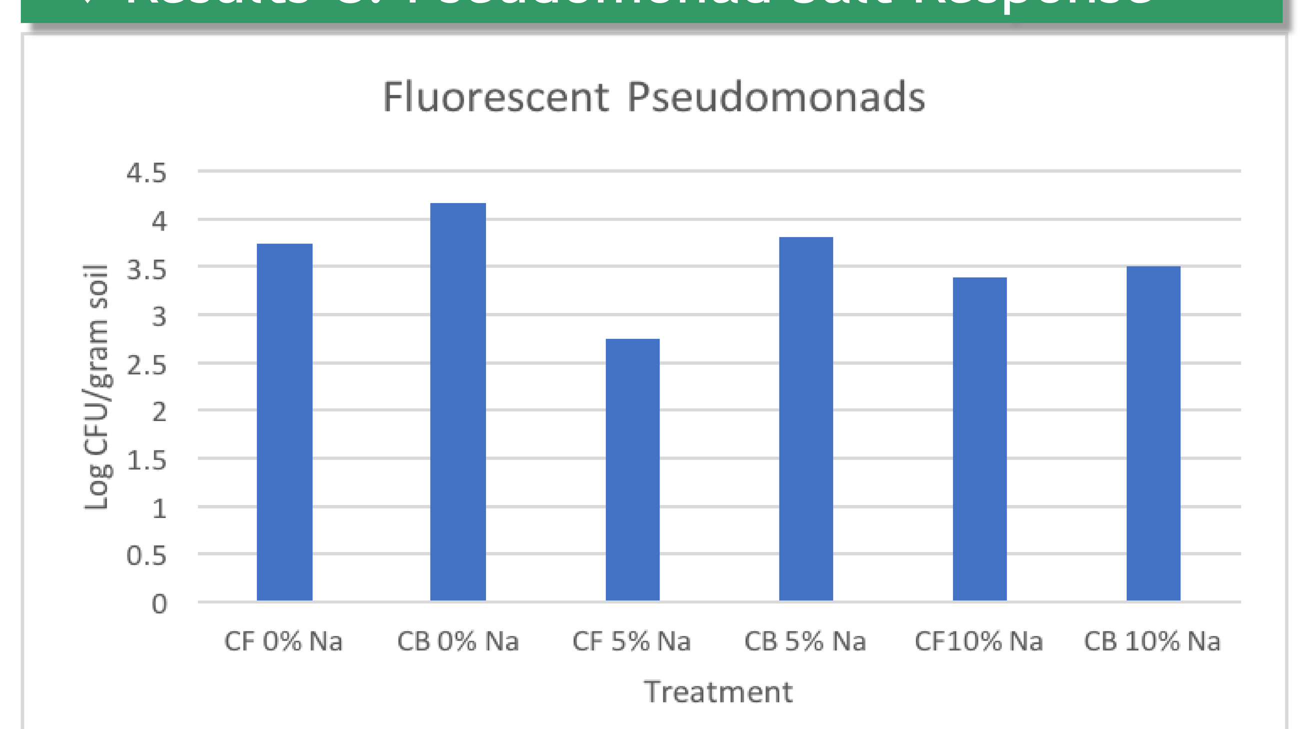


Figure 3. Numbers of Salt-Tolerant Fluorescent Pseudomonad Populations in Control Soils

♦ Discussion

Microbial Populations. Although microbial populations in the soils were relatively high (Figure 2) and consistent with other studies of salt-affected soils, soil amendments had little effect on these populations. Others have demonstrated that organic matter or inorganic fertilizer amendments generally increased microbial numbers. Several rain events as well as irrigation to the plots may have reduced salt levels in surface soils, thus minimizing the effects of elevated salt levels on the microbial communities as well as growth of the three plant species. Additionally, the complex organic amendments applied typically decompose slowly. This organic matter may have been unavailable for microbial communities during the study's timeframe, thus decreasing the likelihood of the amendments influencing microbial population numbers

Soil Respiration Rates. Soil respiration rates ranged from 0.9 to 3.07 g CO_2 m^{-2} hr^{-1} (Table 1). Respiration rates were significantly higher in the bedded amended with mulch treatment than the bedded soil amended with both mulch and gypsum. This may indicate that the addition of gypsum may have had a negative effect on soil respiration. However, these data were only collected during one sample period; respiration rates at other times need to be collected to confirm these results.

Pseudomonad Salt Response. There were no significant differences between numbers of pseudomonads growing on 0% and 5% NaCl or 10% NaCl (Figure 3). This suggests that there is a large number of pseudomonads tolerant of high NaCl concentrations. Some of the pseudomonads growing on 10% NaCl were isolated and characterized for future development as potential inoculants for plants growing in high salinity soils.

♦ Conclusions

- ❖ Low tree mortality in companion study and stable microbial populations indicate low salt stress in surface soil.
- ❖ No discernible effects of soil amelioration treatments on microbial populations.
- ❖ Soil respiration rates were minimally affected by treatments; the addition of gypsum seemed to inhibit soil respiration under some parameters.
- ❖ Salt tolerant fluorescent organisms isolated for further study could be promising inoculants to stimulate plant growth in coastal soils.

♦ Acknowledgments

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