Produktivitas Tambak dan Kualias Air Pada Berbagai Metode Budidaya Udang Vaname (*Litopenaeus vannamei*) di BPBAP Ujong Batee Aceh Besar

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Abstrak
Budidaya udang sistem tradisional mudah terjadi penyebaran penyakit dan produksinya rendah. Penerapan teknologi budidaya dapat mengurangi resiko. Penelitian ini bertujuan untuk mengukur produksi dan menganalisa kualitas air tambak pada budidaya udang vaname dengan menerapkan metode budidaya semi intensif, intensif dan super intensif melalui pengukuran secara langsung dan observasi di lapangan. Hasil penelitian menunjukkan produktivitas tertinggi dihasilkan pada kolam super intensif sebesar 5,4 kg/m², pada metode intensif 2,325 kg/m² dan pada metode budidaya semi intensif 0,575 kg/m². Parameter kualitas air pada metode budidaya semi intensif salinitas berada pada level 30,8 ppt - 35,1‰, super intensif salinitas 29,2-31,9‰ dan pada semi intensif salinitas 30,9-34,2‰. Suhu pada metaete budidaya semi intensif berada pada level 26,7-28,5°C. pada super intensif 25,9-28°C dan pada metoda semi intensif 27,8-29,3°C. pH pada metode budidaya semi intensif berada pada level 7,9-8,3 super intensif pH 7,7-8,6 dan metoda semi intensif pH 7,7-8,2. Oksigen terlarut pada metoda budidaya udang intensif 4.0-5,9 ppm, pada super intensif oksigen terlarut 3.0-3,6 ppm dan semi intensif 3,2-4,0 ppm. Dapat disimpulkan semakin tinggi teknologi budidaya yang diterapkan akan berdampak pada semakin tingginya produktivitas tambak yang dihasilkan. Perbedaan metode budidaya tidak berdampak pada perubahan kualitas air atau ketiga metode budidaya tersebut berdampak yang sama terhadap kualitas air.

Kata Kunci: produktivitas, tambak, vannamei, kualitas air
Pond Productivity and Water Quality in Various Vaname Shrimp (Litopenaeus vannamei) Farming Systems at BPBAP Ujong Batee Aceh Besar

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Abstract
Traditional shrimp farming systems are generally susceptible to disease outbreaks, resulting in low productivity. However, the application of farming technology can reduce these risks. This study aims to calculate the production and examine pond water quality in vannamei shrimp culture by applying semi-intensive, intensive, and super-intensive farming systems through direct measurements and field observations. The results showed that the highest productivity was produced in super-intensive ponds at 5.4 kg/m², in intensive systems at 2,325 kg/m², and in semi-intensive farming systems at 0.575 kg/m². The semi-intensive salinity ranged from 30.8 ppt to 35.1 ppt, the super-intensive salinity ranged from 29.2 to 31.9 ppt, and the semi-intensive salinity ranged from 30.9 to 34.2 ppt. The temperature ranges from 26.7 to 28.5°C for semi-intensive culture, 25.9 to 28°C for super-intensive farming, and 27.8 to 29.3°C for semi-intensive farming. The pH in the semi-intensive farming system is 7.9-8.3, the super-intensive pH is 7.7-8.6, and the semi-intensive system is at pH 7.7-8.2. Dissolved oxygen levels range from 4.0 to 5.9 ppm in intensive shrimp farming, 3.0 to 3.6 ppm in super-intensive shrimp farming, and 3.2 to 4.0 ppm in semi-intensive shrimp farming. Therefore, it can be concluded that the higher the farming technology applied, the higher the ponds’ productivity. Meanwhile, differences in farming systems do not impact changes in water quality.

Keywords: productivity, ponds, vannamei, water quality

INTRODUCTION
Shrimp farming is one of the industries in increasing fishery production (Hikmayani et al., 2012; Karuppasamy et al., 2013). Activities related to shrimp farming include hatchery and rearing. The maintenance process must consider internal and external factors to produce superior shrimp commodities, such as the origin and seed quality, water quality, feeding management, and disease control (Haliman and Adijaya, 2005). Technology applied in shrimp culture affects productivity and the amount of waste released. The higher the technology used, the greater the operational capital required.

Traditional shrimp farming systems are noted to have problems often. Shrimp mortality in this aquaculture system is relatively high due to the emergence of various diseases. In addition, using large amounts of feed results in high ammonia levels and affects the water quality of culture media, making it frequently fall below optimal levels. This causes a decrease in the immune system of cultured shrimp/fish. In the long term, poor water quality can cause shrimp mortality.
Applying technology to shrimp farming, whether semi-intensive, intensive, or super-intensive farming systems, is one way to solve the above issue. These three farming systems offer greater control and harvest success assurance. Therefore, this study examines the relationship between productivity and pond water quality in various Vaname Shrimp farming systems.

**MATERIALS AND METHODS**

**Time and place**

This research was conducted from August to December 2020 and was located at BPBAP Ujong Batee, Aceh Besar District. Different coordinators carried out different Vanamei farming systems.

**Tools and materials**

The materials used in this study are tools and materials commonly used by cultivators in semi-intensive, intensive, and super-intensive vannamei shrimp farming systems, namely shrimp ponds, paddlewheel aerators, HDPE Plastic, feeding tray, Mesh (6 square meters), digital scale, shrimp feed, saponins, fertilizer, and probiotics. Equipment used for water assessment was a pH Meter, thermometer, refractometer, and DO meter. The sample was vannamei seed with an average body weight of 0.02g.

**Data collection**

The data consists of primary data and secondary data. Primary data were collected through direct observation in the vannamei shrimp pond area with semi-intensive, intensive, and super-intensive systems at the Ujong Batee BPBAP. Secondary data were obtained from books, journals, theses, and all literature sources supporting this research. In addition, secondary data includes information from the Department of Fisheries and Marine Affairs and the Central Statistics Agency.

**Sampling Method**

Pond samples for vannamei shrimp were divided into 3 (three) categories: semi-intensive, intensive, and super-intensive. Purposive sampling is used to determine the three pond farming techniques.

**Data analysis**

Data analysis used multiple linear regression, with Y as the dependent variable and X as the independent variable (Sudjana, 1992). The regression model was used for each observation period.

\[
Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + \ldots \ldots \ldots \ (1)
\]

- \(Y\) = Productivity (ton/ha/year)
- \(X_1\) = Temperature
- \(X_2\) = Salinity
- \(X_3\) = pH
- \(X_4\) = Dissolved Oxygen
- \(a\) = Constant
- \(\varepsilon\) = Error
- \(b_1, b_2, \ldots, b_6\) = Coefficients of linear regression
Criteria for Farming System

The vannamei shrimp farming system has special criteria according to the technology applied to each activity. The difference between semi-intensive, intensive, and super-intensive farming systems are shown in the following table 1:

Table 1. Criteria for Vaname Shrimp Farming System

<table>
<thead>
<tr>
<th>No</th>
<th>Criteria</th>
<th>Semi-intensive</th>
<th>Intensive</th>
<th>Super Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pond area (Ha)</td>
<td>≥ 0,5</td>
<td>0,1 s/d 0,4</td>
<td>≤ 0,1</td>
</tr>
<tr>
<td>2</td>
<td>Stocking density (individual/m²)</td>
<td>10 s/d 50</td>
<td>60 s/d 200</td>
<td>210 s/d 1000</td>
</tr>
<tr>
<td>3</td>
<td>Water height (cm)</td>
<td>50 s/d 80</td>
<td>100 s/d 150</td>
<td>200 s/d 300</td>
</tr>
<tr>
<td>4</td>
<td>Paddlewheel aerators</td>
<td>4 unit/ha</td>
<td>10 units/ha</td>
<td>unit/ha+rood blower</td>
</tr>
<tr>
<td>5</td>
<td>Construction</td>
<td>Soil/HDPE</td>
<td>Soil /HDPE</td>
<td>HDPE/Concrete</td>
</tr>
<tr>
<td>6</td>
<td>Cost</td>
<td>Average</td>
<td>High</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Survival Rate

The survival rate is calculated using the equation formula (Muchlisin et al., 2016):

\[ SR = \frac{N_t}{N_r} \times 100\% \quad \text{........(2)} \]

SR = Survival rate (%)
Nt = Number of live shrimp at the end of the study
No = Number of live shrimp at the beginning of the study

Feed Conversion Ratio

Feed conversion was observed to calculate feed conversion (Kusriani et al., 2012):

\[ FCR = \frac{F}{W_t - W_o} \times 100\% \quad \text{.................(3)} \]

FCR = Feed Conversion Ratio (%)
F = Amount of feed given (g)
Wt = Weight of biomass of test shrimp at the end of rearing (g)
Wo = Weight of biomass of the tested shrimp at the beginning of rearing (g)

Feeding Management

The feed is in the form of flour with a protein content of up to 38%. The feeding is done by spreading it in all containers so that the shrimp get the same opportunity to eat. The feeding frequency is 4 times a day: in the morning, at noon, in the afternoon, and in the evening.

Weight Measurement

The average weight of post-vannamei shrimp larvae was measured using an analytical balance with a 0.01-milligram precision. The weighing procedure involved weighing 10 samples of shrimp for each treatment. Tissue paper was used to wipe the water from the shrimp's body to obtain accurate weight data.
RESULTS AND DISCUSSION

Growth performance of white shrimp *Litopenaeus vannamei*

The biological parameters of shrimp observed in this study were productivity, average body weight (ABW), survival rate (SR), and feed conversion ratio (FCR). The results of the analysis of variance showed that the vannamei shrimp farming system had a significant effect on productivity (sig = 0.000), the average weight of shrimp (sig = 0.000), and feed ratio (sig = 0.000). However, it had no significant effect on survival (sig = 0.073). The average biological performance of vannamei shrimp, as referred to above, can be seen in Table 2.

Table 2. Biological Performance of Vannamei Shrimp at different farming systems

<table>
<thead>
<tr>
<th>Farming systems</th>
<th>Productivity (kg/m²)</th>
<th>Weight (g/ekor)</th>
<th>SR (%)</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensive</td>
<td>2.3 ±0.5b</td>
<td>22.7 ± 1.7b</td>
<td>71 ± 19.0b</td>
<td>1.325 ±0.00b</td>
</tr>
<tr>
<td>Super Intensive</td>
<td>5.4 ±0.5c</td>
<td>28.6 ± 0.7c</td>
<td>56.5 ± 4.00a</td>
<td>1.725 ±0.20c</td>
</tr>
<tr>
<td>Semi Intensive</td>
<td>0.5 ±0.1a</td>
<td>14.2 ± 0.70a</td>
<td>49.1 ± 6.50a</td>
<td>1.175 ±0.00a</td>
</tr>
<tr>
<td>LSD</td>
<td>0.33</td>
<td>0.91</td>
<td>9.46</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Note: Numbers followed by the same letter in the same column are not significantly different (LSD Test 0.05)

**Productivity**

Productivity is the ratio of shrimp produced (kg) in a culture area (m²). The productivity of shrimp reared in intensive, super-intensive, and semi-intensive ponds showed significantly different values (P < 0.05). The table above shows that the highest productivity was obtained in super-intensive ponds of 5.4 kg/m², followed by intensive systems at 2.3 kg/m² and semi-intensive at 0.5 kg/m².

Productivity in super-intensive farming systems differed significantly from the intensive and semi-intensive farming systems. The productivity of vannamei shrimp produced by the super-intensive system (5.4 kg/m² or equivalent to 54 tons/ha) was significantly different from the productivity of the other two farming systems. According to a study by Lailiyah et al. (2018), the average production of a super-intensive shrimp pond was 42 tons/ha, with an average harvest weight of 12.8 grams, SR 80%, and FCR 1.7. In accordance with research conducted by Rahim et al. (2021), the SR of vannamei shrimp with the super-intensive system can reach 86% with a FCR of 1.6. Previous studies reported that super-intensive shrimp farming technology was carried out in small-scale intensive farms. This technology is characterized by a pond area of about 1,000 square meters or smaller, a water depth of more than 2 meters with stocking, and high productivity. In addition, the pond is equipped with clean water reservoirs, aquaculture waste treatment plots, and a minimal waste load.

The prospect of developing shrimp ponds with super-intensive technology is an opportunity to increase national shrimp production. The evidence comes from research in Punaga Village, Mangarabombang, Takalar Regency, South Sulawesi, where Vaname shrimp have been harvested three times with total production of up to 37 tons. The study was conducted on three density plots with pond sizes of 1000 square meters and shrimp densities of 750, 1000, and 1250 shrimps per square meter, respectively. This place meets the requirements for Vaname shrimp production. In addition, this super-intensive technology can be developed with a prerequisite for a wastewater treatment plant (WWTP). WWTP is an integral part of the shrimp-rearing process to
avoid degrading the ecosystem's quality and reducing coastal biodiversity due to potential waste from the production process.

**Average Body Weight**

ABW is the average shrimp weight in a population during a certain period. ABW is obtained by calculating the total weight of shrimp divided by the number of shrimp harvested. Based on the analysis shown in Table 4.1, the ABW values in each farming system were significantly different from each other ($P < 0.05$). The ABW of shrimp in the intensive farming system differed significantly from the ABW of shrimp reared in both super-intensive and semi-intensive systems.

Shrimp reared in super-intensive ponds had the best ABW (28.6g). The shrimp grown in an intensive pond had an average body weight of 22.75 g/individual, while shrimp grown in a semi-intensive pond had an average body weight of 14.2 g/individual. Sufficient feed is needed in accordance with the age of the shrimp being reared to support the growth of shrimp. In the research of Lailiyah et al. (2018), the average weight of individual shrimp at harvest is 12.8 g/individual. This data is lower than the results of research conducted at BPBAP Ujung Batee, with an average weight of 28.6 grams/individual.

**Survival Rate**

The survival percentage (survival rate) was calculated by dividing the number of shrimp at the beginning of rearing by the number of shrimp at the end. LSD test explains that there was no significant difference between the SR of shrimp in super-intensive ponds (56.5%) and shrimps reared in semi-intensive ponds (49.125%). However, these two SRs were significantly different compared to shrimp reared in intensive ponds ($P< 0.05$), which was 71%, indicating that the optimum pond for shrimp survival rate is one with an intensive pond. The survival rate reported by Purnamasari et al. (2017) for vannamei shrimp culture is 86.70, which is higher than that of the study conducted at BPBAP Ujong Batee, where the highest SR was 71%.

**Feed Conversion Ratio**

The feed Conversion Ratio (FCR) is the amount of feed needed to produce 1 kg of shrimp. The lower the FCR value, the better. The low value of FCR indicates optimal feed absorption in cultured shrimp. The FCR value in each farming system was significantly different ($P < 0.05$). According to the data obtained in this study, the FCR on the intensive shrimp farming system (1.325) was significantly different from the super-intensive farming system (1.725) as well as from the semi-intensive farming system (1.175). However, the FCR in intensive, semi-intensive, and super-intensive ponds is around 1–1.8. Therefore, this value is technically still in the optimal FCR range (range 1 - 2).

**Water Quality**

Water quality measured in this study includes salinity, temperature, pH, and DO. Water quality data for each farming system is attached in the following Table 3.
Table 3. Water quality of different Vaname Shrimp Farming systems

<table>
<thead>
<tr>
<th>Farming System</th>
<th>Salinity</th>
<th>Temperature</th>
<th>pH</th>
<th>DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensive</td>
<td>33.0 ±2.19</td>
<td>27.64 ±0.88</td>
<td>8.09 ±0.28</td>
<td>5.02 ±0.95 b</td>
</tr>
<tr>
<td>Super Intensive</td>
<td>30.56 ±1.36</td>
<td>27.25 ±1.28</td>
<td>8.19 ±0.43</td>
<td>3.34 ±0.31 a</td>
</tr>
<tr>
<td>Semi Intensive</td>
<td>32.61 ±1.68</td>
<td>28.59 ±0.72</td>
<td>8.00 ±0.22</td>
<td>3.66 ±0.41 ab</td>
</tr>
</tbody>
</table>

Note: Numbers followed by the same letter in the same column are not significantly different (LSD Test 0.05)

a. **Salinity**

Salinity is often defined as the salt content of seawater. Salinity is the total weight of all dissolved solids in 1 kilogram of seawater, expressed in grams. Salinity levels are stated in parts per thousand (ppt). Fardiansyah (2011) stated that the salinity value of freshwater ranges from 0-5 ppt, brackish water range from 6-29 ppt, and seawater range from 30-40 ppt. During the research period, the salinity of pond water in three different farming systems was generally consistent. The dynamics of pond water salinity in different farming systems are illustrated in Figure 1.

![Figure 1. Salinity of vannamei rearing pond in different farming systems](image)

Salinity ranged from 30.8 ppt to 35.1 in the intensive farming system, 29.2 to 31.9 in the super-intensive farming system, and 30.9 to 34.2 in the semi-intensive farming system. The three farming systems have water salinity suitable for vannamei shrimp farming. Shrimp can tolerate salinities between 10 and 35 (Arifin et al. 2007). The results of Martini's research (2017) state that salinity during the study was around 34.43 – 34.90 ppt without fluctuation.

b. **Temperature**

Temperature is the degree of hotness or coldness measured on a certain scale using a thermometer. Water temperature is affected by season, latitude, altitude, time of day, air circulation, cloud cover, and depth of water bodies (Effendi, 2003). The temperature dynamics in intensive, super-intensive, and semi-intensive ponds are presented in Figure 4.2.
Figure 2. Temperature of vaname rearing pond in different farming systems

The intensive farming system has a temperature range of 26.7–28.5°C. The temperature for the super-intensive farming system ranges from 25.9 to 28°C, whereas the temperature for the semi-intensive farming system is from 27.8 to 29.3°C. Therefore, the water temperature in all farming systems is in the optimum range to support shrimp growth. This is in line with Herdianti et al. (2015) research that the temperature during the observation was around 27-29 °C. According to Supito (2017), a pond temperature in the range of 28 C to 32 C is optimal for vannamei shrimp farming.

c. Potential Of Hydrogen

pH is a measure of the hydrogen ion concentration in an aqueous solution. The pH value determines whether the solution is basic, neutral, or basic. pH in different pond systems can be seen in Figure 3.
The pH of the water in the vannamei shrimp culture has a crucial role. pH is closely related to alkalinity, affecting shrimp shells' formation during molting. The pH range for the intensive farming system is 7.9 to 8.3. Meanwhile, the super-intensive system is 7.8 to 8.2 for the semi-intensive pond. The pH of the water in three shrimp farming systems is ideal for vannamei rearing (Arifin et al., 2007). In Musyaffa Rafiqie (2021), pH values between 7.4 and 8.5 are still considered normal. This statement is in accordance with the results of this study at BPBAP Ujong Batee, where pH ranged between 7.7 – 8.6.

d. Dissolved Oxygen

The quantity of oxygen dissolved in water is known as dissolved oxygen (DO). Sources of DO in the water include the process of diffusion from the air and the photosynthesis of phytoplankton or green plants. Figure 4. shows the DO in intensive, super-intensive, and semi-intensive ponds.

![Figure 4. DO of vannamei rearing pond in different farming systems](image)

One of the most important water qualities in shrimp farming is dissolved oxygen. Dissolved oxygen must be measured continuously and maintained above 3 ppm. During the study, dissolved oxygen in the intensive shrimp farming method was observed at 4.0-5.9 ppm. In the super-intensive method, dissolved oxygen was recorded at 3.0-3.6 ppm; in the semi-intensive method, shrimp farming was at 3.2-4.0 ppm. The three methods have sufficient dissolved oxygen, which is more than 3 ppm. According to Susilowati et al. (2017), vannamei shrimp production requires dissolved oxygen concentrations between 4.5 and 6.6. This research found the highest dissolved oxygen in the intensive pond. There is a significant difference between DO in intensive, super-intensive, and semi-intensive ponds. This is in accordance with the research of Herdianti et al. (2015), who reported that DO levels in their study were in the range of 4-6 ppm.

**Correlation between Productivity and Water Quality**

The multiple linear regression analysis results on vannamei shrimp productivity (Y) in semi-intensive ponds show the following model: Y = 1.045 - 0.005 X1 - 0.044 X2 + 0.133 X3 - 0.032 X4 (sig = 0.966). In intensive pond system, the model Y = 1.694-0.024 X1 + 0.052 X2-0.071 X3 + 0.110 X4 (sig = 0.993), while super intensive pond shows a formula Y = 4.917 +0.046 X1-0.003 X2- 0.089 X3-0.061 X4 (sig = 0.984).
Based on the T-test of the regression coefficients, salinity (X1), temperature (X2), pH (X3), and DO (X4), none of these X variables significantly affect productivity. The correlation was not significant based on the correlation test between vannamei shrimp productivity in the three methods.

Several reasons support this analysis, including that weekly water changes maintain the water quality at an acceptable level for shrimp farming activities. In addition, treatment such as siphons at the bottom of the pond also takes part in stabilizing water quality by removing shrimp waste and leftover feed.

**CONCLUSION**

The highest productivity is produced in the super-intensive cultivation method. Shrimp in super-intensive ponds had an average production of 5.4 kg/m² (54 tons/ha), an average weight of 28.6 grams per head, a survival rate of 56.5%, and a feed ratio of 1.725. The average productivity in intensive ponds is 2.325 kg/m² (23.25 tons/ha), and the average shrimp weight is 22.75 grams/head. The average survival rate is 71%, and the average feed ratio is 1.375. The average shrimp weight is 14.2 grams/head, the average survival rate is 49.125%, and the average feed ratio is 1.175.

The higher the cultivation technology applied, the higher the ponds' productivity. Differences in pond systems do not impact changes in water quality because water quality was maintained in all pond systems.

**REFERENCES**


Herdianti, L., Soewardi, K., & Hariyadi, S. (2015). Efektifitas penggunaan bakteri untuk perbaikan kualitas air media budidaya udang vanamei (*Litopenaeus vannamei*) super intensif [The effectiveness of using bacteria to improve the
Pantjara, B. (2006). *Kajian pemantang tambak tanah sulfat masam terhadap peningkatan produktivitas udang windu (Penaeus monodon)* [Study of acid sulphate soil pond bunds on increasing the productivity of tiger shrimp (Penaeus monodon)] [Master’s Thesis Summary]. Universitas Hasanuddin.
[Production performance of Vannamei shrimp (Litopenaeus vannamei) cultivated in semi-intensive system ponds with the application of probiotics].

PENA Akuatika, 16(1), 22-37.