Application of dissemination plastic ponds technology to *Litopenaeus vannamei* shrimp culture as a solution for aquaculture activities in narrow soil

[1]Wahyu P. Astiyani, [1]Dinno Sudino, [1]Ega A. Prama, [1]Muhammad Akbarurrasyid

[1] Department of Aquaculture, Politeknik Kelautan dan Perikanan Pangandaran, Pangandaran, West Java, Indonesia. Corresponding author: W. P. Astiyani, wahyupujiastiyani@gmail.com

Abstarct. This research aimed to determine parameters of shrimp performance, such as growth rate, specific growth rate, final weight and survival rate of *Litopenaeus vannamei* cultured in dissemination plastic ponds with different densities (1,000; 1,500; 2,000 shrimp m^{-3}). The research was conducted using 9 unit ponds, the size of each pond was 1 m height and had a diameter of 1.5 m. Experiments were designed with 3 different stocking densities and repeated 3 times. The specimens used were vannamei shrimps post larvae (PL-9). Shrimp were cultured for a period of 60 days for measuring growth rate, specific growth rate, final weight and survival rate. The daily measurements of salinity, dissolved oxygen and temperature were performed every two weeks. Final weight, growth rate, specific growth rate and survival rate were analyzed by analysis of variance (ANOVA), with a significance level of $p<0.05$. The mean scores of growth rate ranged between 0.048±0.0002 and 0.063±0.001. The effects of the treatments are not significantly different, except for the final weight and the survival rate ($p<0.05$).
Key Words: dissemination plastic ponds, growth, narrow soil, survival rate.

Introduction. The vannamei shrimp, *Litopenaeus vannamei*, is a widely cultivated type of shrimp. Indeed, shrimp have promising prospects and benefits (Rakhmanda et al 2021). *L. vannamei* can be cultured with high stocking densities, as they are able to use food and space efficiently (Muchtar et al 2021). Farming activities include hatchery and rearing activities. To obtain good quality *L. vannamei* products, several factors should be maintained: seed origin and quality, water quality, feed, technology used and the control of pests and diseases. An intensive production of vannamei shrimp continues to be carried out to meet public demand. Various efforts have been made, in particular through the development of cultivation technology (Supono 2021). In general, there are three cultivation methods applied in Indonesia, namely traditional or extensive, semi-intensive and intensive. The difference between these three cultivation methods lies in several aspects including pond type, pond size, commercial capital, stocking density, feeding type, water management and technology used (Elfitasari 2021). The cultivation of *L. vannamei* has spread evenly throughout Indonesia. In Pangandaran, West Java, there are vannamei shrimp production centers scattered around Pangandaran city. The types of ponds used for growing *L. vannamei* vary widely from soil, ponds and ponds covered with plastic mulch or HDPE (high density polyethylene) (Astiyani 2020). The technology used in vannamei shrimp farming is very diverse, with high stocking densities suited to the carrying capacity of the land (Muchtar et al 2021).

The potential of the land for exploitation by applying an intensive technology is limited and requires high investment (Suwoyo & Hendrajat 2021). One of the most suitable solutions for vannamei shrimp farmers who do not have a large area is to cultivation vannamei shrimp on a household scale. The dissemination plastic ponds for *L. vannamei* farming do not require large areas (Purnaningsih et al 2020). The

dissemination ponds use Orchid D3 tarpaulins, having a high durability, so they can be used for multiple harvests. Their size is 1 m height and 1.5 m diameter, as a solution for *L. vannamei* farming on narrow land surfaces. Besides requiring a low cost compared to large-scale shrimp farming, application of environmentally friendly technology using narrow soil is expected to remain profitable and sustainable (Muchtar et al 2021). The aim of this study was to determine the effect of stocking density of *L. vannamei* cultured in dissemination plastic ponds and can support shrimp farmers who do not have a large area to culture shrimps to use the dissemination plastic pond with environmentally friendly products and low cost compared to large-scale vannamei shrimp farming.

Material and Method

Research location. The research was carried out at Politeknik Keluatan dan Perikanan Pangandaran, Pangandaran city, West Java, Indonesia (Figure 1). This research used 9 units of dissemination ponds with an aeration system. The size of each pond is 1 m high with a pond diameter of 1.5 m.

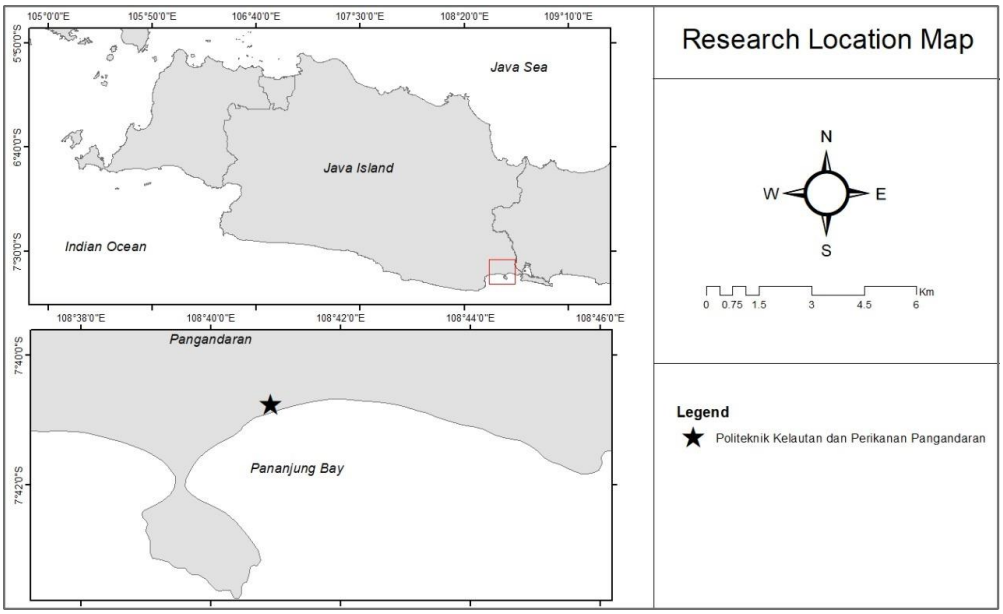

Figure 1. The location of research at Politeknik Kelautan dan Perikanan, Pangandaran, Indonesia.

Experimental treatment. The experiment was based on a fully randomized design; the test animal used was *L. vannamei* PL-9, the treatments' stocking densitieswere: A=1,000 ind m^{-3}, B=1,500 ind m^{-3} and C=2,000 ind m^{-3}, each with three replicates. They were fed around 2 times a day, at a dose of 5% of the biomass weight. The rearing time was 60 days.

Data analysis. The first observed variable was the growth rate of *L. vannamei*. The growth rate for each density treatments was estimated using the formula (Zonneveld et al 1991):

$$GR = (Wt-W0)/t$$

Where:
GR - growth rate;
Wt - the final weight;
W0 - the initial weight;
t - the time of maintence.

The weight was measured using electric scales, at an accuracy of 0.01 g. *L. vannamei* were sampled every 10 days.
The specific growth rate (SGR) was measured using the formula (Zonneveld et al 1991):

$$SGR = (Ln\ Wt - Ln\ W0) \times 100 / t$$

The survival rate was observed by weighing all live shrimps at the end of the study. The survival rate (SR) formula used was (Zonneveld et al 1991; Rakhmanda et al 2021):

$$SR = (Nt/N0) \times 100$$

Water quality variables. Temperature and dissolved oxygen (measured with a DO meter), salinity (measured with a refractometer) and pH (measured with a pH meter) were observed once every 10 days, along with the shrimp growth.

Statistical analysis. All data were presented as the mean ± standard deviation (SD) of the repeated measurements (n=9). Bartlett and Kolmogorov-Smirnov tests were used to test the normality, independence and homogeneity of the data. Final growth, growth rate, specific growth rate, and survival rate, were analyzed by analysis of variance (ANOVA) with significance of the differences was defined at $p<0.05$.

Results. *L. vannamei* pond construction consisted of a circular plastic dissemination pool with a height of 1 m and a diameter of 1.5 m. This dissemination pond is composed of: orchid tarpaulin pool, 6 mm hot ash iron, water hose, corrugated pipe, rope, iron locks, gutter carpet, full set drainage, aeration hose and aeration stone. All the tools are merged following the shape of a pond, as in the picture below.

Figure 2. Dissemination plastic ponds (original photos).

Shrimp performance. The result of shrimp performance growth rate and specific growth rate were shown in the Table 1.

Table 1

Growth rate and specific growth rate of *Litopenaeus vannamei* in dissemination plastic ponds

Parameter	*1,000 (ind m^{-3})*	*1,500 (ind m^{-3})*	*2,000 (ind m^{-3})*
Growth rate (g day^{-1})	0.0637±0.001768^{a}	0.053317±0.002357^{a}	0.048483±0.000236^{a}
Specific growth rate (%)	13.74854±0.046222^{a}	13.4507±0.073681^{a}	13.29317±0.0081^{a}
Final weight (g)	3.824±0.106066^{b}	3.199±0.141421^{a}	2.909±0.014142^{a}
Survival rate	86.1%^{a}	85.3%^{a}	82.1%^{a}

Different letters indicate significant differences ($p<0.05$).

The mean scores of growth rate ranged between 0.048±0.0002 and 0.063±0.001 g. The effect on growth of the treatments were not significantly different (P<0.05) (with the three replications). Also no differences were recorded between the density changes on the specific growth rate. Only the effect of density on the final weight was significantly different between the treatments as shown in Table 1 and Figure 3. The survival rate was significantly different among the treatments (P<0.05): 86.1, 85.3 and 82.1% at a density of 1,000, 1,500 and 2,000 shrimps m^{-3}, respectively.

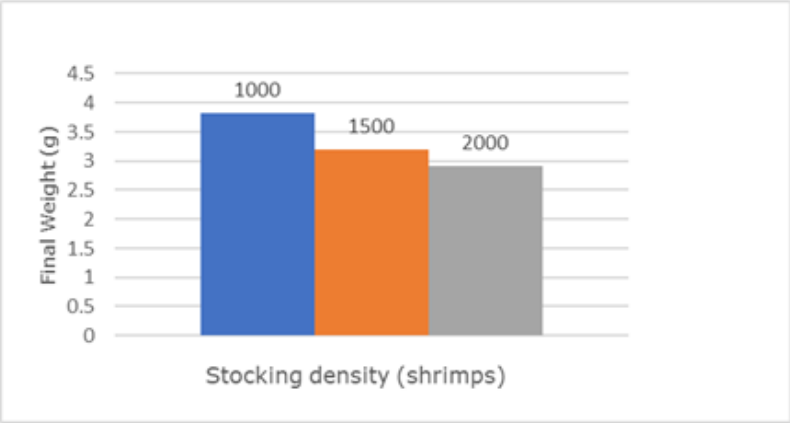

Figure 3. Final weight of *Litopenaeus vannamei* with different stocking densities, grown in dissemination plastic pond.

Water quality. The results of the water quality parameters analysis (salinity, dissolved oxygen and temperature) during the research showed that their values were still tolerated by *L. vannamei*, as shown in Table 2.

Table 2

The average value of water quality parameters of *Litopenaeus vannamei* with different stoking density of dissemination plastic pond

Parameter	*1,000 (ind m^{-3})*	*1,500 (ind m^{-3})*	*2,000 (ind m^{-3})*
Salinity (ppt)	19.16±1.36	19.03±1.07	19.32±1.42
Dissolved oxygen (mg L^{-1})	6.15±0.98	6.29±0.79	5.99±0.77
Temperature (°C)	24.4±2.97	24.52±1.07	25.23±1.01

During cultivation, the water quality parameters are changed frequently, although they did not differ significantly between treatments. Their values ranged for salinity between 19.03-19.32 ppt, for dissolved oxygen between 5.99-6.29 mg L^{-1} and for temperature value between 19.03-19.32°C

Discussion. Growing *L. vannamei* on narrow land can be carried out through the use of several aquaculture alternatives to increase shrimp growth (Hussain et al 2021). Some of these alternatives are: microalgae (Ju et al 2009), biofloc (Crab et al 2012; Ray et al 2010), prebiotics (Zhang et al 2021), and probiotics (Crab et al 2012). The dissemination plastic pond is a pond that uses the application of probiotics to increase the growth of Vannamei shrimp. Dissemination Plastic Ponds are available as a solution for breeders, especially shrimp farming, which is usually performed in soil or High Density Polyethylene (HDPE) ponds that have a sufficient surface area. Besides land for large ponds, the cultivation of vannamei shrimp usually requires very high capital and costs, so that small farmers find it difficult to become vannamei shrimp breeders. The dissemination plastic pond was created to answer all these problems. With the existence of a dissemination plastic pond, small breeders can conduct *L. vannamei* farming activities in a narrower area and with more affordable investment and operating costs.

The results of this research on *L. vannamei* culture in dissemination plastic ponds showed significant differences between low and high density populations ($P<0.05$, Table 1), which was demonstrated by measuring parameters such as growth rate, specific growth rate, survival rate and final weight. As mentioned in the Table 1, the density of 1,000 ind m^{-3} determines a higher final weight production than densities of 1,500 and 2,000 ind m^{-3}. In this study, it appears that a low stocking density causes a gain of weight and promotes the survival rate (Gamal et al 2018). In a treatment pond of 1,000 ind m^{-3}, the space for each shrimp is ideal, so that it can grow optimally. In addition, at this stocking density, the competition for feed is reduced, the contact between individuals can be minimized and the stress can be suppressed, optimizing the use of feed nutrients for shrimp growth. The weight growth of shrimp farmed with different stocking densities is strongly influenced by several factors that can inhibit the growth of shrimp. Several studies have shown that growth is influenced by environmental factors such as temperature and stocking density (Araneda et al 2020), feeding behavior (Bardera et al 2021) as well as stress, health and metabolism of *L. vannamei* (Zhang et al 2021). The water quality during the study showed that all values such as salinity, disolved oxygen and temperature were suitable for *L. vannamei* culture; these parameters do not often change when they are in normal limits (Boyd 1998).

The survival rate in the treatment of 1,000 ind m^{-3} had the highest value compared to the treatments of 1,500 and 2,000 ind m^{-3}. Density had an important role in the survival rate and growth of aquatic organisms (Araneda et al 2020), due to the very high rate of cannibalism of shrimp. Cannibalism in shrimp will appear when the shrimp molt. The molting shrimp becomes prey for other shrimps. This was because the molting shrimp gives off a specific aroma that stimulate the other shrimps's appetite. Freshly molted shrimp tend to limp as they lose a lot of energy during the molting process. In addition, the shell is still soft, making an easy prey for other shrimp. Moving at the pool's surface or with increased intensity and complexity of movements can minimize contact and cannibalism between shrimp during spawning. Several studies have shown that the survival rate of vananmei shrimp is influenced by diet (Herawati et al 2020), salinity (Jaffer et al 2020), artificial substrate and stocking density (Fleckenstein et al 2020).

Conclusions. The study concluded that *L. vannamei* culture using dissemination plastic ponds is an innovation in aquaculture activities, especially related to the use of limited space and low production costs. The *L. vannamei* culture in dissemination plastic ponds is effective with the best density of 1,000 shrimps. This density influence showed best result on GR, SGR, growth and SR. The GR value obtained was 0.0637 g day^{-1} , the SGR was 13.74854%, and SR was 86.1%. However, a higher density culltured in dissemination plastic ponds produced the lowest SR.

Acknowledgements. The authors would like to thank to all who have helped in the current research. This research is funded by Politeknik Kelautan dan Perikanan Pangandaran.

Conflict of interest. The authors declare no conflict of interest.

References

Araneda M., Eucario G. L., Miguel A. V., Roger D. M., 2020 Effect of temperature and stocking density on intensive culture of pacific white shrimp in freshwater. Journal of Thermal Biology 94:102756.

Astiyani, Wahyu P., Ega A. P., Muhammad A., Rani R. T., Guntur P., Dinno S., Miao, Sha, 2020 An economic analysis ecoshrimp white shrimp (*Litopenaeus vannamei*) concept on shrimp culture with plastic pond, Indonesia. Aquacultura Indonesiana 21:68-73.

Bardera G., Matthew A. G. O., Felipe N. F., Jose M. A. C., Mhairi E. A., Katherine A. S., 2021 The influence on of density and dominance on pacific white shrimp (*Litopenaeus vannamei*) feeding behaviour. Aquaculture 531:735949.

Boyd C. E., 1998 Water quality for pond aquaculture. Department of Fisheries and Applied Aquaculture, Auburn University, Alabama, 39 p.
Crab R., Defoirdt T., Bossier P., Verstraete W., 2012 Biofloc technology in aquaculture: beneficial effect and future challenges. Aquaculture 356-357:351-356.
Fleckenstein L. J., Nathan A. K., Thomas W. T., Jil C. F., Benjamin C. L., Andrew J., 2020 The effects of artificial substrate and stocking density on pacific white shrimp (*Litopenaeus vannamei*) performance and water quality dynamics in high tunnel-based biofloc systems. Aquacultural Engineering 90:93-102.
Gamal M., Samadan, Rustadi, Djumanto, Murwantoko, 2018 Production performance of whiteleg shrimp *Litopenaeus vannamei* at different stocking densities reared in sand ponds using plastic mulch. AACL Bioflux 11(4):1213-1221.
Herawati V. E., Piandoyo, Darmanto Y. S., Nurmanita R., Johannes H., Slamet B. P., Ocky K. R., 2020 Effect of feeding with *Phronima* sp. on growth, survival rate and nutrient value content of Pacific white shrimp *(Litopenaes vannamei*) post-larvae. Aquaculture 529:674-735.
Husssain A. S., Deyaaedin A. M., Wafaa S. S., Nahla M. S., Allen D., 2021 Effect of culturing the pacific white shrimp *Paneus vannamei* in "biofloc" vs "synbiotic" system on the growth and immune system. Aquaculture 542:736905.
Jaffer Y. D., Saraswathy R., Ishfaq M., Jose A., Bundela D. S., Sharma P. C., 2020 Effect of low salinity on the growth and survival of juvenile pacific white shrimp, *Penaeus vannamei*: A revival. Aquaculture 515:561734.
Ju Z. Y., Forster I. P., Dominy W. G., 2009 Effect of supplementing two species of marine algae or their fraction to a formulated diet on growth, survival and composition of shrimp (*Litopenaneus vannamei*). Aquaculture 292:243-273.
Muchtar M., Farkan, Mugi M., 2021 Productivity of Vannamei shrimp cultivation (*Litopenaeus vannamei*) in intensive ponds in Tegal City, Central Java Province. Journal of Aquaculture and Fish health 10:147-154.
Supono, 2021 Current status of technical and economic analysis of inland shrimp culture in Lampung Province, Indonesia. AACL Bioflux 14(1):218-226.
Rakhmanda A., Agung P., Parjiyo, Bobby I. G. W., 2021 Production performance of white shrimp *Litopenaeus vannamei* with super-intensive culture on different rearing densities. Jurnal Akuakultur Indoensia 20:56-64.
Ray A. J., Seaborn G., Leffler J. W., Wilde S. B., Lawson A., Browdy C. L., 2010 Characterization of microbial communities in minimal-exchange, intensive aquaculture system and the effects of suspended solids management. Aquaculture 310:130-138.
Zhang H., Miao L., Rui S., Jinjin Z., Rantao Z., Beiping T., Qinghui A., Kangsen M., Min W., 2021 The effects of different lipid sources on the growth, intestinal health, and lipid metabolism of the pacific white shrimp (*Litopenaeus vannamei*). Aquaculture 548:655-737.
Zonneveld N., Huisman E. A., Boon J. H., 1991 Principles of fish cultivation. PT Gramedia Pustaka Utama, Jakarta, 104 p.

Received: 19 April 2022. Accepted:12 August 2022. Published online: 26 August 2022.
Authors:
Wahyu Puji Astiyani, Politeknik Kelautan dan Perikanan Pangandaran, Department of Aquaculture, Pangandaran 46396, Indonesia, e-mail: wahyupujiastiyani@gmail.com
Dinno Sudinno, Politeknik Kelautan dan Perikanan Pangandaran, Department of Aquaculture, Pangandaran 46396, Indonesia, e-mail: 16.dinno@gmail.com
Ega Aditya Prama, Politeknik Kelautan dan Perikanan Pangandaran, Department of Aquaculture, Pangandaran 46396, Indonesia, e-mail: ega.prama88@gmail.com
Muhammad Akbarurrasyid, Politeknik Kelautan dan Perikanan Pangandaran, Department of Aquaculture, Pangandaran 46396, Indonesia, e-mail: akbarurrasyid3@gmail.com

How to cite this article:
Astiyani W. P., Sudino D., Prama E. A., Akbarurrasyid M., 2022 Application of dissemination plastic ponds technology to *Litopenaeus vannamei* shrimp culture as a solution for aquaculture activities in narrow soil. AACL Bioflux 15(4):2152-2157.