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Intelligence

Effect of water depth on growth of the macroalgae Ulva lactuca in a biofloc system

10 July 2023

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Shallow culture resulted in strong macroalgae growth rates

In shrimp farming, only 25 to 30 percent of the nitrogen and phosphorus from formulated feeds and fertilizers are incorporated by the shrimp, and most is leached and lost in the culture water. Selecting species for culture that can reuse the nutrients and maximize production is essential for more sustainable systems.

The cultivation of macroalgae associated with other aquatic organisms has gained momentum due to the increasing focus on sustainable systems with nutrient recycling. As inorganic consumers, macroalgae use nitrogen and phosphate compounds in the water for their growth. Several studies have shown a better performance of macroalgae when cultivated in shrimp farm effluent and/or in integrated systems.

This article – summarized from the **original publication** (https://doi.org/10.3390/phycology3020018) (Carvalho, A. et al. 2023. Growth of the Macroalgae *Ulva lactuca* Cultivated at Different Depths in a Biofloc Integrated System with Shrimp and Fish. *Phycology* 2023, 3(2), 280-293) – presents the results

This study evaluated different depths of culture for the macroalgae *Ulva lactuca* in an integrated biofloc system with Pacific white shrimp and Nile tilapia. Photo by AnypReyes, via Wikimedia Commons.

of a study to evaluate the cultivation of the green macroalgae *Ulva lactuca* in different water depths in a biofloc-integrated system with shrimp and fish, and to determine how macroalgae influence total suspended solids.

Study setup

The objective of this work was to evaluate different depths of culture structure for the macroalgae *U. lactuca* in an integrated system with Pacific white shrimp (*Litopenaeus vannamei*) and Nile tilapia (*Oreochromis niloticus*) in a biofloc system. The study was conducted in a greenhouse at the Marine Aquaculture Station (Estação Marinha de Aquicultura–EMA), Institute of Oceanography, Federal University of Rio Grande (FURG), Rio Grande, Rio Grande do Sul, Brazil.

The 70-day experiment involved six culture systems each with a 16-cubic-meter shrimp tank, a 3-cubic-meter fish tank and a 3-cubic-meter algae tank, with water recirculation between all the tanks. Two algae culture treatments were used, including a shallow float (10 cm depth) system and a bottom float system at 30 cm from the water surface. For detailed information on the study setup, refer to the original publication.

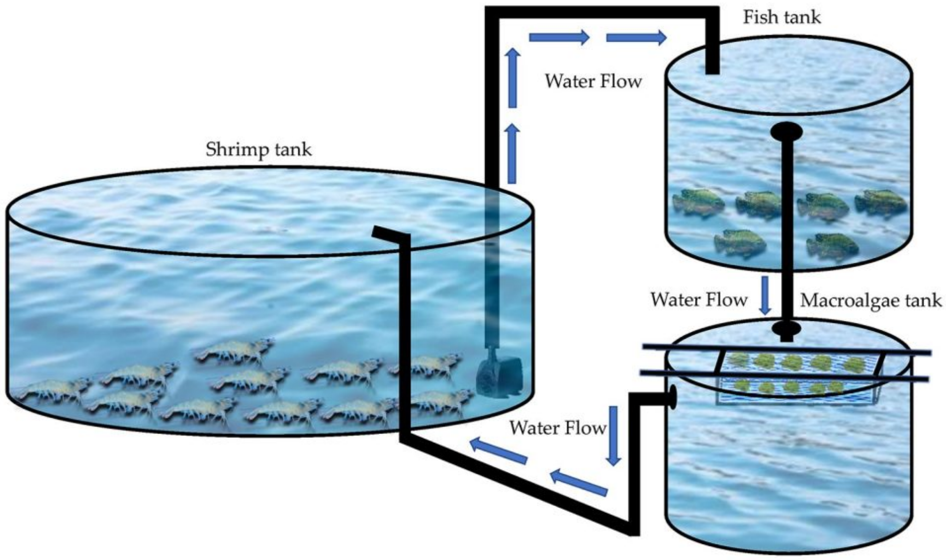

Fig. 1: Diagram of the experimental recirculation system used in this study, with a 16-cubic-meter shrimp tank, a 3-cubic-meter fish tank and a 3-cubic-meter algae tank. Floats were used to grow the macroalgae during the study.

Results and discussion

The biomass of macroalgae in the shallow treatment showed, throughout the experimental period, a significant difference ($p \leq 0.05$) from the bottom treatment. The bottom float treatment showed a decreasing trend in macroalgae biomass throughout the experimental period (Fig. 2).

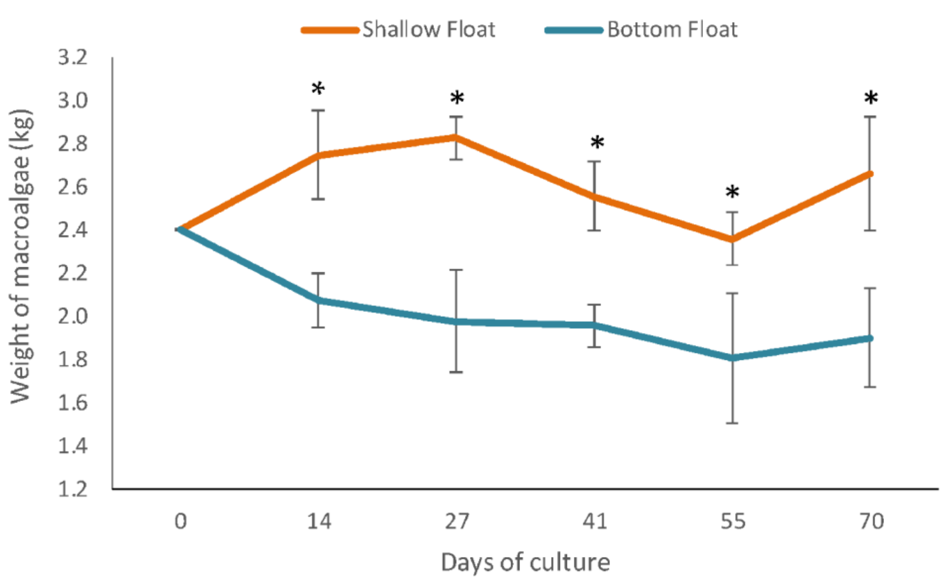

Fig. 2: Mean macroalgae weight (kg fresh weight) of the treatments, shallow float (between 5 to 10 cm depth) and bottom float (between 25 to 30 cm depth) during the 70-day experiment. Asterisks (*) represent significant differences ($p \leq 0.05$) among treatments.

In the 70 days of the experiment, the relative growth rate of macroalgae in the shallow float treatment was 0.14 ± 0.14 percent per day, with an increase in biomass in the first weeks of culture (up to 0.95 ± 0.54 percent per day) and a decrease in biomass between sampling on days 41 and 55 of culture. At the end of the experiment, the shallow treatment showed a gain in macroalgae biomass. There was no difference in the performance of fish and shrimp between the treatments during the 70 days of culture.

Integrated culture requires that water quality conditions meet the optimal levels for the cultivation of all species produced so that stress and poor development do not occur. The use of a mature biofloc inoculum with the establishment of bacteria and the presence of nitrate in this experiment provided high concentrations of total ammoniacal nitrogen and nitrite, which were controlled during culture, and no water quality problems were observed. As there was no control treatment without macroalgae, the uptake of nutrients by macroalgae was not verified. However, since there was no difference in the nitrogen content between the treatments, the loss of biomass in the bottom treatment did not cause nitrogen problems. The biomass of macroalgae used in the experiment was also low compared to the entire volume of the system, probably not causing significant nutrient uptake.

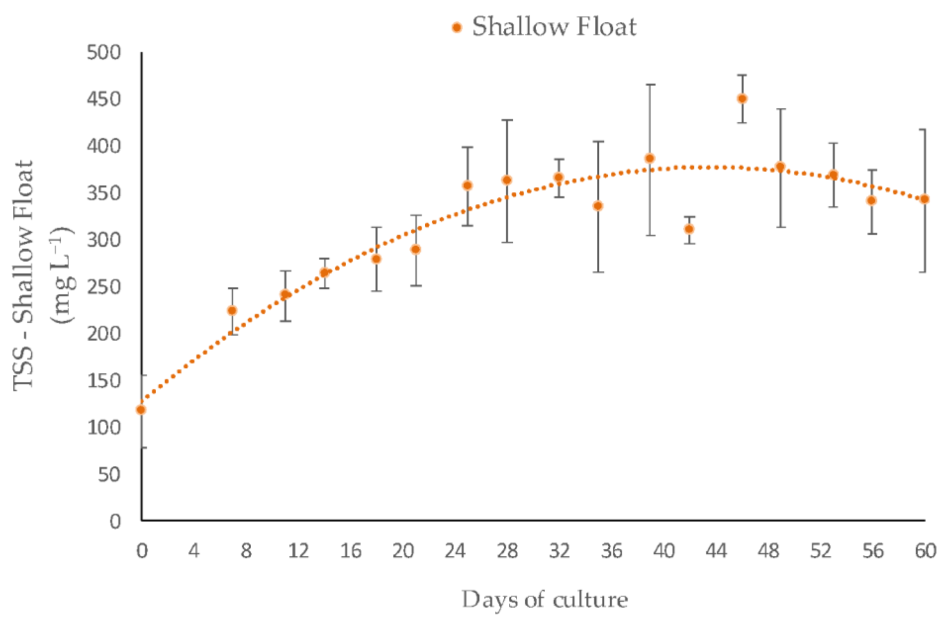

Fig. 3: Mean ± standard deviation of total suspended solids (TSS) over the course of the cultivation days (n = 3).

In this study, solids were deposited on the macroalgae and were not accounted for in the water quality analysis, with an overall average increase of 39.4 percent and 40.1 percent in total suspended solids in the shallow and bottom float treatments, respectively. Even when the total suspended solids concentrations were higher than 300 mg per liter and clarifiers were used, the solids were not removed from the system. The water going to the clarifier contained only the solids in suspension in the water column. The formation of this physical barrier of macroalgae may serve as a substrate for bacteria and help support and improve water quality, but little is known about this relationship or the chemical effects between macroalgae and solids.

In addition to the deposition, the production of solids from feces, feed residues, and growth of bacterial biomass was continuous throughout the days of culture. High concentrations of solids were found on days 40 to 48, exceeding 400 mg per liter total suspended solids, requiring the permanent use of clarifiers. The accumulation of solids in this period may have influenced the decrease in biomass of the macroalgae between sampling on days 41 and 55. The high organic load may prevent light from entering the water, decreasing the macroalgae's photosynthetic efficiency and overall performance. Our results suggested that better *U. lactuca* performance integrated into a BFT system can be obtained from waters with TSS concentrations lower than 300 mg per liter by using clarifiers.

The increase in depth of the bottom float structures (15 to 25 cm) provides more space for macroalgae movement and greater carrying capacity for the macroalgae biomass. However, according to **Luo et al.** (https://doi.org/10.1016/j.aquabot.2012.03.006), the biofloc system has great light limitations, with ammonia removal occurring predominantly by bacteria, as they do not need much light and can develop better in the system. **Reis et al.** (https://doi.org/10.1016/j.aquaculture.2019.04.067) studied with different colors and wavelengths for the culture of *L. vannamei* shrimp and evaluated the penetration of each wavelength at the surface and at 20 and 40 cm of depth.

These authors showed that the light penetration decreased with depth due to reflection or absorption by suspended particles in the water. Wavelengths of 79.05 ± 42.00 μmol/m^2/m and of 20.45 ± 23.40 μmol/m^2/m are absorbed, respectively, at the surface and at 20 cm depth, in white light. This decrease of light in the water column may be a determinant in reducing macroalgae growth, causing the loss of biomass seen in the bottom float treatment.

Despite the deposition of solids on the macroalgae in both treatments, the shallow float treatment (5 to 10 cm) provided better conditions for macroalgae growth. The proximity to the surface probably allowed the macroalgae to capture more light for photosynthesis. The proximity to the surface and the adaptation of the macroalgae to the biofloc environment before the beginning of the experiment were possibly determining factors for better performance.

Better management and water quality parameters still need to be established for maximum macroalgae growth to occur in integrated biofloc culture. The use of clarifiers to remove solids and the maintenance of a concentration of 100 mg per liter of total suspended solids would probably favor greater light input. The shallow float allowed the macroalgae to grow in culture, and the use of aeration within the macroalgae structure would probably be more efficient in moving the macroalgae in the structure, and less settling of solids would occur. An improved management protocol could include partial harvests, which can decrease the density, promoting greater light penetration and nutrient availability.

In our study, tilapia were added to both treatments to consume the solids, but there was no quantification of the solids consumption. However, the addition of an organic consumer along with the macroalgae may help to reduce the solids and improve the light incidence in the water, favoring the growth of the macroalgae.

Perspectives

The integrated culture in a biofloc system presents distinct characteristics compared to conventional cultures in clear water due to the high load of solids and nutrients. The insertion of the macroalgae in the integrated biofloc system showed deposition of solids on the macroalgae, decreasing the concentrations of total suspended solids and avoiding solids exiting the system by clarification.

Even with this result, there was growth of the macroalgae *U. lactuca* in an integrated system with the shrimp *L. vannamei* and Nile tilapia *O. niloticus*, showing the algae culture viability at depths of up to 10 cm in a biofloc system with an average TSS concentration of 300 mg per liter.

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