Salinity and Fertilization Effect on *Sagittaria lancifolia (Bulltongue)* Growth

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Introduction

Sea-level rise is a constant and increasing threat to all coastal areas (Gornitz, 1995). The wetlands along the Gulf coastal area struggle to survive the conditions and that are directly related to sea-level rise (Warren & Niering, 1993). Although coastal marshes are under duress from increasing salinity caused by the inland movement of Gulf waters, there are select native species, namely *Sagittaria lancifolia*, that have the potential to better withstand these changes.

Louisiana native *Sagittaria lancifolia* is a perennial that primarily grows in fresh and oligohaline marshes. This tall, smooth plant has an extensive, clustered rhizome root system that supports rapid regrowth after disturbances, such as hurricanes, flooding and marsh fires. Saltwater intrusion events are very stressful on *Sagittaria lancifolia.* Researchers have found *Sagittaria lancifolia* resilient in flood conditions but less tolerant of salinity (Baldwin & Mendelssohn, 1998; Howard & Mendelssohn, 1999; Visser & Sandy, 2009). It's the unique rhizomes root system that allows for rapid lateral growth, making it one of the fastest recovering freshwater species (Flynn et al., 1985) (Flynn, McKee, & Mendelssohn, 1995).

The following experiment explores the robustness of *Sagittaria lancifolia* by monitoring its aboveground growth and measuring the dried harvested belowground biomass after 12 weeks of various salinity and fertilizer applications. We hypothesized that the growth of *Sagittaria lancifolia* will show a positive relationship between fertilization and salinity.

Methods

On May 14, 2014, *Sagittaria lancifolia* L. plants were collected from White Lake Wetlands Conservation Area in Vermilion Parish, La, a freshwater marsh with healthy, undisturbed vegetation. Sections of sod with one or more plants were dug out of the marsh and placed in buckets for transport to Lafayette, La. The next day, plants were separated and 40 plants were placed in individual three gallon pots with generic potting substrate. Each pot was then placed in a 5 gallon bucket with a 6 in brick at the bottom, to allow room for root growth and to simulate a floating marsh environment. The 5 gallon buckets were then filled with water to the substrate surface.

Plants were allowed to recover from transplant for two weeks. After this time, the five smallest and the five largest plants were dried and weighed to establish an aboveground and belowground biomass base line. The individuals in these groupings were further divided into three components: 1) living leaves, 2) dead leaves and 3) roots. Leaves were cut at the base of the plant; roots were washed to remove all soil then placed in the oven for three days at 60^{o}C. Once dried, their weight was measured to the nearest gram. The 30 remaining plants were randomly assigned to a complete factorial design of five salinity (0, 1, 2, 4, or 8 ppt) and six nitrogen (0.0, 0.1, 0.2, 0.4, 0.8, or 1.6 g N per pot) treatments. Throughout the experiment salinity levels were measured with a YSI 63salinity probe; when necessary, An Instant Ocean solution, was added to maintain salinity at predetermined levels. To reach and maintain desired nitrogen levels, Miracle Gro® (24N-8P-16K) was weighed to the nearest 0.01 gram and added to the buckets once at the beginning of the experiment.

Plants were measured weekly; each measurement was to the nearest 5 mm, starting from the tip of the arrow head down to the base of the plant. Leaves that were yellow or more than half way brown were recorded as dead. Flowers were considered alive as long as there was one live flower on the stem. The number of flowers, live leaves, and dead leaves were recorded weekly to establish an estimated growth rate. At the end of the 73 day growing period (June 6 to August 18), the remaining plants were harvested to determine their aboveground and belowground biomass. All leaves were cut at the base of the plant and placed in paper bags to be dried in the oven for three days at 60^0C. Roots were washed to remove all the soil and were placed in paper bags and dried in the oven for three days at 60^0C. Once dried, their weight was measured to the nearest gram.

Growth rates (cm/day) for each plant were determined by linear regression of total stem height as a function of time. We limited the range of the growing season to the first measurement taken and the last measurement taken on July 19. After July 19, growth decreased in all plants as the plants entered their natural senescence period.

The relationship between growth rate, aboveground biomass, belowground biomass, and total biomass was determined by fitting regression surfaces with salinity and nitrogen levels as the independent variables. We started by fitting curvilinear relationships, because we expected that there would be optimum salinity and nitrogen conditions within our experimental space.

Results

A statistically significant relationship was detected between combinations of salinity and nitrogen treatments and their effect on total aboveground biomass and live aboveground biomass (Table 1). Aboveground biomass generally increased with increased nitrogen (positive slope Table 1, Figure 1). However, in the lower two salinity treatments, the highest nitrogen level had a negative effect (Figure 1), this effect is detected by the significant interaction term between

Table 1: Multiple Parameter Regression Analysis

Dependent Variable	Intercept	Salinity	Salinity^2	Nitrogen	Nitrogen^2	Interaction	R^2
Total Aboveground Biomass (g/pot)	4.11	4.93	-0.65	31.72*	-13.93	0.38*	0.37
Live Aboveground Biomass (g/pot)	0.73	2.95	-0.46	23.21*	-10.85	0.32*	0.40
Belowground (g/pot)	158.61	24.14	-3.02	46.33	-15.79	6.39	0.04
Total Biomass (g/pot)	162.71	29.07	-3.67	78.05	-29.72	6.77	0.06
Growth Height (mm/day)	23.56	2.66	-1.33	156.21*	-107.04**	15.63*	0.38

Significance code: ***=0.001, **=0.01, *=0.05.

salinity and nitrogen. No significant relationship between treatments and Belowground or Total Biomass was evident. Growth had a significant curvilinear correlation with nitrogen and also showed a significant interaction between nitrogen and salinity.

When salinity concentration was the lowest (0ppt and 1ppt) growth is significantly reduced in pots containing N1.6 (Figure 2, top two panels). Plants in the 2ppt and 4ppt salinity treatment had the greatest aboveground growth when exposed to increasing nitrogen levels (Figure 2 middle two panels). There is a similar growth rate in treatment 8ppt compared to the 2ppt and 4ppt, but the higher salinity leads to a dcrease of the growing season by approximately two weeks.

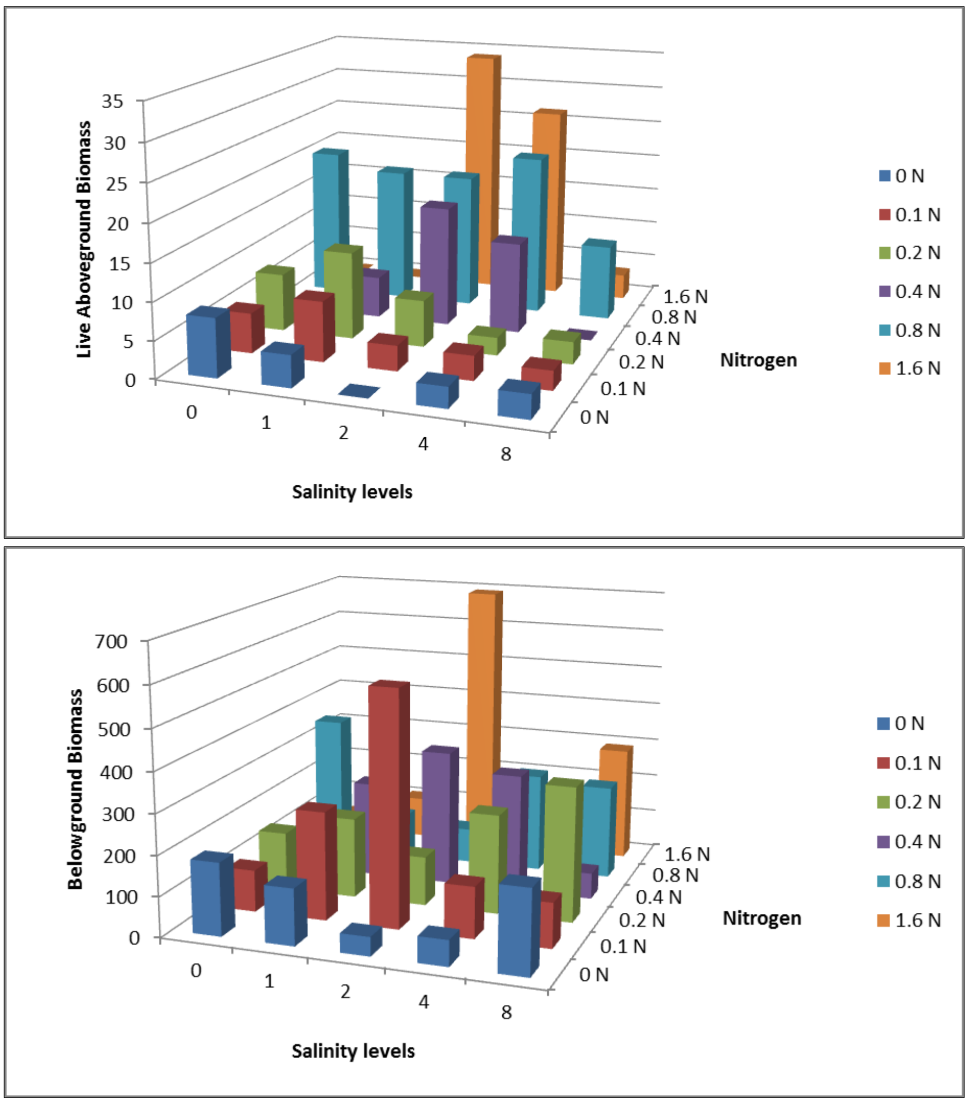

Figure 1. Biomass harvested at the end of the experiment. Top pannel shows live aboveground biomass. Bottom pannel shows belowground biomass.

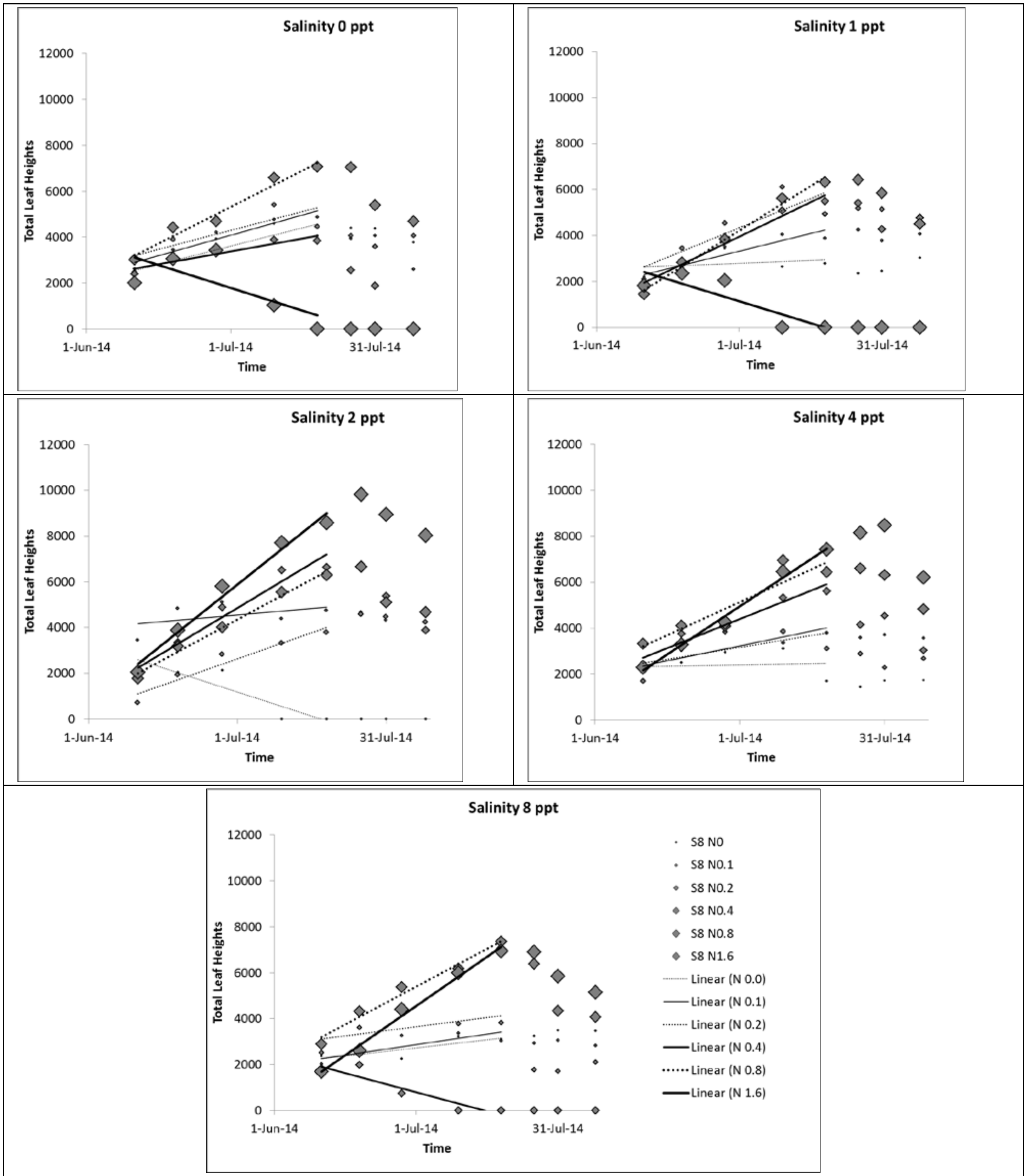

Figure 2. Growth of the plants over the experiment. Linear regressions were fitted to the data up to Julky 19, 2014 for all plants, because natural senescence occurred after this date.

Discussion

In the overall experiment *Sagittaria lancifolia* plants reacted to the salinity treatments consistent with previous researcher results indicating the salinity tolerance of this species (Flynnet al. 1995; Howard & Mendelssohn, 1999; Pezeshki et al. 1987; Visser & Sandy 2009). Howard and Mendelssohn (1999) found *Sagittaria lancifolia* to brown and curl old leaf edges to conserve moister when exposed to salinity. It was the first species in their study to show tissue damage from salinity stress, although it continued to provided new leaves to replace the damaged ones (Howard & Mendelssohn, 1999). The new leaves are crucial for the plants photosynthetic process (Pezeshki et al., 1987). This survival technique has likely contributed to the dominance of this species in fresh water marshes.

The result from the Live Aboveground Biomass Bar Graphs (Figure 1) show notable stress from the salinity levels yet there is no supporting data that suggests parallel effects on belowground biomass. Similar results in Baldwin and Mendelssohn (1998) study showed *Sagittaria lancifolia* biomass is significantly lower when introduced to salinity conditions then flooded disturbances. More specifically the aboveground biomass encountered damage whereas belowground biomass had inconclusive data (Baldwin & Mendelssohn, 1998). In Visser and Sandy (2009) experiment, *Sagittaria lancifolia* decreased in belowground biomass when flooded. Like studies suggest that excessive nutrients in wetland environments increase plant aboveground biomass while simultaneously decreases belowground biomass, due to the root system is receiving sufficient nutrients load (Darby & Turner, 2008; Nyman, 2014). We found a negative effect of high nutrient concentrations on growth and aboveground biomass at low salinity, but at higher salinity growth was stimulated. We found no effect of salinity or nitrogen on below ground biomass in this relatively short experiment.

This finding of this experiment confirms a significant curvilinear relationship between varied salinity levels and fertilizer treatments. In conclusion *Sagittaria lancifolia* has a higher salinity tolerance with the presents of fertilizer. For future research on this experiment one would add more treatments to specifying the range around the significant relationship salinity and fertilizer share. Since we used only one plant per treatment, it is premature to reach far reaching conclusions from these results. But we found significant correlations that can assist the development of models to evaluate the effects of diversions on *Sagittaria lancifolia*.

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