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INFLUENCE OF ZERO-WATER EXCHANGE CULTURE ON THE GROWTH PARAMETERS OF PACIFIC WHITE-LEG SHRIMP, *L.VANNAMEI* IN EARTHEN PONDS

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ABSTRACT

Shrimp farming has been expanding rapidly, causing pollution of coastal ecosystems due to discharge of nutrient rich water. The alternative for the sustainability of shrimp culture is considered as Zero Water Exchange Mode (ZWEM) of culture. Present study assesses growth and water quality parameters in the two culture modes – ZWEM and 10% Water Exchange Mode. The SGR, FCR, Yield and Survival recorded were 4.27 ± 0.12; 1.2±0.3; 0.43±0.20; 62.3±22.7 respectively in the ZWEM and the corresponding figures in 10% Water Exchange culture were 5.10 ± 0.1; 1.0± 0.1; 0.61 ± 0.16 and 76.4± 18.5. Though the growth parameters in 10% Water Exchange Mode were better, they are not very significant. Hence it was concluded that the ZWEM is advisable in the perspective of preserving coastal ecosystems.

KEYWORDS: Zero Water Exchange Culture, SGR, FCR, Sustainable Aquaculture

INTRODUCTION

Success of aquaculture depends on providing animals with a satisfactory environment (Boyd and Tucker, 2009). Over the past few decades, shrimp farming in India has expanded rapidly to a vibrant export industry with the export production of 3, 57,505 MT worth USD 3.7 Billion (MPEDA, 2015) for 2014-15. The corresponding figures for 2015-16 in USD are 3.1 Billion (MPEDA, 2016). Given the ever-increasing consumer demand, high foreign exchange earning potential and stagnation in the wild catch, the shrimp farming has been expanding at phenomenal proportions (Abraham and Debasis, 2009). The world needs an extra 40-60x10^6 tons of food fish by 2020 (De Silva and Davy, 2010). Therefore culture is transforming rapidly into an intensive type of semi-intensive mode. Growth and development of aquaculture should be sustainable. The growing aquaculture industry is haunted by a number of environmental and social issues (Boyd, 1990).

Aquaculture at inappropriate sites can lead to habitat conversion and ongoing operational impacts. One of such issues of concern involved in the aquaculture is the discharge of polluted and nutrient-rich water into the aquatic habitats resulting in eutrophication and challenges of biosecurity (Weirich et al., 2003). Aquatic animals need a high concentration of protein in the feed, because of their energy production pathways depend, to a large extent, on the oxidation and catabolism of protein (Heaper, 1988). It was found that fish or shrimp in a pond (Avnimelech and Lacher, 1979; Boyd, 1985; Muthuwani and Lin, 1996) assimilate only about 25% of the nitrogen added in the feed. The rest is excreted as NH or as organic N in feces or feed residue.). Upsurge in coastal aquaculture activity induced by high profitability is reported to have caused adverse impacts on coastal ecosystems and social environments (Parthasarathy and Nirmala, 2000). The crustacean farming sector has received criticism for excessive use of formulated feed containing high protein, of which around 50% gets accumulated at the pond bottom as unconsumed (Avnimelech, 1999; Hari et al., 2004, 2006).

The wasted feeds undergo the process of degradation and results in the release of toxic metabolites to the culture system. Reduction of protein in the feed, manipulation and utilisation of natural food in the culture system are the remedy for the above problems.. Ever-expanding aquaculture needs land and water resources on a large scale. Already 41% of the global population is worst affected with water scarcity. And by 2050, more than 70% of world population is going to be water scarce. Much research has been attempted on the zero water exchange culture with the addition of artificial substrates or otherwise. But the work on shrimp culture with respect to zero water exchange and minimal water exchange has been very less. Hence the study of comparing minimal exchange with no water exchange has been undertaken. In this scenario, the aquaculture industry has recognized the importance of zero water exchange mode of farming which has got the potential of sustaining the aquafarming for decades to come. This study aims at comparing the growth, survival and water quality parameters of Zero Water Exchange Mode (ZWEM) with that of 10 percent water exchange mode of culture of Litopenaeus vannamei in earthen ponds for 80 days of culture. The study was carried out at Allur near Nizampatnam coast of Andhra Pradesh

MATERIALS AND METHODS

The study was conducted at Allur Village near Nizampatnam Coast of Andhra Pradesh, India. Three replicates for each mode of culture were chosen. The ponds of 0.5 acre, for two types of culture i.e Zero Water Exchange and 10% Water Exchange were selected. Pre-stocking management was done. Brackish water of 14 ppt salinity and 7.9 pH was fed from Tungabhadra Creek upto 1.3 meter depth. SPF PLs were purchased from CAA approved Gayathri Hatchery, Bapatla and stocked at the size 1.68 ± 0.51 g at 40 PLs /m^2 density.. The feeding was done 4 times a day. The experiment was carried out for 90 days. The growth parameters were measured along with regular monitoring of water quality parameters**.** SGR % per day, FCR, Total Yield and Survival were measured using the appropriate formulae. Two – way ANOVA was employed to find out if the two experiments were significantly different.

Table 1: Composition of Feed

Nutrient Component	Percentage
Crude Protein	36
Crude Fat	8.7
Carbohydrate	42
Ash	8.3
Moisture	10

RESULTS AND DISCUSSIONS

Table 2: Growth Parameters of L. Vannamei in Zero Water and 10% Water Exchange Models

Parameter	Type of Culture	
	Zero Water Exchange	10% Water Exchange
SGR % per day	4.27 ± 0.12	5.10 ± 0.10
FCR	1.2 ± 0.3	1.0 ± 0.1
Yield	0.43 ± 0.20	0.61 ± 0.16
Survival	62.3 ±22.7	76.4 ± 18.5

Table 3: ANOVA for the Growth Parameters

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	27.7885	1	27.7885	*F* = 0.02425
Within-treatments	6875.8619	6	1145.977	
Total	**6903.6504**	**7**		

Table 3: Water Quality Parameters of L. Vannamei in Zero Water and 10% Water Exchange Models

Parameter	Type of Culture	
	Zero Water Exchange	10% Water Exchange
Transparency	40.0 ± 3.0	50.0 ± 1.0
pH	8.3 ± 0.02	7.8 ± 0.01
TAN (mg/L)	0.35 ± 0.06	0.29 ± 0.03
NO_2^- N (mg/L)	1.09 ± 0.16	0.91 ± 0.08
NO_3^- N (mg/L)	6.51 ± 0.90	5.03 ± 0.7

Zero exchange pond production reduced the risk of introduction and spread of disease while providing the nutritional benefits of natural productivity within ponds (McIntosh et al., 2000; Bratvold and Browdy, 2001; Moss et al., 2001; Samocha et al., 2001; we rich et al., 2002; Burford et al., 2003). It has been suggested that the enhanced natural productivity in zero exchange shrimp production systems allows for the use of lower protein feeds. Use of lower protein feeds is more cost effective and more environmental friendly because the fishmeal component is reduced. It is known that natural production can supplement shrimp feeding as observed by Moss (2002) and Decamp et al. (2002). Browdy et al. (2001) also showed the positive effect of natural productivity achieving similar production of L. vannamei in ponds fed on 30% and 45% crude protein (CP). Samocha et al. (2004), however, reported no statistical differences between the growth parameters of L. vannamei fed on 30% and 40% protein, in intensively managed tanks without water exchange.

The levels of water supply appeared to influence on size at first maturity in shrimp. Shrimp that received more water exchange rate grew faster and matured at larger size. In the present study, the 10% water exchange ponds showed better growth performance. This may be due to the more dissolved oxygen availability, replacement of decomposed water etc., Similar observations have been made in a number of shrimp species viz., *Metapenaeus macleayi, Peneaus indicus and L.vannamei* (Allan and Maguire.1993; Ani and Noble.1993; Otoshi et al.2001). Water exchange rate influenced mean final weight and FCR significantly. The tiger shrimp, *Peneaus monodon* which received 20% water exchange showed significantly more mean final weight and FCR than the shrimp received 10% (Gaber et al.2012).

Burford et al. (2004) reported that up to 29 percent of daily feed intake of *L.vannamei* could be bacterial microalgae or bacterial flock from heterotrophic culture system. The microbial biomass would be relatively high so also the natural productivity in zero water exchange ponds. Hence there was not a significant difference in the growth parameters of zero water exchange and 10% water exchange ponds. Bacterial floc contains high levels of protein (Tacon et al.2002). Nutrients are usually high in Zero exchange ponds. And the growth of bacteria, phytoplankton (mostly autotrophic flagellates) and protozoa is stimulated in the nutrient ponds. These organisms lower TAN in these ponds. This is due to high rate of NH_4^+uptake by the bacteria (Burford et al.2003) In intensive systems of zero-water exchange, water has high values of chlorophyll a and pH ($P<0.05$) and exchange is not necessary to maintain low concentrations of NH_3 (Castille-Soriano et al.2010). In Zero Water Exchange Culture ponds, the nutrients keep on accumulating and this increases the natural productivity (Anand et al.2014).

Nitrogen (N) and organic carbon (C) inputs, in the form of fishmeal-based feed, grain-based feed and molasses, resulted in high concentrations of dissolved organic and inorganic N (2.29–5.56 and 0.17–10.66 mg l^{-1}, respectively) and dissolved organic C (14.20–48.10 mg l^{-1}). Phosphate levels were also high, ranging from 0.07 to 1.17 mg l^{-1}. The high nutrient concentrations promoted the growth of bacteria, phytoplankton (mostly autotrophic flagellates) and protozoa. Up to 40% of the bacteria were associated with flocculated matter. However, bacterial numbers and oxygen (O_2) consumption in the water column did not appear to increase with crop age. This may be due to a reduction in the C/N ratio below the optimum for bacterial growth. Up to 22% of the O_2 consumption was due to nitrification and there was some indication of lowering of total ammonical N (TAN) concentrations and an increase in nitrite and nitrate levels in older crops. Both phytoplankton and bacteria were responsible for high rates of ammonium uptake. In ponds with high nitrate concentrations, nitrate uptake rates were also high.

Water quality deterioration occurs in the latter part of the production cycle. Semi-intensive farming in Central America uses no aeration and is firmly based on water exchange, usually on daily basis (Teichert-Coddington, 1995). Excessive water exchange wastes fuel, sedimentation of water supply canals and ponds, and may increase total nutrient discharge from ponds. Water exchange is primarily done to correct low early morning Oxygen concentrations. However, it discharges metabolites that hinder shrimp growth. Water exchange is routinely used in mitigating ammonia, nitrite and organic matters concentrations and preventing algal blooms in conventional intensive shrimp culture (Panjaitan.2010) The level of water exchange appears to influence size in shrimp. The shrimp that receive less water exchange grow slowly, and mature at smaller size (Palomino et al. 2001). The changes in growth of shrimp are physiological response to environmental condition (Coman et al.2002). Growth rate and FCR were clearly influenced by the water exchange. Allan and Maguire (1993); Gaber et al. (2012) reported similar results for *P.semisulcatus* and *P. monodon* respectively.

López et al. (2003) has shown that the relatively more biosecure, intensive, zero-water exchange system has the capacity to manage the White Spot Virus and other viruses better than semi-intensive farm methods in Nicaragua. The zero-water exchange technology also has the potential to be profitable, given that technical recommendations (such as zero water exchange during the grow-out period, high stocking densities, and ponds adequately lined and aerated) are applied. The yield per hectare generated by the intensive, zero-water exchange technology can be higher than most of the other methods of shrimp farming. To maintain the water quality, large amount of water exchanges are inevitable in such rearing system. Operations in this kind of system not only waste water resource but also cause eutrophication of the coastal aquatic ecosystems (Audelo-Naranjo et al.2012). Correlation C: N ratio level with levels of ammonia, nitrite, dissolved oxygen, pH and shrimp growth in Penaeus monodon shrimp culture with Zero Water Exchange Model (ZWEM) using molasses as carbon resource. It was found that addition of molasses to shrimp farming with ZWEM had a role in removing ammonia and nitrite. Also, application of molasses to laboratory tanks increased the growth and percentage weight gain of shrimps and increased the population of heterotrophic bacteria.

CONCLUSIONS

The study found that the ZWEM of shrimp culture is beneficial economically though the exchange of water culture show somewhat better growth performance.

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