The performance of tilapia culture in biofloc technology (BFT) and floating net cage (KJA) systems as a candidate for the next tilapia culture in Indonesia

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Abstract. The waste from Tilapia culture in Floating Net Cage (KJA) is suspected to be a cause of pollution in the reservoir. One alternative replacement is biofloc technology which has water efficiently and environmentally friendly. A field study on tilapia aquaculture has been carried out with a biofloc and KJA system to determine its productivity performance. The fingerling size of tilapia 10-20 g were maintained for 90 days with stocking densities of 6-80 individual/m³. Then, 30 fish were carried out for biofloc technology and 27 fish were carried out for KJA. The biofloc technology experiment was carried out in circular ponds with volume sizes of 10 and 20 m³ using probiotic bacteria. While in KJA system, the size of net cage were 172, 368, and 1800 m³. Fish were fed with commercial pellets of 5-10% biomass weights per day. The performance of biofloc technology experiment for tilapia culture were 14.81 ± 3.79 kg/m³ (productivity), 72.94 ± 8.17% (survival), 80.66 ± 11.92% (feed efficiency), 3.20 ± 0.63 g/day (ADG), and 16.353 ± 1.017 IDR/kg (production cost). While the performance of KJA technology experiment for tilapia culture were 1.72 ± 0.67 kg/m³ (productivity), 61.94 ± 12.78% (survival), 73.90 ± 7.62% (feed efficiency), 2.32 ± 0.40 g/day (ADG), and 16.168 ± 1.283 IDR/kg (production cost).

Keywords: productivity, probiotic, production factors, superior tilapia, efficiency

1. Introduction
The floating net cage (KJA) system in lakes or reservoirs has a significant contribution to the economy in Indonesia, which is around 17.70% (2014) and 18.35% (2015) of the total national production of freshwater aquaculture [1]. However, along with the uncontrolled use of the number of KJA, many adverse events have occurred as a result of the decline in the quality of the environmental factors of the open waters used. Mass mortality and the breakout diseases or epidemics with a level of loss that is not small has been experienced in several reservoirs or lakes [2-9].

KJA as a direct user of water in a lake environment are suspended to be the main factor causing water pollution in reservoirs or lakes. Although in some situations, lakes or reservoirs are also used as industrial waste disposal sites in the upper reaches of the watershed and disposal of household and urban waste. Sutrisno et al. [10] found that the waste had affected the level of heavy metal pollution in the reservoir. Various options have been offered to overcome this situation, one of which is the
scheduling of the growing season relating to the prediction of mass mortality but has not been widely adopted by farmers. In the area of West Java, the last option that has been taken is to reduce the number of KJA in reservoirs or lakes through the “Citarum Bersih” program which reduced the number of KJA from 33,000 in 2016 to 27,000 in 2017. This will lead to a significant decrease in production and reduce the level of economic profit [11]. This situation requires the right solution. One of them is the utilization of biofloc technology. Biofloc technology (BFT) was introduced in the world since the 1970s. This technology has been developing since the last decade with various research activities carried out by researchers [12-14]. In Indonesia, research on biofloc has also been carried out including catfish [15], tilapia [16-18], and shrimp [19].

BFT has several advantages including maintaining or cultivating fish with minimal water and land requirements even sometimes without replacing water and a high level of feed efficiency [20]. In this technology, the leftover of the feed and the results of fish excretion which usually becomes waste pollution are converted into feed ingredients for fish use for growth thereby reducing the amount of feed needed. The balance that occurs between non-pathogen bacteria, feed, and carbon supply and supported by aeration keeps water quality conditions good, and flocks composed of several organic materials, plankton, and bacteria can be used by fish as food [12].

BFT development on a business scale needs to be seen as an effort to replace the KJA used in reservoirs or lakes. In this order, a field study was conducted in 2019 to obtain information about the ability of BFT as a tilapia culture technology on a commercial scale compared to the results of KJA.

2. Materials and methods

2.1. Location and time

This field study was carried out using a total of 27 circular ponds with a volume of 10 tons of water in the Cianjur area and 28 KJA units in the Jatiluhur reservoir with a volume of 171 - 1800 m$^3$ of water in the Pasirlaya area during March-May 2019.

2.2. Biofloc technology (BFT)

BFT used refers to the methods from Avnimelech [14] and Crab et al. [13]. Modifications were conducted by adding bacteria in the preparation. The bacteria used in the preparation process were the type of Bacillus sp. about 105 cells/mL. The condition of the floc was maintained by the addition of a carbon source (C) in the form of molasses with a concentration of C/N ratio > 15 [13]. The fish used are the results of breeding tilapia program with a weight size of 20-30 g/individual. Tilapia fingerlings reared in the circular tank with density of 55–80 fish/m$^3$ or equal as 0.7–3 kg/m$^3$. The feed used was floating pellets which contained 32% protein content, feed three times a day for about 5-10% biomass weight. The total fish were harvested after reaching a consumption size of between 200-400 g per individual.

2.3. KJA Technology (KJA)

The KJA system used in this experiment was the result of modification by giving feed directly without two layers with carp (single layer). Fingerlings are maintained in the KJA units (172, 368, and 1800 m$^3$) and density of 6-19 fish/m$^3$ or equal as 0.15-1 kg/m$^3$. The feed (floating pellets, 32% protein content) were given as much as 5-10% of biomass weight per day with a feeding frequency of three times a day. Total fish were harvested after fish weight reached 200-400 g per individual.

2.4. Data analysis

The parameters observed were feed efficiency, survival rate, daily weight growth rate, fish size at harvest, total productivity, and biomass. While the factors of production studied consisted of the rearing time, amount of feed, size, and stocking density.

Feed efficiency is calculated using the following formula:

$$EP = \left(\frac{W_t - W_0}{P}\right) \times 100\%,$$

whereas

$$W_t = \text{weight at harvest},$$
$$W_0 = \text{initial weight},$$
$$P = \text{amount of feed}.$$
EP = Feed efficiency (%)  
Wt = Harvest weight (kg)  
Wo = Stock weight (kg)  
P = Amount of feed (kg)

- Survival is calculated by the following formula:
  \[ SR = \frac{N_t}{N_o} \times 100\% , \text{ whereas} \]  
SR = Survival Rate (%)  
Nt = Number of harvest fish (individual)  
No = Number of stocking fish (individual)

- Daily weight growth is calculated by the formula:
  \[ ADG = \frac{W_t - W_o}{t} , \text{ whereas} \]  
ADG = Average daily weight growth (g/day)  
Wt = Average individual of harvest weight (g)  
Wo = Average individual of initial weight (g)  
t = time (day)

- Productivity is calculated by the following formula:
  \[ Pr = \frac{W_t}{V} , \text{ whereas} \]  
Pr = Productivity (kg/m³)  
Wt = total harvest weight  
V = water volume

Data were analyzed using SPSS 16 program. While the relationship between production factors and observed parameters was analyzed by regression method using the Excel program.

3. Results and Discussion

3.1. Performance
The performance of tilapia culture using the BFT system has an average productivity value of 16.59 kg/m³ with a daily weight gain of 3.53 g, survival rate 72.04%, feed efficiency 85.65%, fish harvest size 332.8 g, and operational costs per kg of fish Rp 16,353. While the performance of tilapia aquaculture with KJA system has the successive value of 2.04 kg/m³ productivity, weight gain 2.31 g/day, survival rate 60.84%, feed efficiency 73.75%, fish harvest size 218.02g, and operational cost per kg of fish Rp 16.118 (Table 1).
Table 1. BFT and KJA performance values

| Parameter | Type | Survival rate (%) | Feed efficiency (%) | Productivity (kg/m³) | Average daily weight gain (g/day) | Harvest size (g) | Operational cost per kg fish (IDR) |
|-----------|------|-------------------|---------------------|----------------------|---------------------------------|-----------------|----------------------------------|
|           | BFT  | 72.04 ± 2.94      | 85.65 ± 6.39        | 16.59 ± 3.49         | 3.53 ± 0.09                     | 332.83 ± 0.87   | 16,353 ± 1,017                   |
|           | KJA  | 60.84 ± 6.43      | 73.75 ± 5.55        | 2.04 ± 1.13          | 2.31 ± 0.06                     | 218.02 ± 3.24   | 16,118 ± 1,283                   |

The level of BFT productivity achieved in this study was equivalent to the results obtained by Rakocy et al. [21] on the intensive enlargement of tilapia in a 200-ton volume pond with a bacterial basis with a productivity value of 13.7-14.4 kg/m³. Widanarni et al. [16] get productivity results between 2.77 - 4.23 kg/m³ in the culture of red tilapia with a biofloc system for 3.5 months with a density level of 25-100 ind/m³. Furthermore, Luo et al. [22] get a level of productivity ranging from 32.60-35.83 kg/m³ by using superior varieties of tilapia that were kept at a salinity level of 0 to 20 ppt.

The daily weight gain achieved in the BFT system studied was relatively greater than that produced by Luo et al. [22] which is between 1.36-1.43 g/day. Both activities use seeds from breeding varieties with seed sizes between 15-30 g. Whereas Haraz et al. [23] gained an average weight gain on 5.23 g black tilapia of 0.36 g/day. In red tilapia with a larger seed size of 77.80-78.56 g, it has an average weight gain value of 0.52-1.17 g/day [16].

The survival rate (SR) produced by the BFT system in this study is lower than the previous studies in black tilapia [22-24] and red tilapia [16] with SR 90%. Mortality generally occurred one week after stocking might be caused by the damage of the fish skin during the handling time.

The feed efficiency (FE) of tilapia with the biofloc system used in this study which ranged from 79.26% to 92.04%. This results was in line with Luo et al. [22] with ranged 68.49% (20 ppt) - 71.94% (10 ppt), black tilapia ranged 96.15% - 108.70% [23], and red tilapia ranged 44.80% - 68.99% [16]. Furthermore, for the average size of fish at harvest on the grow up results with the BFT system for 90-100 days of maintenance was 332.83 g. Meanwhile according to Luo et al. (2017) using the size of black tilapia seed similar with in this study, after being kept for about 150 days, the weight reached 230.32 g. In red tilapia raised by the BFT system with an initial weight of 70-80 g for 105 days, the average weight was 216.46 g.

The overall parameters of BFT production in this study were relatively better than the value of production produced in tilapia nursery by the KJA system. The same thing was also obtained by some researchers who obtained the level of production in cultivation with the BFT system compared with the non-enlargement of the BFT system [16, 22-24]. This condition provides information that the enlargement of tilapia with the BFT system can be convincingly used as an alternative to replace the system of tilapia culture from the KJA system in Indonesia. The challenge in the future is the efficiency of this system in terms of operational costs due to the use of electricity in the BFT system, so that operational costs will relatively greater than Rp 16,353 ± 1,017 per kg compared to enlargement of tilapia with the KJA system and the operational cost of Rp 16,168 ± 1,283 per kg.

3.2. Correlation

The results of the regression analysis showed that there were several factors of production that were observed to have a relatively significant relationship to the parameters of productivity and feed efficiency both on the enlargement of tilapia with the BFT system and the KJA system. The production factor which has a relatively large r² value is the amount of feed given, the stocking density used, and the initial size of the seed. While the rearing time factor has a relatively small r² value in both culture systems. In tilapia culture with the BFT system, feed efficiency parameters have a relatively large correlation value with stocking density factor (r² = 0.7267) followed by the amount of...
feed given ($r^2 = 0.7121$) and the initial size of fish seed ($r^2 = 0.5978$). While the productivity parameters only have a relatively large close relationship with the initial size of the seed used ($r^2 = 0.5241$).

In tilapia culture by using the KJA system, only the productivity parameter is relatively influenced by the factor of the amount of feed given by the value $r^2 = 0.7440$ and initial fish density ($r^2 = 0.7391$). Whereas the feed efficiency parameter $r^2$ value of all observed production factors is relatively small with a value of less than 50% (Table 2).

### Table 2. Correlation between production factors and parameters

| Production Factor | Production Parameter | KJA Equation | BFT Equation | r² |
|-------------------|----------------------|--------------|--------------|----|
| Rearing time      | Feed Efficiency      | $y = -18.49\ln(x) + 156.29$ | $y = -0.0677x^2 + 11.257x - 382.04$ | 0.1368 |
|                   | Productivity         | $y = -0.0005x^2 + 0.0767x - 1.1947$ | $y = -0.0089x^2 + 1.5126x - 48.961$ | 0.0304 |
| Initial size      | Feed Efficiency      | $y = 0.0078x^2 - 0.8409x + 87.866$ | $y = 0.0219x^2 - 1.6725x + 101.1$ | 0.0551 |
| of seed           | Productivity         | $y = 0.0113x^2 - 0.561x + 8.3188$ | $y = -0.031x^2 + 1.0395x + 9.0968$ | 0.1073 |
| Number of         | Feed Efficiency      | $y = -4E-06x^2 - 0.0025x + 79.749$ | $y = 0.0003x^2 - 0.2617x + 121.83$ | 0.3129 |
| feed supply       | Productivity         | $y = -9E-07x^2 + 0.0004x + 2.2018$ | $y = -8E-05x^2 + 0.0417x + 10.204$ | 0.7440 |
| Initial number    | Feed Efficiency      | $y = 0.0001x^2 - 0.0976x + 83.749$ | $y = 0.0091x^2 - 1.0589x + 100.6$ | 0.3772 |
| of seed           | Productivity         | $y = -2E-05x^2 - 0.0038x + 2.4839$ | $y = -0.0052x^2 + 0.3476x + 11.687$ | 0.7391 |

The practical application of this information is if the increase in productivity of tilapia culture using the targeted BFT system, the selection of the right seed size is one alternative. Based on the resulting regression equation ($y=0$), the optimal seed size is 16.77 g to produce the highest level of productivity. Meanwhile, to get the best feed efficiency, it can be done by applying the amount of feed given in one period of 436.17 kg and the stocking density of fish seeds used is 117 fish/m³.

In tilapia culture using the KJA system, only productivity parameters that are strongly related to several factors of production are observed, namely the amount of feed given and the initial amount of fish stocked/initial density. The optimal amount of feed used in a maintenance period is 222.22 kg and the density of seed stocked is 38 fish/m³. As for FE in tilapia enlargement in KJA is closely related to a variety of outside factors observed in this study, including the condition of reservoir water quality.

### 4. Conclusion

Biofloc technology (BFT) has the potentiality to be able to replace the floating net cage (KJA) system in the cultivation of tilapia. Statistically, BFT has better ability on productivity parameters (14.42 kg/m³) and survival (85.80%) than KJA with a value of 1.62 kg/m³ and 60.64%. Production costs per kg of fish were relatively similar between BFT and KJA. The amount of feed and stocking density used has the greatest correlation value on feed efficiency in the BFT system and the KJA system.

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