Joshua Guerrero
July 10, 2018
BIOL F116X F81
Research Project 1

Nutrient competition between plants in aquatic ecosystems

Abstract: Competition for nutrients in the soils occurs between plants in ecosystems but not all nutrients are found in even concentrations. This experiment was designed to observe how nutrient competition would occur if two aquatic plants, *Elodia* and *Salvinia,* were to be placed together in a watery environment that was saturated with nutrients that were evenly dispersed. Three treatments were created in order to test how different levels of nutrients would affect competition: full fertilizer, half fertilizer, and no fertilizer. Competition did occur in the fertilized treatments but a third organism, algae, grew in the presence of high nutrient concentrations and small amounts of light exposure. Out of the three organisms present, *Salvinia* showed the most amount of growth in biomass and length while *Elodea* showed the greatest amount of decline as well as a majority of the *Elodea* specimens perishing after the four week period.

Introduction

Resources are never infinite in ecosystems and more organisms means more competition. As populations grow, the dynamics between the inhabitants become more complex as resources become more scarce. Some of these organisms provide key functions in the ecology of the habitat and their death might send a wave that could disrupt a coexisting species' ability to survive. Human intervention, through such acts as clearing land for agricultural purposes, can also remove or even destroy established resources that nearby organisms utilize, increasing competition dramatically (Diamond *et al.* 1989).

In soil, nutrients may not be mixed thoroughly or evenly, increasing competition between plant life. With this uneven dispersal, some plants may even selectively reduce certain nutrients in the surrounding soil to a lower than optimal point and affecting other nearby species that are also competing for these nutrients (Craine and Dybzinski, 2013).

Aqueous plants, on the other hand, may obtain dissolved nutrients from either or both the sediment and the surrounding water. If the plant is non-rooted yet floating in the water, additional nutrients may be captured from the atmosphere, such as carbon dioxide, in addition to those found in the water they are submerged in. (Lacoul and Freedman, 2006)

In this experiment, we are interested in determining the degree of competition for nutrients that would occur if two aquatic plants were isolated and placed in a habitat saturated with nutrients. We hypothesize that, although plants will grow when nutrients are present in the treatment, competition for those nutrients will occur if more than one plant is present. In treatments with higher concentrations of nutrients, we predicted that there would be equal amounts of relative growth of biomass since the abundance of nutrients would reduce the need for competition.

Methods

Treatments

In order to test our hypothesis, samples of two different aquatic plants, *Elodea* and *Salvinia*, were used for this experiment. These plants were both non-rooted plants and grew by free-floating in the water treatments created. With these plants, three different treatments types were tested in order to observe how the abundance of nutrients affected competitive growth between the two plants:

1) Full amount fertilizer treatment (0.234mL fertilizer / 1800mL water)
2) Half dose of fertilizer (0.117ml fertilizer / 1800mL of water)
3) No fertilizer

Treatments with no fertilizer mixed-in acted as the control groups for the experiment since no additional nutrients would be available for competition to occur.

Aquatic Environment

Each treatment consisted of a single sample of each plant type that was placed in a cup filled with 12oz (~0.35L) of treatment solution and was let standing without any manipulation for four weeks. Every week, water levels would be checked and replenished with concentrated solution if needed.

Order of Treatment Testing

We used 10 replicants per treatment for a total of 30 treatments. In order to reduce observation bias, containers were assigned one of three treatments and the order of the placement of plants into containers were randomly chosen using random number generator in Microsoft Excel.

Competitive Growth Measurement

Before being placed into cups of treatments, the biomass of the plants were measured to the nearest 1/100 of a gram and the lengths of the stems were measured to the nearest 1/10 of a centimeter. At the end of the experiment, the final biomass and length measurements were recorded in order to determine the differences in the rate of growth between fertilized and unfertilized treatments.

Mean Difference in Biomass

10 replicates for each treatment were created for a total of 30 treatments and 60 individual plant samples. The biomass and length of each of the two plants in each treatment were recorded at the beginning and the end of the experiment in order to compare the amount of growth that had occurred over time. The average of the weights and lengths for each treatment would then be used to calculate a percentage of change that had occurred over time across the four week period.

$$Mean\ Initial/Final\ =\ Sum\ of\ all\ replicant\ data\ /\ \#\ of\ replicants$$
$$Mean\ Difference\ =\ Mean\ Initial\ -\ Mean\ Final$$
$$\%\ Change = (Mean\ Difference\ /\ Mean\ Initial) * 100$$

Results

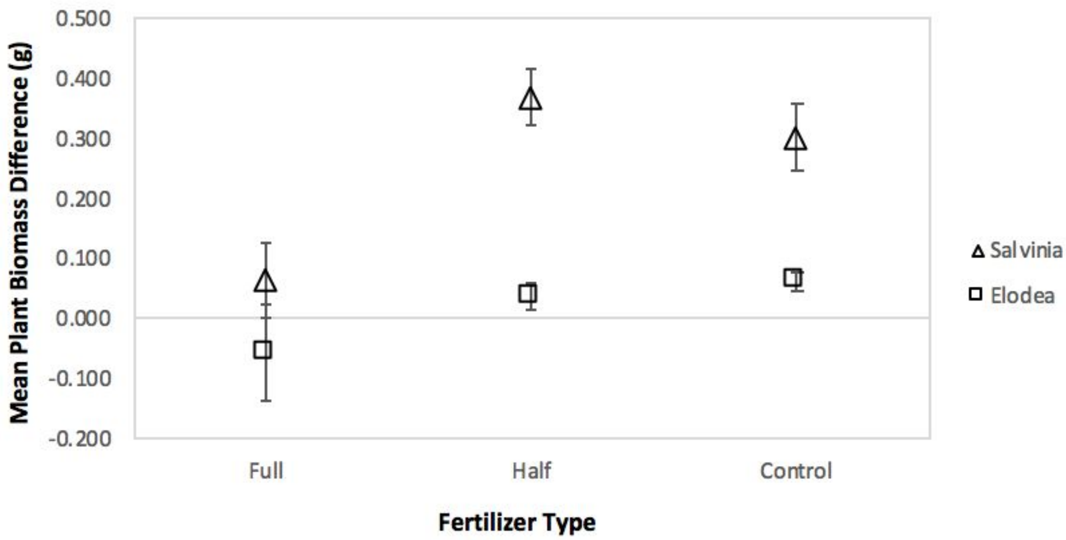

Figure 1. Mean difference in biomass (g) of plants over the course of four week growth period. Replicant types represented include: *Elodia* (square) and *Salvinia* (triangle). Treatments represented as fertilizer strength include: full (0.234mL per 1800mL water), half (0.117 per 1800mL water), and control (no fertilizer). Points show means based on 10 replicants of same plant type. Error bars show standard error of the mean.

For treatments of full strength fertilizer, the mean mass of the *Elodea* plant lost a little over a quarter of its initial mass (-0.056 ± 0.082 grams) while the *Salvinia* plant increased over half of its initial mass (0.119 ± 0.063) (Fig.1).

For treatments of half strength fertilizer, the mean mass of the *Elodea* plant gained a quarter of its original mass (0.039 ± 0.023 grams) while the *Salvinia* plant increased almost over three times of its original mass (0.331 ± 0.047 grams) (Fig.1).

For the control treatments, the mean mass of the *Elodea* plant gained over half of its original mass (0.062 ± 0.017 grams) while the *Salvinia* plant increased almost three times its original mass (0.241 ± 0.056 grams) (Fig.1).

Overall, the Salvinia plant experienced a net growth in all treatments with the greatest amount of growth occurring in the half fertilizer treatment. The *Elodea* plants lost the most biomass in the full-fertilizer treatment and gained the most in the control.

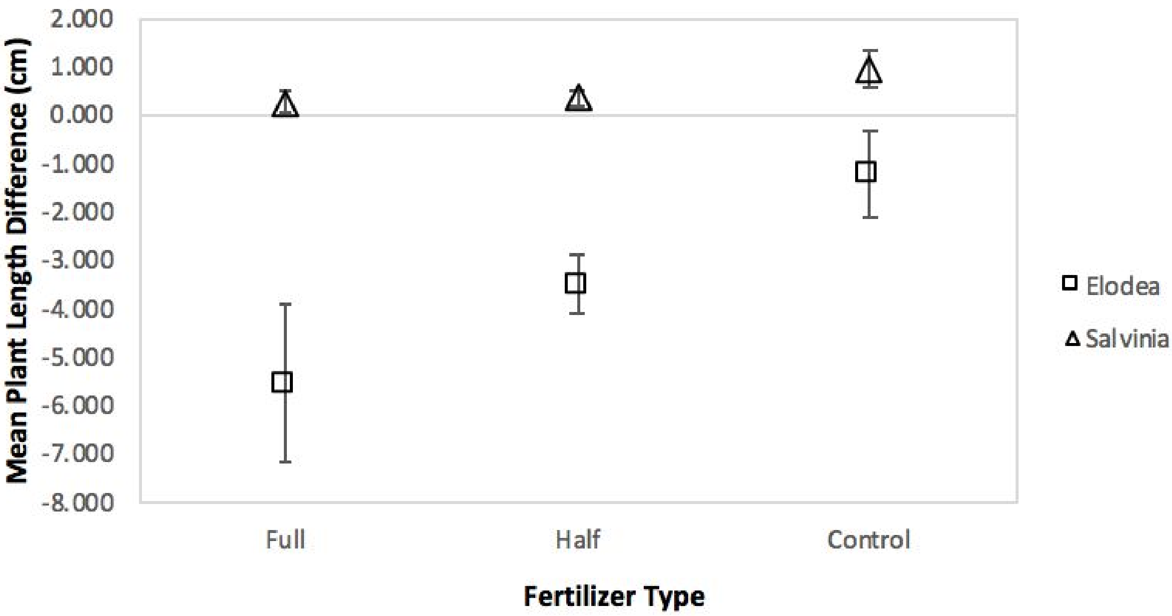

Figure 2. Mean difference in length (cm) of plants over the course of four week growth period. Replicant types represented include: *Elodia* (square) and *Salvinia* (triangle). Treatments represented as fertilizer strength include: full (0.234mL per 1800mL water), half (0.117 per 1800mL water), and control (no fertilizer). Bars show means based on 10 replicants of same plant type; error bars show standard error.

For treatments of full strength fertilizer, the *Elodea* plants lost a little over half of its initial mean length (-5.793 ± 1.633 cm) while the *Salvinia* plant increased about one tenth of its initial mean length (0.260 ± 0.217 cm) (Fig.2).

For treatments of half-strength fertilizer, the *Elodea* plants lost about a third of its initial mean length (-3.840 ± 0.617 cm) while the *Salvinia* plant increased about one tenth of its initial mean length (0.350 ± 0.138 cm) (Fig.2).

For the control treatments, the *Elodea* plants lost about a quarter of their initial mean length (-2.190 ± 0.9 cm) while the *Salvinia* plants increased one-fifth of its initial mean length (0.960 ± 0.365 cm) (Fig.2).

In every treatment, the *Elodea* plants' mean difference in length decreased by at least one quarter of the original mean length with the full-fertilizer treatment showing the most loss. The *Salvinia* plant showed the opposite of the *Elodea* and all of its mean lengths increased, the greatest being from the plants in the control treatments.

Discussion

After compiling the results of the experiment, we can conclude that our hypothesis was refuted by our data. We proposed that the treatments with higher concentrations of fertilizer would yield equal amounts of growth in relative biomass in each of the plants present. In the full concentration treatments, biomass was decreased in the *Elodea* plants and increased in the *Salvinia* plants instead of growing equally as we originally hypothesized.

There was also a considerably greater amount of plant death in the *Elodea* samples as compared to the *Salvinia* after the four week period. For the *Elodea* plants, 18 were counted as dead: four in the control group, six in the half-strength treatment, and eight in the full-strength treatment. For the *Salvinia* plant, only two had been counted as dead, both from the half-fertilizer treatment. With the death of the *Elodea* plants, biomass was lost in the form of flowers that fell off and decomposed as the plant died, leaving only the stem for a majority of the biomass measurements.

In almost all of the treatments with nutrients added, visible amounts of green algae formed. Since algae requires exposure to light for full utilization of the nutrients supplied (Anderson et. al 2002), the small amount of light that the plants were exposed to could have also caused an accelerated growth to a tiny amount of algae present from the tanks the plants were originally pulled from. With the formation of these blooms, more competition for the limited nutrients may have occurred and growth of the *Elodea* plants may have been significantly hindered.

Other variables that could have influenced the growth of these plants were factors such as the accidental and unintended introduction of small animals that feed on plant material, inconsistent amounts of light, and damage to the plant via drying out during transfer from their original tanks to the treatment cups.

From this experiment, we can conclude that nutrient competition takes place to some extent but we are unable to solidly determine which of the two plants had the most impact due to the introduction of algae as a third dependent variable. If further experimentation would occur, caution should be taken to try and limit growth factors for algae and other organisms if possible in order to get more accurate observations.

Literature Cited

Diamond, J.M., N.P. Ashmole, and P.E. Purves. 1989. The Present, Past and Future of Human-Caused Extinctions [and Discussion]. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 325:469-477

Craine, J.S., and R. Dybzinski. 2013. Mechanisms of plant competition for nutrients, water and light. Functional Ecology 27:833-840.

Lacoul, P., and B. Freedman. 2006. Environmental influences on aquatic plants in freshwater ecosystems. Environmental Reviews 14:89-136.

Anderson, D. M., P. M. Gilbert, J. M. Burkholder. 2002. Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences. Estuaries and Coasts 25: 704-726.

Original Final Data Collection

D = dead
B = broke

Cup #	Elodea (cm)	Elodea (g)	D/B	Lemna (cm)	Lemna (g)	D/B
1	11.5	.145	(D)	3.5	.066	
2	10,	.258		3.5	.213	
3	4.5	.431		4.5	.413	
4	7.1	.285		3	.223	
5	7.5	.204		3.2	.~~20~~.213	
6	6.6	.182		3.7	.516	
7	1.5	.026	D	2.2	.257	
8	3.5	.043		3.6	.558	
9	6	.179	D	3.2	.476	
10	5	.114	D	3	.268	
11	10.5	.344	D	3	.570	
12	7.5	.143		3.3	.215	
13	7.5	.308	D	4	.342	
14 AN	1.5	.022	D	2.8	.198	
15 AN	~~I~~		D	3	.234	
16 AN	5	.047	D	3.5	.152	
17	11	.267	D	4	.556	
18	7	.243		3.5	.578	
19	6	.205	D	3.5	.157	
20	~~4~~7	.149	D	3	.209	
21	4.5	.106	D	~~2.5~~ B2.5	.198	
22	21.2	.698	D	3.8	.491	
23	6.5	.126	D	3.5	.291	
24	5	.115		3.5	.567	
25	3	.073		5	.905	
26	2.7	.047	D	~~1.5~~	~~.085~~	D
27	3	.089	D	3.5	.46	
28	3	.092	D.5	3.3	.331	
29	12	.359		4.5	.408	
30	6	.125	D	2	.305	D