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Effect of different total suspended solids concentrations on the growth performance of *Litopenaeus vannamei* in a BFT system

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ABSTRACT

Decreased *Litopenaeus vannamei* performance resulting from excess total suspended solids (TSS) has been highlighted in previous studies. Therefore, the aim of this study was to evaluate the effect of different TSS concentrations on the *L. vannamei* growth performance in a BFT system for 42 days. Five TSS concentrations were used—250, 500, 1000, 2000, and 4000 mg L^{-1}—in three replicates identified as T250, T500, T1000, T2000, and T4000, respectively, in 200 L-tanks each. Dissolved oxygen concentration (DO) was maintained above 5 mg L^{-1}. Shrimp with an initial average weight of 4.57 ± 1.07 g were stocked at a density of 277 shrimp m^{-2}. The physical and chemical parameters were monitored. Water quality parameters and animal performance were subjected to analysis of variance (ANOVA – one way). The physical and chemical parameters were within the recommended range for *L. vannamei*. Weekly weight gain, feed conversion rate, survival, and productivity showed no significant differences ($p > 0.05$). The high TSS concentrations did not seem to affect the performance of this species when DO concentrations were maintained above 5 mg L^{-1}.

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1. Introduction

Several of the current production systems of penaeid shrimp utilize parallel microorganism cultures that supplement the food of the target species (Wasielesky et al., 2006a; Ballester et al., 2007). The BFT system contributes directly by means of microorganisms that use ammonia as nutrients for the formation of bacterial proteins (Wasielesky et al., 2006a). Simultaneously, the water quality benefits from the recycling of nutrients that are present throughout the culture as bioflocs (Ebeling et al., 2006).

An increase in stocking density implies an increase in feeding because of biomass increases (Krummenauer et al., 2011) and consequent rises in particulate organic matter in cultured water that is involved in the formation and aggregation of microorganisms. The water storage in lined tanks in systems with minimal or no water renewal exposes the organisms in direct contact with higher amounts of the organic particles and also determine the importance of aeration and water movement in BFT systems (De Schryver et al., 2008). The dynamics caused by mechanical aeration promotes the mixing and distribution of particles (Hargreaves, 2006) that vary in size and composition. These variations can be expressed by microbial composition that reflects in the structure of bioflocs. The microbial composition may determine the size and density of bioflocs in water and also reflect in the consumption by cultured organisms (Ekasari et al., 2014).

Microorganisms consume dissolved oxygen (DO) to maintain metabolic activities during the decomposition of organic matter (Avnimelech, 2009). In this sense, the aeration system must be sufficient to supply dissolved oxygen to the target species and microorganisms (Van Wyk and Scarpa, 1999; De Schryver et al., 2008). However, in some studies, the DO concentrations were not maintained until the end of the cycle, especially in conditions of high concentrations of suspended solids (Ray et al., 2010a; Gaona et al., 2011; Krummenauer et al., 2011). Furthermore, the absence of aeration in BFT systems can lead to a reduction of dissolved oxygen to lethal levels after approximately 30 min (Vinatea et al., 2010). The increase of suspended solids in BFT systems is constant and could pose hazards to production. The recommended maximum concentration of total suspended solids is 500–600 mg L^{-1} (Samocha et al., 2007; Gaona et al., 2011; Schveitzer et al., 2013). As mentioned in previous publications, the suspended particulate matter excess can cause interactions with water quality parameters (Furtado et al., 2011; Gaona et al., 2011), which can cause stress to cultured organisms (Ray et al., 2010a). In a study assessing the

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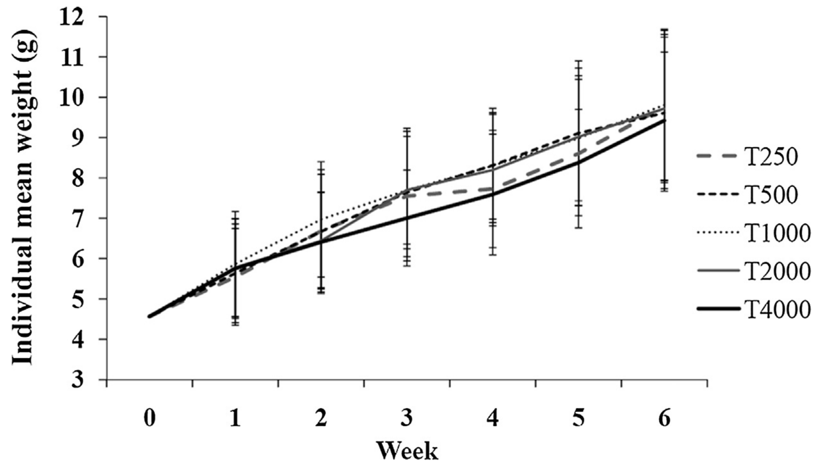

Fig. 1. Individual mean weight of *L. vannamei* in different TSS concentration in a BFT system. Vertical bars indicate one standard deviation.

degree of gill occlusion in *Litopenaeus vannamei*, Schveitzer et al. (2013) reported that higher suspended solids concentrations may have clogged the gills and committed to respiration of the shrimp.

The aim of this study was to evaluate the effect of different concentrations of TSS on the growth performance of *L. vannamei* in BFT culture systems.

2. Materials and methods

2.1. Experimental design

The study was conducted at the Marine Station of Aquaculture Prof. Marcos Alberto Marchiori (EMA) under the Oceanographic Institute of the Federal University of Rio Grande—FURG, located at Cassino Beach in Rio Grande, RS, Southern Brazil (32°11′S; 52°10′W). The experiment lasted 42 days.

The treatments were defined according to the concentrations of total suspended solids (TSS): 250, 500, 1000, 2000, and 4000 mg L^{-1} in three replicates, which were identified as T250, T500, T1000, T2000, and T4000, respectively. Fifteen tanks, with a volume of 200 L each, were installed in a greenhouse for culture studies of marine shrimp in BFT systems. Aeration was supplied by a 2 hp blower for air diffusion in the water column via hose with micropores (Aero-Tube™, Swan®, Marion, OH, USA) in order to maintain DO concentrations at high levels.

To begin the study, the proposed TSS concentrations were used with concentrated biofloc inoculum from clarifiers (Gaona et al., 2011) with approximately 5000 mg L^{-1}. For each treatment, appropriate dilutions were performed for each concentration, maintaining a salinity of 33. Fresh and salt water were used and were chlorinated with 10 ppm and dechlorinated with 1 ppm of ascorbic acid, even when replacements were needed by evaporation. To keep the TSS levels constant in each treatment throughout the experimental period, 50 μm mesh filters were used.

2.2. Biological material and feeding

The animals for the experiment were kept in a nursery tank inside a greenhouse in a Marine Aquaculture Station (EMA). The shrimp were stocked with an initial average weight of 4.57 ± 1.07 g at a stocking density of 277 shrimp m^{-2} (500 individuals m^{-3}).

The shrimp were fed twice a day (at 9:00 and 16:00) with commercial feed (Potimar Active 38–Centro Oeste Rações SA, Campinas, SP, Brazil) containing 38% crude protein and 8% lipids. The food was offered on feeding trays (Wasielesky et al., 2006a) at an initial rate of 5% of shrimp biomass and was adjusted according to consumption observed in a 24-h period. This value was subsequently adjusted according to the consumption observed in the trays within each interval between feedings.

2.3. Physical and chemical water parameters

Physical and chemical parameters were monitored daily (dissolved oxygen, pH, temperature and salinity) using multiparameter equipment YSI® mod. 556 (YSI Incorporated, Yellow Springs, OH, USA). Water quality was monitored by measuring total ammonia nitrogen levels (TAN), nitrite (NO_2^-–N), nitrate (NO_3^-–N), orthophosphate (PO_4–P), total suspended solids (TSS), and alkalinity. Daily samples were collected to analyze ammonia and nitrite (UNESCO, 1983; Bendschneider and Robinson, 1952, respectively), and samples were collected once a week for nitrate (Aminot and Chaussepied, 1983), alkalinity (APHA, 1998), and turbidity measurements using a turbidimeter Hach® mod. 2100P (Hach Company, Loveland, CO, USA). TSS was monitored every two days to the adjustment of levels according to the treatments (Strickland and Parsons, 1972; AOAC, 2000). When necessary, corrections were made to maintain pH values above 7.2 using calcium hydroxide ($Ca(OH)_2$) according to the dosages suggested by Furtado et al. (2011).

2.4. Shrimp performance

The shrimp growth performance was monitored weekly using biometrics. Thirty shrimp were collected at random from each experimental unit. The animals were individually weighed and then returned to their respective tanks. The amount of supplied feed was adjusted according to Jory et al. (2001). At the end of the experiment, all animals were counted in order to assess survival and final biomass.

To evaluate the *L. vannamei* performance, the following parameters were used:

- Survival (%) = (final n° of shrimp ÷ initial n° of shrimp) × 100;
- Weekly Weight Gain (WWG) (g $week^{-1}$) = (final mean weight − initial mean weight) ÷ week of culture
- Feed Conversion Rate (FCR) = offered feed/(final biomass − initial biomass);
- Productivity (kg m^{-3}) = (final biomass − initial biomass) ÷ volume.

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