Production Performance of Sangkuriang Catfish (*Clarias gariepinus* Burchell-1822) N-2 (Nursery-2) Cultured on Recirculation System with Different Filter Media

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Abstract. Sangkuriang catfish (*Clarias gariepinus* Burchell-1822) is one type of freshwater fish that has been widely cultivated in the community. This study was to investigate the production performance of sangkuriang catfish N-2 (nursery-2) cultured on recirculation system with different filter media. The test fish used were 17 days old with a density of 7,000/2 m³ each with a 20-day maintenance time. This research was conducted using an experimental method and a complete randomized design consisting of 3 treatments and 3 replications. The treatments are P1 (*Kaldnes* 100%), P2 (*Kaldnes* 50% and Bioball 50%) and P3 (*Bioball* 100%). The data observed included growth (SGR, %/day) survival rate (SR, %), production (fish), Feed Conversion Ratio (FCR), and water quality. Growth performance was carried out by linear regression test. The results showed that the performance of SGR, SR and production were the highest in P1. With the respective values as follows; The regression test results in absolute weight were $Y_1 = 0.060 + (-0.121)x$ and the value of $r^2 = 0.921$ with a weight of $1.29 \pm 0.02$ gram, while at absolute length were $Y_1 = 0.176 + 1.480x$ and $r^2 = 0.988$ with length $3.87 \pm 0.15$ cm, SGR of $15.86 \pm 0.55$ %/day, SR of $97.85 \pm 0.74$ % and seed production of $6849 \pm 51.73$ fish. The result of Volumetric TAN removal rate (g/m³/day) at P1 is higher with a value of $1.19 \pm 0.39$, compared to P2 and P3 which have a lower value of $1.11 \pm 0.19$ and $0.81 \pm 0.16$ g/m³/day.

1. Introduction
The *C. gariepinus* is an important commercial fish that is in great demand by the public. Hence, it is not surprising that the demand is increasing from year to year. One of the efforts to increase the production of *C. gariepinus* can be done through intensive scale cultivation, with high stocking density [1]. However, increased stocking density will add to the problem of water quality, since amount of ammonia loading rate will also increase significantly [2]. Weaknesses in intensive scale cultivation of *C. gariepinus* seeds are leftover feed and fish feces which will become one with maintenance water, resulting in decreased water quality and high mortality in the seeds of *C. gariepinus*. Conventional water quality management can be periodic water changes, but this is not effective because it requires expensive costs and less effective time spent. Therefore, there is a need for technological innovations in cultivation containers to overcome water quality problems, one of which is using biofilter [3]. Based on previous studies [4][5], *Kaldnes* media is a biofilter that can improve the survival rates of...
fish, because it can reduce ammonia in the waters. While, Bioball media is a breeding ground for various types of bacteria needed to process ammonia in water [6].

2. Research Methods
The fish used in this study was the seed of *C. gariepinus* from the Industry Faculty of Fisheries and Marine Science, Diponegoro University, Semarang. Catfish Seeds 17 days old with weighed of 0.06 ± 0.01 (grams) and length of 1.7 ± 0.1 (cm) [7]. Fish density as treatment 7,000 fish/pond with water height as high as 30 cm, so that the volume was 2 m³. The seeds were first adapted in a tarpaulin pond for 1-3 days, the seeds were expected to be able to adjust the conditions to their new environment. The seeds were measured in total length using millimeters block and weight measurements were carried out with a sampling of 10 fish using electric scales (accuracy of 0.001 g) before and after the maintenance period. Seed maintained period was 20 days.

The feed that used in this research was commercial pellet, food size made based on the mouth opening of seeds. *Tubifex* sp also used as food. The pellets that are given are light brown in color and are 0.5 mm - 0.7 mm in size. Nutrient content in these feeds is as: protein min 39-41%; 5% min lipid; crude fiber max 4%; Ash max 11% and max water content 10%. The content of *Tubifex* sp. were protein (57%), lipid (13.3%), crude fiber (2.04%), and ash content (3.6%) [8]. Feed was given with the at satiation method, the feed was given little by little up to 80% until fish did not response to the feed (Hastuti and Subandiyo, 2014). The amount of feed in each given was weighed so that it can be known the amount of feed given for each time and the total amount of feed given during the maintenance period. The frequency of feeding twice a day, i.e. morning (08.00) and afternoon (15.00).

This research was conducted using an experimental method and a complete randomized design consisting of 3 treatments and 3 replications.

Treatment P1: *Kaldnes* 100%
Treatment P2: *Kaldnes* 50% and *Bioball* 50%
Treatment P3: *Bioball* 100%

2.1. Filters design
Filters use plastic baskets, and waring is adjusted to the shape of the basket container. Installation of dacron with a size of 1 meter is adjusted to the basket, after that the pump is installed into a container that already contains dacron. The next step, filter 1 filled with *Kaldnes* media with a volume of 17 liters, filter 2 (*Kaldnes* 8.5 liters and *Bioball* 8.5 liters) and filter 3 filled with a 17-liter *Bioball*. The filter media design is presented in Figures 1 and 2.

![Figure 1. Design Kaldnes Media](image-url)
2.2. Collecting data
Data collected in this study included absolute length growth, absolute weight growth, specific growth rate (SGR), survival rate (SR), Production, Feed Conversion Ratio (FCR), and water quality.

a. Absolute weight growth (WG)
The Absolute weight growth is calculated using this formula [9]:
\[ \text{WG} = W_t - W_o \]  \hspace{1cm} (1)
Where \( W_t \) and \( W_o \) are initial and final body weight (g/fish)

b. Absolute length growth (L)
The Absolute length growth was calculated using this formula [9]:
\[ L = L_t - L_o \]  \hspace{1cm} (2)
Where \( L_t \) and \( L_o \) are initial and final body length (cm/fish)

c. Specific growth rate (SGR)
Specific growth rate was calculated using this formula [10]:
\[ \text{SGR} = \left( \frac{\ln L_f - \ln L_i}{T} \right) \times 100\% \]  \hspace{1cm} (3)
Where \( L_i \) and \( L_f \) are initial and final body weight (g/fish)
\( T \) is the maintenance period

d. Production
The number of seeds stocked produces the number of seeds harvested during the 20-day maintenance period. Size of pond 3 m\(^3\) with 2000 L water volume.

e. Feed Conversion Ratio (FCR)
The FCR is calculated using this formula [11]:
\[ \text{FCR} = \frac{F}{B_f - B_i} \]  \hspace{1cm} (4)
\( F \) is the feed consumption per period (g),
\( B_f \) is the final biomass (g), and
\( B_i \) is the initial biomass (g) over a period.

f. Survival rate (SR)
The SR was calculated using this formula [12]:

Figure 2. Design Bioball Media
SR = Total fish end of research \times \frac{100\%}{\text{Initial total fish}} \tag{5}

Nt is the total fish end of research, No is the initial total fish.

g. Volumetric TAN removal rates (VTR)
The efficiencies of the biofilters were calculated using the following equations [13]:

\[
VTR = \frac{1.11114 \times (\text{TAN}_{\text{in}} - \text{TAN}_{\text{out}}) \times Q}{V}
\]

Where TAN\text{in} is the concentration (mg/L) of total ammonia nitrogen in the biofilter inlet, TAN\text{out} is the concentration (mg/L) of total ammonia nitrogen in the biofilter outlet, Q is total water flow (m³/day) through the filter, V is the volume (m³) of the filter bed, and 1.44 is a conversion factor.

h. Water quality
Water quality checks on the research media included several parameters including temperature, dissolved oxygen (DO), power of hydrogen (pH), and ammonia (NH₃) content. Observation of water quality consisting of ammonia (NH₃) content is carried out every 5 days at the inlet and outlet, measuring pH, temperature and DO is carried out every day.

2.3. Data analysis
Data analysis was carried out on the data of absolute weight growth value (WG), absolute length growth (L), specific growth rate (SGR), survival rate (SR), production, Feed Conversion Ratio (FCR). Data before analyzing the variance were first tested for normality, homogeneity test and additivity test to ensure that the data spread normally. Homogeneous and additive. Then the data continued with analysis of variance (ANOVA) with a 95% confidence interval to see the effect of treatment. After the analysis, if the treatment was found to be significantly different (P < 0.05) the Duncan test was conducted to find out the difference in the middle values between treatments. Data analysis was performed using SPSS version 20.0 and Ms Excel 2013. Water quality such as ammonia was carried out by analysis of variance (ANOVA) with 95% confidence interval and Duncan test. Water quality such as temperature, Do and pH were analyzed descriptively to see the feasibility of supporting the growth of sangkuriang catfish (C. gariepinus).

3. Result and Discussion
Based on the results of maintenance of C. gariepinus for 20 days, we obtained data on (WG), (L), (SGR), (FCR), (SR) and the production of C. gariepinus seeds. Summary of the calculation results of H, Pm, SGR, FCR, SR and production are presented in Table 1.

Table 1. The average value of growth weight (H), Absolute length (Pm), specific growth rate (SGR), survival rate (SR), feed conversion ratio (FCR), and production on the seeds of C. gariepinus during the study

| Variabel Data                  | Perlakuan |       |       |
|--------------------------------|-----------|-------|-------|
|                                | P1        | P2    | P3    |
| Growth weight (H) (g/fish)(±SD)| 1.29±0.02  | 1.09±0.05  | 0.96±0.07 |
| Absolute length (Pm)           | 3.87±0.15  | 3.60±0.10  | 3.30±0.10  |
| Variabel Data | Perlakuan | P1 | P2 | P3 |
|---------------|-----------|----|----|----|
| (cm/fish)(±SD) |           |    |    |    |
| Spesific growth rate (SGR) (%) | 15.87±0.55<sup>a</sup> | 15.11±0.07<sup>b</sup> | 14.40±0.17<sup>c</sup> |
| Survival rate (SR) (%) (±SD) | 97.85±0.74<sup>a</sup> | 94.23±1.06<sup>b</sup> | 86.59±2.28<sup>c</sup> |
| Production (initial total fish) (±SD) | 6.849±51.73<sup>a</sup> | 6.596±74.08<sup>b</sup> | 6.061±159.63<sup>c</sup> |
| Feed Conversion Ratio (FCR) (±SD) | 0.79±0.02<sup>a</sup> | 0.83±0.05<sup>a</sup> | 0.94±0.13<sup>a</sup> |

Values (mean of duplicates ± SD) in same row with different letters are significant different ($P < 0.05$).

Regression test results in absolute weight are $Y_1 = 0.060 + (-0.121)x$ and the value of $r^2 = 0.921$ with a weight of $1.29 ± 0.02$ gram, the regression test results at absolute length are $Y_1 = 0.176 + 1.480x$ and $r^2 = 0.988$ with length $3.87 ± 0.15$ cm. With the pattern of growth in weight and length presented in Figures 3 and 4.

![Figure 3. Weight growth pattern of C. Gariepinus](image_url)
Table 2. Total Ammonia Nitrogen (TAN) in C. gariepinus cultured Using Different Biofilter

| Water quality parameters          | P1             | P2             | P3             | Note               |
|----------------------------------|----------------|----------------|----------------|--------------------|
| Inlet TAN concentration (mg/liter)| 0.31±0.02*     | 0.47±0.08*     | 0.60±0.14b     | *<1mg/liter        |
| Outlet TAN concentration (mg/liter)| 0.22±0.05*     | 0.39±0.06b     | 0.53±0.15b     | **<1mg/liter       |
| Volumetric removal rate of TAN   | 1.19±0.39      | 1.11±0.19      | 0.81±0.16      |                    |

* [14]; ** [15]; Values (mean of duplicates ± SD) in same row with different letters are significant different (P < 0.05)

The results of measurements of water quality parameters for Inlet and Outlet, i.e temperature, pH, and DO were 25.1-27.0°C; 7.01-8.03 and 3.00-3.89 mg/l, respectively. Those values still within the range feasible for the cultivation of C. gariepinus [7][14].

3.1. Growth Performance

Absolute weight growth results on C. gariepinus showed that the use of different filter media had a significant effect (P <0.05). Kaldnes 100% media use (P1) resulted in the highest absolute weight growth (1.29± 0.02 gr), Kaldnes 50% and Bioball 50% that was 1.09± 0.05 g) and Bioball 100% was 0.97±0.08 grams. This is presumably because the water quality conditions in the Kaldnes media maintenance pond were in good condition, so that the appetite for seeds will increase. The results of previous study [16] mentioned that the Bioball media for Barramundi fish farming (Lates calcarifer) requires a long time for the growth process which is 180 days with a density of 30-40 kg/m and the ammonia is <0.1 mg/l. Kaldnes media is able to maintain water quality in tilapia cultivation with high density (168 kg/m) [17].

The results of research on C. gariepinus showed that the highest absolute length growth value at P1 (Kaldnes) was 3.87± 0.12cm and the lowest was at P3 (Bioball) of 3.30 ± 0.06cm. Based on these results, it can be concluded that the use of Kaldnes is able to increase the length of growth of 0.57cm. The results of the use of Kaldnes media can improve the growth results of fish Red Seabream (Pagrus major) which is 29.7± 0.61 gram to 41.0± 0.73grams with a TAN value of 0.73 ± 0.02 [18].
shows an increase in growth by using Kaldnes media for 9 days. The results of previous research that used of Bioball media for the growth of Red Rainbow fish (Glossolepis incisus Weber) is less effective, with a growth value of 1.85± 0.58 grams with a maintenance time of 6 months [19].

The high value of the specific growth rate at P1 (Kaldnes) was 15.87 ± 0.55% and the lowest in P3 (Bioball) was 14.40 ± 0.17% allegedly because of the different role of biofilter media, Kaldnes role in maintaining water quality more effective compared to Bioball. Water quality in good conditions will increase fish appetite. According to that Kaldnes media is able to maintain the condition of aquaculture water quality and is able to remove ammonia by 50 g/m³/day, so that fish can grow well [20].

3.2. Survival rate (SR)
Based on the results obtained that the use of different filter media on C. gariepinus has a significant effect on survival rates. The highest value is the use of Kaldnes media 100% (97.85%) and the lowest value on the media of Bioball 100% (86.59%). Based on these results it can be concluded that the use of Kaldnes can reduce mortality by 11.26%. This is presumably because of the recirculation system with the help of biofilter giving a real influence. Based on water quality such as temperature, pH and DO, it is still within the range that is feasible for the cultivation process of C. gariepinus. Kaldnes media is able to maintain water quality conditions in this case (TAN), so that with high density, fish can survive with the help of biofilter media. Based on the results of research from the recirculation system with Kaldnes media for Turbot fish cultivation was able to reduce the mortality rate to 15-20%.[21].

The Kaldnes type K1 media has a Specific Surface Area (SSA) of 500 m²/m³, with the total surface area of the media the bacteria will grow well [22]. The Bioball that media has a SSA of 378 m²/m³ [23]. This shows that the Kaldnes media has more space than the Bioball media for bacterial life.

3.3. Production
Production results obtained in treatment P1, P2 and P3 were 9247.23 ± 169.82, 7,563.04 ± 361.32 and 6,343.43 ± 187.50 fish, respectively. The recirculation system were able to maintain water quality in the maintenance pond of C. gariepinus. This can be seen from the results of survival, the use of Kaldnes 100% media (P1) showed higher results compared to P2 and P3. The growth of weight and length in Kaldnes 100% media (P1) showed higher results compared to other treatments, presumably because the TAN average values on P2 and P3 were higher. The TAN will increase due to the presence of food and feces that settle under the pond and the biofilter used is less effective in reducing TAN, which will cause the mortality and decrease of fish appetite of the fish [2]. The TAN accumulation in cultivation media is one of the causes of water quality degradation which can result in the growth of cultured fish, so that the failure of cultivation production will occur.

3.4. Feed conversion ratio (FCR)
The value FCR from each treatment of C. gariepinus did not have a significant effect on growth. The FCR values at P1, P2 and P3 were 0.79, 0.83 and 0.94. The use of Kaldnes 100% media (P1) produces a good FCR value compared to other treatments. This is presumably due to the condition of water quality in P1 (Kaldnes 100%) in safer conditions, so that the appetite of the fish increases and the feed given will be used for the growth process. The protein content in the feed given will also affect the growth of the fish, the seeds of C. gariepinus are fed with Tubifex sp. and pellets. Factors that influence the value of FCR height and amount or the amount of feed consumed by fish, namely environmental conditions, such as water quality (temperature, DO, pH and TAN), and quantity of feed, and the condition of the fish growth process. Tubifex sp. have a high nutrient content [8]. This is consistent with the other research results that the treatment using feed 75% Tubifex sp. and 25%
pellets were weighed before giving to fish, and had the most efficient feed conversion value of 0.69 in *C. Gariepinus* [24].

3.5. Filters Effectiveness

Based on the measurement data of TAN concentration in treatment P1, P2 and P3 were increased. The highest TAN concentration occurred in P3 (Bioball). Intensive system cultivation needs to be additional technology to be able to maintain water quality (ammonia) in a range that is feasible for cultivation [1]. The TAN comes from excess feed and feces of organisms that are considered as major contaminants in cultivation [3][25].

Based on the results of Table 2, volumetric removal rate of TAN in Kaldnes (1.19 ± 0.39 g/m³/day) showed good performance compared to Bioball filter media and mixed media (Kaldnes and Bioball). It can be concluded that the Kaldnes media is able to eliminate TAN per day as much 1.19 g/m³/day. In contrast to the Bioball media, it only removed TAN by 0.81 g/m³ day. This is related to the characteristics of filter media. With high (SSA), the media will work effectively and bacteria will grow more. The media can eliminate TAN higher, presumably because the total water flow through the filter is higher and the TAN value is higher [18]. The specific surface area (SSA) of the media can be used to determine the TAN reducing performance that passes through the filter [4]. Study results of tilapia culture using Kaldnes media produced a VTR value of 267 ± 123 g TAN removed/m³ [26]. The study of recirculation system using Bioball which was inoculated with bacteria and Bioball without bacterial inoculation gave an effect on the VTR yield of 6.40 mg/l per day to 7.81 mg/l per day [27].

The Kaldnes media has a Specific Surface Area (SSA) of 500 m²/m³, with the SSA area the bacteria are able to grow well [22]. The Bioball media has a Specific Surface Area (SSA) of 378 m²/m³ [23]. The maximum TAN total removal in Kaldnes type K1 media is 0.30 gr NH₄-N (m³/d) [28]. The specific area (SSA) of the media will determine TAN removal performance [4][18].

The Kaldnes and Bioball media used were discolored. The entire Kaldnes media used was discolored. However, not all colors change in the Bioball media this is thought to be due to the greater gravity of the Bioball, so that the Bioball will coincide with each other and cause the performance of Bioball to be less effective. Kaldnes is made to have an active surface area for bacterial living media. Kaldnes which have been overgrown with bacteria will turn brown. Kaldnes media has a specific gravity value of 0.660 and the Bioball media has a specific gravity value of 0.851 [29]. Based on the gravity value of each media that Kaldnes has a lower or lighter value compared to Bioball, so the performance of Kaldnes is better than Bioball.

4. Conclusion

The conclusion that can be drawn based on the results of research that has been done that the performance of growth, survival and production is the highest in treatment P1. With the respective values as follows; Regression test results in absolute weight are Y1 = 0.060 + (- 0.121) x and the value of r² = 0.921 with a weight of 1.29 ± 0.02 gram, the regression test results at absolute length are Y1 = 0.176 + 1.480x and r² = 0.988 with length 3.87 ± 0.15 cm, SGR of 15.86 ± 0.55%/day, SR of 97.85 ± 0.74% and seed production of 6849 ± 51.73 fish. The result of Volumetric removal rate of TAN (g/m³/day) at P1 is higher with a value of 1.19 ± 0.39, compared to P2 and P3 which have lower values of 1.11 ± 0.19 and 0, 81 ± 0.16.

Recommendation

Kaldnes and Bioball media are able to maintain water quality below the threshold. For the best research, Kaldnes Media use is recommended on the production scale. further testing is needed on bacteria kind that grow on biofilter media.
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