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Microbial Augmentation on Intensive Grow Out Shrimp Culture to Improve Water Quality, Growth and Shrimp Production

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Abstract. The objective of this study is to evaluate the microbial augmentation on intensive shrimp culture to improve water quality, growth, and shrimp productivity. This study was conducted on intensive shrimp grow out ponds of the farmers in Pangkep Regency, South Sulawesi. There were four grow out ponds used for study with different pond size. All ponds used zero or minimal water exchange systems. All inputs used in this study such as high quality of commercial feed, seed, intensive aeration with paddle wheels, vitamins and minerals. Treatment with a consortium of flock forming bacteria as a starter each given every week. Shrimp growth ponds used intensive culture system with condition water depth of ponds 120 – 130 cm, feeding rate was four time a day. Water quality parameters measured are salinity, pH, water temperature, dissolved oxygen (DO) and turbidity. Survival rate (SR), average daily gain (ADG), feed conversion ratio (FCR), and MBW were measured every week. The results of this research showed that shrimp production 1,600 – 5,600 kg. Growth rate: ADG 0.34 – 0.45; survival rate 90 – 97 %; FCR 1.02 – 1.1 and MBW 22.8 – 29.40. Water quality parameters such as dissolved oxygen, water temperature, water depth, salinity, pH and water transparency were 2.8 – 5.5 mg L⁻¹; 26 – 31°C; 75 – 125 cm; 15 -30 mg L⁻¹; 6.8 – 9.6 and 15 – 30 cm; respectively. In summary, shrimp production increased significantly with microbial augmentation, and water quality parameters were a suitable condition.

Keywords: microbial augmentation, zero water exchange, intensive production, *Litopenaeus vannamei*

1. Introduction

The state of the World Fisheries and Aquaculture stated that fisheries and aquaculture are the one of the fastest-growing food producing sectors which play a significant role in reducing hunger, improve health and reducing poverty [1]. Most of the shrimp farmers are currently developing of shrimp culture with traditional systems. The increasing of shrimp production can be achieved if the farmers will shift the culture management system from traditional to intensive cultured strategy. Intensive aquaculture



systems are the possible choice because of the limitation of natural resources such as water and land. They have been proven the success of the increasing of fish and shrimp production; on the other hand, these systems are facing two important limiting factors such as environmental deterioration and high-cost production [2].

Development of shrimp culture with intensification system is characterized by using high densities of seed, high commercial feed, paddle wheels, and a good management system. Intensive aquaculture produces large quantities of wastes and nutrients which have a negative impact on the environment and aquatic organisms [3]. Reducing the water quality of these systems caused by the rapid accumulation of feed residues, organic matter and toxic inorganic nitrogen [2]. There are three ways to remove inorganic nitrogen in aquaculture systems such as photoautotrophic removal by algae, nitrification process and heterotrophic bacterial conversion of ammonia to microbial biomass [4]. The most common water treatment in aquaculture systems are divided into different types of water treatments : 1) earthen treatment ponds, 2) a combination of solid removal and nitrification process, 3) periphyton treatment technique, and 4) biofloc technology [5].

Application of biofloc technology in intensive aquaculture systems make possible to minimize water exchange and water usage by maintaining good water quality within culture unit and produce a microbial protein which can serve as natural feed cultured [5][6]. The advantages of development of biofloc production in aquaculture are to improve environmental control over production, to prevent the introduction of disease to a farm from incoming water, to encourage solids and associated microbial community to accumulate in water [7].

The objective of this study is to evaluate the addition of microbial floc on intensive shrimp culture on shrimp growth, water quality, and shrimp production.

2. Methodology

2.1 Water source and treatment

The study was conducted at four of shrimp grow-out ponds in Pangkep Regency, South Sulawesi. Brackish water (14 30 ppt) was pumped from the river into the ponds. Incoming water was filtered through 200 μm filter bag and then chlorinated with kaporite 60% with concentration 5 – 10 ppm and aeration with paddle wheel 24 hours. Before stocking of shrimp, phytoplankton was grown using synthetic fertilizer such as urea, Trisuper phosphate (TSP) and traditionally fermented substance. All earthen ponds were stocked with PL 10 specific pathogen free (SPF) white shrimp, *Litopenaeus vannamei* which were purchased (PT. Central Prorotaina Prima Tbk. Indonesia). Each pond was stocked with different stocking density with range 49 – 193 individuals m^{-2} . The shrimp were fed with commercial feed with 30% crude protein (CP) (Irawan, PT. Central Proteina Prima Tbk.). Water depth of ponds is different with range 75 – 125 cm.

2.2 Shrimp production

This study was conducted at intensive grow out ponds with culture shrimp periods were varied from 100 – 107 days. During the rearing shrimp, all shrimp cultures were fed four times a day, at 08.00, 10.00, 14.00 and 16.00. Application of floc-forming microbes as biostarter was carried out every week to promote growth selected microbial for biofloc formation in the culture shrimp water. Addition of molasses to increase C/N ration in the water of shrimp culture. The feed was provided manually. Daily rations for the first week were based on a fixed percentage of the estimated total shrimp biomass in each pond. Rations from the second week were adjusted based on feed consumption; shrimp mean weight, the estimated survival, and FCR. The amount of feed per feeding time was determined based on shrimp feeding response. Feed trays were used to determine the amount of feed in each pond being consumed. This information was used to help adjust feed ration for the next feeding.

All ponds were operated with zero water exchange. However, water was added as needed to replace water loss due to evaporation and solid waste (sludge) removal, approximately 5% with water

from the artesian well. Each pond was aerated with 3- 4 paddle wheels creating a circular current. Sludge that accumulated in the pond center as a waste product of feeding and detritus was removed weekly using siphon system. Sampling for shrimp growth and biomass monitoring was performed once a week. The end of this culture period, total shrimp number and biomass were counted and calculated to determine survival rate (SR), growth, total yield and feed conversion ratio (FCR).

2.3 Water quality parameter

Water quality parameter such as dissolved oxygen, pH, temperature and water transparency was measured twice a day, in the morning and afternoon. Salinity was measured every week. Phytoplankton population was measured every week all culture period. Biofloc volume index was sampled by using inhoff cone for one liter and make settle 15 – 20 minutes. Water quality measured using YSI multi parameters for temperature, dissolved oxygen, and pH. Salinity measured using a refractometer and water transparency by using Secchi disk.

2.4 Harvesting management process

The harvesting system of shrimp was carried out with a partial system which three times before final harvesting at the end of the experiment. The partial harvesting was conducted at 80 days of culture shrimp to reduce population and the next harvesting every week. The partial harvesting process was intended to increase shrimp growth and water quality stability and growth health.

3. Results and discussion

3.1 Water quality

The result of this study showed that application of microbial floc on intensive shrimp farming culture in shrimp grow out ponds could increase water quality parameters, shrimp growth, and its shrimp production. Profile of shrimp grow out pond conditions, and water quality parameters can be seen in Table 1.

Table 1. Profile of the intensive shrimp grow out cultured pond with the application of biofloc-forming microbes with zero water management systems

Parameters	Pond 1	Pond 2	Pond 3	Pond 4
Pond size (m ²)	2000	800	2500	2300
Stocking density (inds m ⁻²)	193	143	100	49
Culture period (days)	107	101	102	100
Water depth (cm)	120 -125	75 - 100	85 -100	100 -115
Water transparency (cm)	20 -25	18 - 30	20 -25	15 -25
DO (mg L ⁻¹)	4,2 - 5,3	4,5 - 5,5	4,2 - 4,7	2,8 - 4,8
pH	6,8 - 8,3	8,4 - 9,6	7.4 - 8,6	7.9 - 8,5
Salinity (ppt)	18 - 25	15 - 30	14 - 16	15 -17
Temperature (°C)	28 -31	26 - 31	29 -30	29 - 30

Table 1 showed that the size of shrimp culture growth ponds used in this study was a different size from 800 m² to 2,500 m² as well as stocking densities were different from 49 to 193 inds m⁻². Water quality parameters such as water depth, water transparency, dissolved oxygen, pH, salinity and temperature showed a good performance, and they were in acceptable range for shrimp culture, *L. vannamei* during culture periods. Water transparencies were good and brownish green. Phytoplankton stabilities had a good performance and dominated with Chlorophyta and diatoms. Dissolved oxygen (DO) and pH during the culture periods were in good enough.

3.2 Shrimp performance

Growth performances of shrimp in this study showed that survival rate, MBW, ADG, Feed conversion ratio (FCR) and production were in a high improvement. Growth parameters of shrimp culture can be seen in Table 2.

Table 2. Growth parameters of shrimp *L. vannamei* cultured with the application of floc-forming microbes with zero water exchange management systems

Parameters	Pond 1	Pond 2	Pond 3	Pond 4
ADG final	0.4	0.41	0,34	0. 45
MBW final	29,40	27 - 71	24,7	22,8
Survival rate (%)	97	98	90	96
Total feed (kg)	5500	2303	4100	2335
FCR	1.16	1.02	1.1	1, 1
Shrimp size (inds kg ⁻¹)	34	36	40	43
Yield (kg)	4,600	2,110	3,500	1,690

Table 2 showed that shrimp growth parameters such as ADG, MBW, shrimp size and survival rate at the final culture has a significant increase. The survival rate of the shrimp culture was obtained more than 90% and feed efficiency 1.1. The shrimp size of final harvesting was with the range 34 – 43 inds kg⁻¹. Shrimp production was in the range 1,690 kg – 4, 600 kg.

Water quality of intensive aquaculture systems such as shrimp and fish cultures depends on stocking density of seeds, commercial feed, paddlewheels, and management system. Production can be increased by using in a large number of seeds of shrimps and high quality of commercial feed as well as using of intensive paddle wheel to support available oxygen for shrimp culture. Intensive shrimp cultures produce waste from feed residues, organic matter toxic inorganic nitrogen [2]. The more intensive aquaculture, the more waste produced. It can be avoided that shrimp and fish use 20-30% feed nutrient as biomass and the other is excreted and accumulate in the water pond [2]. The result of this study showed that water quality parameters, i.e. pH, dissolved oxygen and water transparency measure two times a day during period cultures in a suitable range for shrimp growth.

This study was carried out in four shrimp grow out ponds with zero water exchange. This water management strategy supports microbial development in pond water. Intensive nutrient inputs lead to increase microbial communities. These microbes will colonize suspended particles (biofloc) and then contribute to water quality maintenance and natural feed for culture species. The color of shrimp pond water was brownish green and stable during the culture period. It means that microbial population especially algae group include chlorophyte and diatoms. There are three important microorganisms groups in minimal exchange, intensive aquaculture systems which play an important role include algae, zooplankton, and bacteria. Addition of floc-forming microbes as biostarter in this study provides selected microorganisms to grow and develop in shrimp ponds to promote biofloc formation to control and maintain the stability of water quality in these systems.

Application of bio-augmentation agent twice per week has significantly enhanced the efficiency of waste removal, reduced the level of luminous *Vibrio* and stabilized phytoplankton density. Water quality parameters including dissolved oxygen (DO), pH, water transparency and temperature remained stable and within the optimum range throughout the culture period. The stable level of oxygen in this study could be attributed to proper aeration by intensive paddle wheel usage. Biofloc formation in shrimp culture increased after five days of treatment which characterized by water transparency low and high biofloc volume index. Feed conversion ratios were low with range 1.1 – 1.16. This data showed that flocculated materials (biofloc) play an important role as natural feed in intensive shrimp grow-out ponds. Natural biota as flocculated particles can contribute substantially as

nutrition for shrimp [2][8]. Effect of natural products in a zero water exchange suspended microbial floc in super intensive culture system for white shrimp increase survival rate, weight gain final biomass and low feed efficiency consumption (FCR) [9].

4. Conclusion

Microbial augmentation as biostarter for biofloc formation on intensive shrimp culture can maintain the water quality of shrimp culture and shrimp growth and shrimp production. Biofloc as flocculated material in shrimp culture contribute both water quality stability and natural feed for shrimp culture.

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