Water Quality, Survival, and Growth of Red Tilapia, *Oreochromis niloticus* Cultured In Aquaponics System

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Abstract. Red tilapia, *Oreochromis niloticus* is the main commodity of freshwater fish in Indonesia. Red tilapia have a good price compared to tilapia. The aims of this experiment to determine of survival, growth, and water quality of red tilapia cultured in aquaponic system. The treatment of this experiment, namely A) Red tilapia cultured without aquaponic (control), B) Red tilapia cultured with pakcoy, and C) Red tilapia cultured with caisin. The result showed that the highest of survival rate, weight, and length absolute found at Red tilapia cultured with pakcoy (96.00±1.73%, 32.31±0.74g, and 7.57±0.21 cm) and Caisin (96.00±1.73%, 32.31±0.74g, and 7.57±0.21 cm) than that of without aquaponic (86.67±1.15%, 25.77±1.05g, and 6.43±0.31 cm) ($P<0.05$). Vegetable leaf production of pakcoy was 6.57±0.16 Kg and Caisin was 6.17±0.11 Kg. The water quality parameters such as DO, TAN, nitrite, and nitrate of Red tilapia cultured using aquaponics was better than that of without aquaponic.

1 Introduction

The main cultivated freshwater species in the world belong to carps and tilapia. The Nile tilapia, Oreochromis niloticus is one of the most important freshwater fish in world aquaculture. It is widely cultured in many tropical and subtropical countries. Some of advantages of Nile tilapia are rapid growth, high tolerance to environment conditions, easy to spawn, resistance to disease, and good consumer acceptance make it a suitable fish for culture [1]. This species is the most familiar and popular fishes in Indonesia, especially, in Sumatera, Java, Bali, and Borneo Islands.

The production of aquaculture technique is usually extensive, semi-intensive and intensive culture systems, but the commonest technique in Indonesia is semi-intensive and intensive systems. The intensive culture has usually high level of management input such as feed and fertilizers are intensively applied following appropriate recommended rates. Most commercial farm adopts this approach due to the fish grow is very faster compare to the others [2]. However, intensive culture system has encountered many problems such as high cost due to commercial food utility during the operation where commercial food constitutes 50 – 70% of the total production cost [3].

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On the other hand, intensive culture system by product such as uneaten feed, feces, and urine have resulted in poor of water quality and eutrophication which negative effect to fish production [4]. Feed leachate into aquaculture systems results in the release of additional nitrogen (N), phosphorus (P), organic matter and trace elements into the water environment [5]. Annual nutrient discharge of about 5100kg N, 2900kg P, and 29500kg organic matter from a fish farm due to high level of feed, feces, and excreta in the water [6]. This condition affects water quality such as depletes of dissolved oxygen and increase concentration of nitrite and ammonia, which are toxic for fish [7, 8, 9]. Thus, poor of water quality has resulted in low production due to high mortality [4].

Some efforts of Nile tilapia culture have been carried out to increase productivity in order to fulfill fish demand such as polyculture using deep pond technology [10], constructed wetland [4], stock density [11], polyculture [12], probiotic utility [13], and aquaponic system [14]. Although these techniques can increase fish production, but base on economy value is still unprofitable due to high price of commercial food, unless fish culture in aquaponic system [15]. Therefore, technology innovation of aquaculture in term of increasing fish production and eco-friendly is needed. Aquaponics is an integrated farming concept that combines fish and vegetable (hydroponic). This integration aims to convert the normally wasted nutrients excreted by fish into valuable plant biomass [16]. The purpose of this experiment is to determine water quality, survival, growth, and biomass of Red Tilapia cultured in an aquaponics system.

2 Materials and Methods

The experiment was conducted from June to August 2017 at Research Station for Freshwater Aquaculture Environment Technology and Toxicology, Cibalagung, Bogor, Research Institute for Freshwater Aquaculture and Fishery Extension, Bogor, West Java, Indonesia.

Nine of concrete pond with size of 3 length m x 3 wide m x 0.7depth m was used. 11 bucket with volume of 12 L was used for aquaponics where the bucket with volume of 25 L was used for physical filter. All pond were installed water pump and completed by aeration. Clearly, the layout of aquaponics design construction was shown in Figure 1.

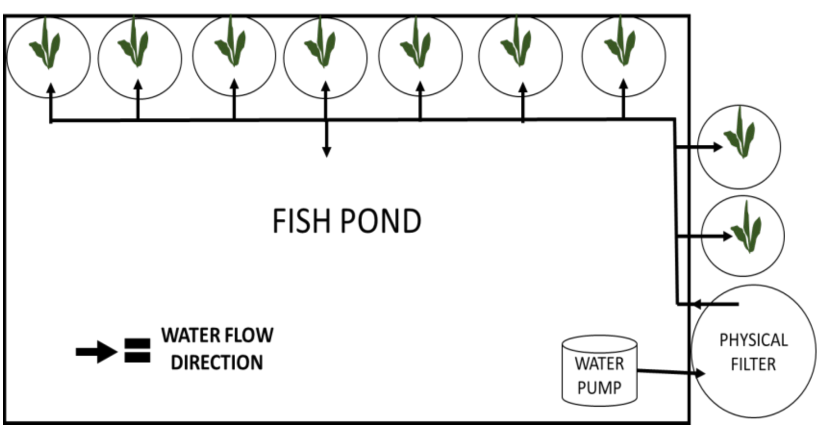

Fig. 1. Layout of design construction of aquaponics on Red Tilapia culture

Red Tilapia with average of 3.37 cm in total length and 2.67 g in body weight was used. Stocking density was 50 fish m^{-3}. Feeding rate was 5% a day biomass-1. Culture period was 50 days. 20 fish were sampled at the beginning and at the end of the experiment. Vegetable plant species was Pakcoi and Caisin. The substrate of aquaponics were lime stone with diameter of 4-5 cm, gravel with diameter of 2-3 cm, and fern root. One bucket was planted by three plants. Parameters observed for fish was survival, growth (absolute length and absolute weight), and biomass where vegetable parameter observed was biomass (wet weight). The treatment of this experiment were as followed: A) Red Tilapia cultured without aquaponic, B) Red Tilapia cultured with Pakcoi, and C) Red Tilapia cultured with Caisin

Water quality parameter such as dissolved oxygen (DO), pH temperature, total ammonia (TAN), nitrite, nitrate, and alkalinity were measured using water checker and analyzed in the laboratory. Water sample was taken at the beginning, in the middle, and at the end of the experiment.

Data of survival, absolute weight, absolute length, and biomass was calculated using formula [17, 18] were ass followed:

Survival Rate

$$SR = \left(\frac{Nt}{No}\right) \text{ x } 100\% \quad (1)$$

where: *SR* = Survival Rate (%)
Nt = Number of fish at the end of experiment
No = Number of fish at the beginning of the experiment

Absolute Length

$$Pm = Lt - Lo \quad (2)$$

where : Pm = absolute length growth
Lt = length average of individual at day t (cm)
Lo = length average individual at initial day/day 0 (cm)

Absolute Weight Growth

$$\Delta W = Wt - Wo \quad (3)$$

where: ΔW = absolute weight growth
Wt = Weight average of individual at day t (g)
Wo = weight averageof individual at initial day/0 (g)

Biomass:

$$B = W \text{ X } N \quad (4)$$

Where: B : Biomass
W : weight average (g)
N : number of population (fish)

All data such as survival, growth, and biomass were analyzed using statistic (ANOVA), except water quality parameters (DO, pH, temperature, TAN, nitrite, nitrate, and alkalinity) and vegetable biomass using descriptive only. Completed randomized design with three treatments and three replicates were performed. If there was significant different among the treatments, Duncan test was performed.

3 Results and Discussions

Water quality parameters such as dissolved oxygen (DO), pH, temperature, total ammonia (TAN), nitrite, nitrate, and alkalinity during the Red Tilapia cultured is shown in Table 1.

Table 1. The range of water quality parameters (Dissolved oxygen, pH, temperature, total ammonia (TAN), nitrite, nitrate, and alkalinity) during culture period of Red tilapia in aquaponics system

Parameters	Unit	Treatments			Optimal Range
		A	B	C	
Dissolved Oxygen (DO)	mg⁻L	3.05-3.87	3.12-4.67	3.08-4.61	≥ 3 [19,20]
pH		6.71-7.34	6.73-7.45	6.72-7.41	6-9 [19]
Temperature	^{o}C	25.8-27.6	25.6-27.2	25.5-27.7	26-30 [19,20]
Total Ammonia (TAN)	mg⁻L	0.267-0.582	0.052-0.192	0.055-0.185	0.17-3.87 [21]
Nitrite	mg⁻L	0.065-0.183	0.011-0.078	0.015-0.072	0.02-0.12 [19,20]
Nitrate	mg⁻L	0.924-5.763	0.478-3.924	0.517-3.586	0.2-219 [,21]
Alkalinity	mg⁻L	116.14-158.71	117.22-149.84	116.10-159.87	20-200 [20]

Remaks: [19]Government regulation No. 82 (2001),[20] Cavalcante et al. (2014), [21]Caldini et al. (2015)

All water quality parameters were within the threshold, except for nitrite was slightly beyond the optimal range for Tilapia culture (Table 1). However, the water quality parameters at Red Tilapia cultured using aquaponics whether Pakcoy or Caisin showed the lowest than that of Red Tilapia cultured without aquaponics. This imply that Pakcoy and Caisin are great efficient for reducing the waste, especially total ammonia, nitrate, and nitrite. Some of studies have been reported that the aquaponics system can reduce the total nitrogen was 30,6% [22], 25% [23], 40,32 % [24], 78,3% [25], and 41,5% [26]. The different result that had been reported caused by different fish species, feeding management, design construction, retention times, and plant species affect the different removal efficient [4]. The optimum range such as temperature (16-30 ^{o}C), pH (5.5-7.5), ammonia (<30). Nitrite (<1), nitrate (-), and dissolved oxygen (>3) for plant growth have been reported [27]. The present experiment shows that all water quality parameters are within the optimal range for plant grows.

The survival, absolute weight, absolute length, and biomass of Red tilapia cultured in without aquaponincs and aquaponics system and also biomass of Pakcoy and Caisin is shown in Figure 2.

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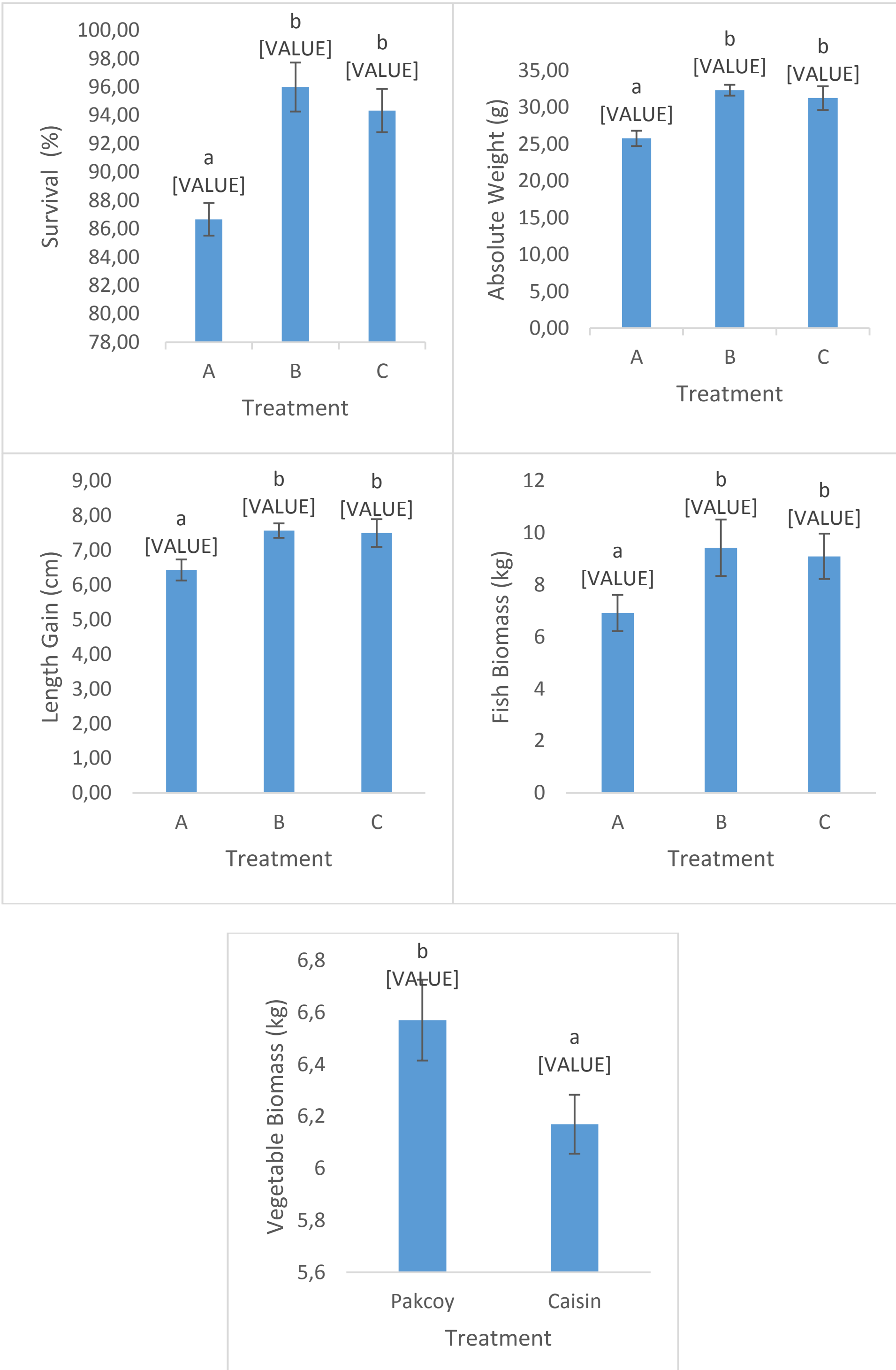

Fig 2. Survival, Absolute length, absolute weight, and biomass of Red Tilapia cultured without aquaponics and with aquaponics system and biomass of Pakcoy and Caisin

Survival, absolute weight, absolute length, and biomass of Red Tilapia was the higher than that of Red tilapia cultured without aquaponics system ($P<0.05$) but no significantly different ($P>0.05$) Red Tilapia cultured in aquaponics using Pakcoy and Caisin (Figure 2). This indicated that aquaponics system affect the survival, absolute weight, absolute length, and biomass. Low in survival, growth, and biomass might be caused by water quality. As mentioned above (Table 1) that water quality of Red Tilapia cultured without aquaponic system showed poor water, especially nitrite concentration. Water quality is very important in aquaculture as a limiting factor. Nitrite are toxic to fish and influence on fish growth in sub-lethal concentration [28, 29].

4 Conclusion

Red tilapia reared in aquaponics system was better than that of without aquaponics in term of survival, absolute weight, absolute length, biomass, and water quality (total ammonia, nitrite, and nitrate). The biomass both of Pakcoy and caisin are the same.

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