

COMPARATIVE ANALYSIS OF POND SHAPES IN INTENSIVE CULTURE OF VANNAMEI SHRIMP (*Litopenaeus vannamei*) FROM PL12 TO DOC50 ON PRODUCTION PERFORMANCE

Analisis Perbandingan Bentuk Kolam Pada Budidaya Udang Vannamei (*Litopenaeus vannamei*) PI 12 Hingga Doc 50 Dengan Sistem Intensif Terhadap Produksi

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ABSTRACT

Intensive aquaculture of whiteleg shrimp (*Litopenaeus vannamei*) often encounters technical challenges due to high stocking densities, making pond design a critical factor in optimizing production. This study aimed to evaluate the effect of pond shape—round tarpaulin versus rectangular concrete—on the production performance of *L. vannamei* cultured from PL12 to DOC50. The research was conducted at UD. Hidayah Vaname, Probolinggo, using a quantitative descriptive method and comparative approach. Six ponds were used as experimental units (three round and three rectangular), each stocked with 92,400 post-larvae. Data were analyzed using the Shapiro-Wilk normality test and paired sample t-test. The results showed that average shrimp production in rectangular ponds (227.43 kg) was higher than in round ponds (182.28 kg), although the difference was not statistically significant ($p > 0.05$). These findings suggest that, under limited-scale intensive farming conditions, pond shape does not significantly affect shrimp production.

Keywords: *Litopenaeus vannamei*, pond design, intensive aquaculture, round pond, rectangular pond

ABSTRAK

Budidaya intensif udang vannamei (*Litopenaeus vannamei*) kerap menghadapi kendala teknis akibat padat tebar tinggi, sehingga desain kolam menjadi salah satu aspek penting dalam optimasi produksi. Penelitian ini bertujuan untuk mengevaluasi pengaruh bentuk kolam—bundar terpal dan kotak beton—terhadap hasil produksi udang vannamei dari stadia PL12 hingga DOC50. Studi dilakukan di UD. Hidayah Vaname, Probolinggo, menggunakan pendekatan deskriptif kuantitatif dan metode komparatif. Enam kolam digunakan sebagai unit percobaan (tiga kolam bundar dan tiga kolam kotak) dengan kepadatan awal 92.400 ekor per kolam. Analisis data dilakukan menggunakan uji normalitas Shapiro-Wilk dan uji *paired sample t-test*. Hasil menunjukkan bahwa produksi rata-rata pada kolam kotak (227,43 kg) lebih tinggi dibanding kolam bundar (182,28 kg), namun perbedaan tersebut tidak signifikan secara

statistik ($p > 0,05$). Temuan ini mengindikasikan bahwa dalam sistem budidaya intensif berskala terbatas, bentuk kolam tidak berpengaruh signifikan terhadap produktivitas.

Kata kunci: *Litopenaeus vannamei*, desain kolam, budidaya intensif, kolam bundar, kolam kotak

INTRODUCTION

The whiteleg shrimp (*Litopenaeus vannamei*) is a leading aquaculture commodity native to the western Pacific coast of Latin America, with a distribution ranging from Peru to northern Mexico. This species is known for its high environmental adaptability, rapid growth, and disease resistance, making it a primary choice for cultivation in various countries, including Indonesia (Akbarurrasyid *et al.*, 2024). Morphologically, whiteleg shrimp consist of three main parts: the cephalothorax, the abdomen, and the tail, each of which plays a crucial role in locomotion and survival (Supono, 2018).

Since its official introduction in Indonesia in 2001, whiteleg shrimp have rapidly developed as a high-value aquaculture alternative (Nababan *et al.*, 2015). Indonesian aquaculture systems are generally divided into three types: traditional, semi-intensive, and intensive. The intensive system is the preferred choice due to its high productivity through standardized pond management and the application of modern technologies such as aerators, autofeeders, and water quality sensors (Supono, 2018). This subsector contributes significantly to the national economy. According to data from the Ministry of Maritime Affairs and Fisheries (KKP), national vannamei shrimp production reached 881,599 tons in 2020 and increased to 953,176 tons in 2021 before declining slightly to 918,550 tons in 2022 (Anas *et al.*, 2015). Export value is also significant, reaching USD 2.22 billion in 2021 (Firmansyah, 2021), making optimization of aquaculture systems crucial for maintaining competitiveness and production sustainability (Farkan *et al.*, 2025). One characteristic of intensive systems is the application of extreme stocking densities, which can reach more than 100–300 shrimp per square meter to maximize yields (Zaujatz *et al.*, 2016). However, high stocking densities pose technical challenges such as decreased water quality, increased stress, and the risk of diseases such as vibriosis or white feces disease (Marzuki & Dwi, 2021). To address these challenges, a partial harvest strategy is often implemented, removing a portion of the shrimp population before full harvest, aiming to reduce density and maintain environmental stability (Ramadani *et al.*, 2024). This approach also serves as a technical evaluation tool to assess growth, feed efficiency, and pond performance (Putra *et al.*, 2023; Nababan *et al.*, 2015), while also providing economic benefits through flexibility in harvest timing (Pamenang *et al.*, 2023).

In addition to density management, pond design and environmental conditions also influence cultivation success. Circular tarpaulin ponds are considered more efficient in water circulation and waste control than concrete square ponds (Andriyanto *et al.*, 2013; Supriatna *et al.*, 2020; Difinubun *et al.*, 2023). Cultivation success is also determined by the stability of environmental parameters such as salinity (15–25 ppt), temperature (28–32°C), pH (7.5–8.5), and dissolved oxygen levels >4 mg/L (Pratiwi *et al.*, 2021; Al Mubarak, 2024). An imbalance in these factors can cause physiological stress and decreased growth performance (Pronanda, 2021). Given the complexity of the variables involved, research into the relationship between pond shape, partial harvest strategies, and environmental quality is crucial for creating an efficient, adaptive, and sustainable vannamei shrimp cultivation system (Subyakto *et al.*, 2009).

RESEARCH METHODS

Place and Time

This research was conducted from October to December 2024 at an intensive cultivation site owned by UD. Hidayah Vaname, located in Pesisir Village, Dringdu District,

Probolinggo Regency, East Java. This location was chosen due to the consistent implementation of the intensive cultivation system and the availability of ponds of various shapes within a single management unit.

Tools and Materials

This research utilized various tools and supporting materials. The tools used included a DO meter and pH meter for water quality measurements, a precision digital scale for biomass weighing, and other supporting equipment such as scoops, sampling nets, plastic basins, and stationery. Materials used in the research included shrimp fry, commercial feed with quality appropriate to the life cycle, agricultural lime for sterilization, and probiotics as part of water quality management. Seawater with a salinity of 28–32 ppt was used as the maintenance medium.

Test Animals

The test animals used were PL12 stage whiteleg shrimp (*Litopenaeus vannamei*) fry obtained from a certified hatchery. The fry had an initial mean body weight (MBW) of 0.018 grams and were declared healthy based on morphological observations.

Research Container

A total of six ponds were used as experimental units, consisting of three tarpaulin-lined circular ponds (C4, C5, C6) and three concrete rectangular ponds (C1, C2, C3). All ponds had an effective volume of approximately 40 m³, with a stocking density of 92,400 individuals per pond. The selection of the number and type of ponds followed standard intensive farming practices commonly applied in the field (Irsyam *et al.*, 2019; Supriatna *et al.*, 2020).

Research methods

This study used a quantitative descriptive approach with a comparative experimental method. The independent variable in this study was pond shape (circular vs. square), while the dependent variable was shrimp production, measured by total biomass (kg) at the end of the cultivation period. Control variables included the management system, stocking density, feed type, and water quality management, which were standardized across all ponds.

Research Procedures

The research stages consist of three main phases: preparation, implementation, and observation.

1. Preparation Stages

The preparation phase begins with sterilization and preparation of the culture media. The ponds are first drained and cleaned of any remaining organic matter, then sterilized with agricultural lime to suppress the population of pathogenic microorganisms. The ponds are then filled with seawater with a salinity of 28–32 ppt to reach an effective volume of approximately 40 m³. The water is left for 3–5 days for stabilization, while probiotics are administered and an aeration system is installed evenly in each pond. The next phase is the acclimatization of the fry. The PL12 fry are acclimatized to the pond water for approximately 24 hours to avoid stress due to differences in environmental parameters. After acclimatization, the fry are released simultaneously into all experimental ponds at a stocking density of 92,400 per pond.

2. Implementation Stages

The implementation stages begin from the time the fry are released until the 50th day of cultivation (DOC50). Feeding is carried out regularly 4–5 times per day with

commercial feed adjusted to the size and growth phase of the shrimp, using blind feeding and tray feeding methods to control consumption. Probiotics are administered periodically through the water and feed to support digestive tract health and maintain water quality. During the cultivation period, routine monitoring of pond conditions is carried out, including visual observation of shrimp behavior, as well as maintenance of aeration equipment to ensure optimal performance. Partial harvesting is carried out at the end of the cultivation period (DOC50) by sorting using a fine scoop. Harvested shrimp are weighed to obtain production biomass data, which will be used in the analysis.

3. Observation Stages

The observation phase involved recording water quality parameters and production data. The physical-chemical parameters measured included temperature ($^{\circ}\text{C}$), pH, dissolved oxygen (DO, mg/L), and salinity (ppt), measured daily in the morning and afternoon using digital equipment. Furthermore, the weight of shrimp harvested from each pond was recorded as the main variable in the comparison. All collected data was then statistically analyzed to evaluate the effect of pond shape on production.

Data Analysis

The data analysis in this study aims to determine whether there is a significant difference in vannamei shrimp production between circular tarpaulin ponds and concrete box ponds during the rearing period from PL12 to DOC50. The analysis was conducted quantitatively using a parametric statistical approach involving basic assumption testing and inferential hypothesis testing.

1. Normality Test

A normality test was performed on the production data using the Shapiro-Wilk method, which aims to determine whether the data from the two groups of ponds are normally distributed. This test is important for determining whether the data meet the requirements for subsequent parametric statistical tests. Data are considered normally distributed if the significance value (p) is greater than 0.05.

2. Homogeneity of Variance Test

After ensuring a normal distribution, a homogeneity of variance test was performed using Levene's Test to determine whether the variance between the two data groups (circular pools and square pools) was homogeneous. Homogeneity of variance is an important requirement for conducting a paired two-sample t-test. If the significance value (p) is > 0.05 , then the data variance is assumed to be homogeneous.

3. T-test

To determine the difference in initial and partial harvest weights of shrimp fry, a t-test was conducted. This test was used because the research design used paired data from ponds managed uniformly but with different pond shapes. The significance value (p) obtained from this test will determine whether the cultivation method has a statistically significant effect on shrimp production.

4. ANOVA test

To analyze whether there are significant differences in water quality parameters (temperature, pH, DO, and salinity) between the circular and rectangular ponds, a one-way ANOVA test was used. This test is suitable for comparing the averages of more than one group (Widiyanto, 2013)

RESULT

Vannamei Shrimp Production Results

Based on observations of six aquaculture ponds, consisting of three rectangular ponds (C1, C2, and C3) and three circular ponds (C4, C5, and C6), data were obtained regarding the initial stocking rate, initial biomass, final production, and average production yield. After treatment with different pond shapes, complete information on these parameters can be seen in Table 1 below.

Table 1: Data on initial stocking rate, initial stocking MBW, initial stocking biomass, final production, and average production, after treatment with different pond shapes.

Pool Number	Initial Number of Stockings (Tails)	MBW Initial Spread (Gram)	Initial Stocking Biomass (Kg)	Final Production (Kg)	Average Final Production (Kg)
SQUARE POOL					
C1	92.400	0,018	1,7	186.24	227,43.
C2	92.400	0,018	1,7	297.09	
C3	92.400	0,018	1,7	198.97	
ROUND POOL					
C4	92.400	0,018	1,7	164.29	182,28.
C5	92.400	0,018	1,7	228.49	
C6	92.400	0,018	1,7	154.05	

Referring to Table 1, to evaluate whether the initial production data (pre-test) and final production (post-test) were normally distributed, a normality test was first performed. This test used the Shapiro-Wilk method due to the relatively small sample size. The results of the normality test for the initial weight and final production data, after being treated with different pond shapes, are shown in Table 2.

Table 2 Normality Test for Initial Weight (Pre-test) and Partial Production (Post-test)

Variabel	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Pre-test		6			6	
Post-test	0.211	6	0.200*	0.903	6	0.392

Description: Significance level $\alpha = 0.05$

Referring to Table 2, the results of the normality test using the Shapiro-Wilk method show that the significance value for the pre-test (initial weight) and post-test (final production) data is 0.392, which is greater than the significance level of 0.05. Thus, it can be concluded that both the initial weight and final production data after being given treatment in the form of differences in pond shape are normally distributed (H_0 is rejected, H_1 is accepted).

DISCUSSION

This study aims to evaluate the effect of pond shape on the production of whiteleg shrimp (*Litopenaeus vannamei*) during the rearing period from PL 12 to DOC 50. Two types of ponds were used in this study: circular tarpaulin ponds and concrete square ponds, with three units of each.

Table 3. T-test for differences in initial weight and partial production.

Partner	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	Df	Sig. (2-tailed)
Pre_test - Post test	-203.29500	52.17866	21.30185	-258.05314 s.d. -148.53686	-9.544	5	0.000

Based on the t-test, there was a very significant increase in production between the initial maintenance (pre-test) and partial harvest results (post-test). The average production value increased from 1.66 to 204.96, with a significance value of 0.000 ($p < 0.05$). This indicates that the applied cultivation treatments (including pond preparation, feed management, probiotics, and water quality management) have had a positive impact on the growth and harvest yield of vannamei shrimp. The average difference of 203.30 grams reflects the effectiveness of the intensive cultivation system. Therefore, H_0 of the T-test comparing initial weight and partial production is rejected and H_1 is accepted.

Table 4 T-Test of Partial Harvest Results in 2 Pond Types

Assumed Variance	Levene's Test (F)	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	1.129	0.348	-1.074	4	0.343	-45.15667	42.06154
Equal variances not assumed	—	—	-1.074	3.480	0.352	-45.15667	42.06154

A comparative analysis of vannamei shrimp production between two types of ponds, namely circular tarpaulin ponds and concrete square ponds, was conducted using a t-test. Based on the analysis, the average production yield from circular ponds was 182.28 grams, while the average production from square ponds reached 227.43 grams. Descriptively, this indicates that square ponds provide higher production yields than circular ponds. However, the statistical test results showed a significance value (Sig. 2-tailed) of 0.343, which is greater than the significance threshold of 0.05. Therefore, there was no statistically significant difference between the two pond types in vannamei shrimp production during the first partial rearing period, from PL 12 to DOC 50. Therefore, H_0 of this study, stating that there is no significant difference between the two pond types in the vannamei shrimp cultivation process, was accepted.

This indicates that although there was a difference in the average figures numerically, the difference was not strong enough to be declared statistically significant. There are several field factors that can biologically and technically explain the insignificance of these results:

1. Technical treatments across all ponds were identical. All ponds received the same amount and type of feed, an initial biomass stocking density of 92,400 fry per pond, and consistent use of probiotics, fertilizers, aeration, and water quality management. This uniformity of treatment naturally minimizes differences in performance between ponds, including the contribution of pond shape. Studies have shown that uniformity in biofiltration systems and water quality management between ponds can minimize differences in growth outcomes between container shape treatments (Marzuki & Dwi, 2021).
2. Partial harvest was conducted at 50 DOC, which physiologically has a high potential to coincide with the mass molting phase. Molting is a critical biological process that can cause fluctuations in body weight due to the loss of the exoskeleton and delayed

accumulation of new tissue. In this context, timing measurements when the shrimp are in or have just finished molting can temporarily reduce body weight, thus affecting the SGR value and overall partial harvest yield.

3. Research by Wahyuni *et al.* (2024) states that high molting frequency is closely correlated with increased growth, but also causes fluctuations in daily weight values depending on the time of measurement. This is also supported by research by Yulihartini *et al.* (2017), which shows that the active molting phase can cause a decrease in daily growth rate when it occurs en masse, although in the long term it contributes positively to total biomass.
4. During the rearing period, typical symptoms of White Feces Disease (WFD) were observed, which is widely recognized as one of the main diseases causing decreased performance in vannamei shrimp cultivation. WFD attacks the digestive tract and causes impaired nutrient absorption, reduced appetite, and worsened feed conversion to biomass. A study by Marbun *et al.* (2019) found that shrimp infected with WFD experienced drastic changes in gut bacterial composition, particularly an increased dominance of *Vibrio* sp. and *Rubritalea*, which correlated with intestinal tissue damage and an increased feed conversion ratio (FCR) and a decreased specific growth rate (SGR). Furthermore, WFD infection causes severe damage to the hepatopancreas, including necrosis and fatty degeneration, which disrupts the shrimp's overall metabolism (Farastuti *et al.*, 2023).
5. All ponds in this study used the same partial harvesting method: inserting a net into the pond, manually guiding it to a corner, and then lifting the catch. This technique was performed identically in each pond, minimizing technical variables that could affect harvest yields. While this technique is simple and operational, there is potential for selectivity in catches toward shrimp that are more active or located in certain areas of the pond. A study by Ramadani *et al.* (2024) emphasized that while sampling methods can introduce bias in shrimp population estimates, consistent use of the technique across all experimental units will minimize potential errors between treatments.

Considering these four factors, it is understandable that pond shape does not significantly influence shrimp growth performance. Variability in yield is largely determined by natural biological factors (molting, disease), as well as technical procedures that tend to be homogeneous across ponds. Therefore, the influence of pond shape in intensive farming contexts is minor compared to other systemic factors. Further research requires an experimental approach with tighter control of environmental variables and more sensitive measurements of molting phase and disease incidence.

CONCLUSION

This study aims to determine the effect of pond shape on whiteleg shrimp (*Litopenaeus vannamei*) production in an intensive culture system, compare production yields between circular tarpaulin ponds and concrete square ponds, and identify factors influencing production yields. The following conclusions are drawn from this research:

1. The average production value increased from 1.66 to 204.96, with a significance value of 0.000 ($p < 0.05$). This significance was determined based on the paired sample t-test. This indicates that the applied cultivation treatments (including pond preparation, feed management, probiotics, and water quality management) have had a positive impact on the growth and yield of vannamei shrimp.
2. There was a difference in production results between the two types of ponds in the six test ponds. The circular tarpaulin ponds (C4, C5, C6) produced 546.83 kg with an average production of 182.28 kg, while the concrete square ponds (C1, C2, C3)

produced a total production of 682.30 kg with an average of 227.43 kg. However, the independent sample t-test showed that this difference was not significant ($p > 0.05$). This indicates that under uniform cultivation conditions, the shape of the pond has not been proven to significantly affect shrimp production results. Thus, H_0 of this study, which states that there is no significant difference between the two pond shapes in the Vannamei Shrimp cultivation process, is accepted.

3. During the maintenance period from PL12 to DOC50, water quality in both ponds was within the ideal range for vannamei shrimp cultivation. Temperature parameters were recorded in the range of 29–31°C, pH between 7.8–8.2, dissolved oxygen (DO) at 5.1–6.8 mg/L, and salinity between 28–32 ppt.
4. The statistically insignificant results between pond types are most likely due to several factors: the application of uniform cultivation management between ponds (feeding, aeration, water quality management), the relatively short maintenance duration past the molting phase, the presence of White Feces Disease in the majority of ponds, and biological variation between individual shrimp.

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