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Original Paper

THE ROLE OF SEAWEEDS *Sargassum polycistum* AND *Gracilaria verrucosa* ON GROWTH PERFORMANCE AND BIOMASS PRODUCTION OF TIGER SHRIMP (*Penaeous Monodon Fabr*)

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ABSTRACT

Due to deterioration of shrimp farming environment, it is necessary to develop the technique of shrimp culture that environmentally friendly and sustainable. One of important technique to fulfill the need is integrated model with seaweeds. We investigated two different integrated model using different seaweeds species, Sargassum plagyophyllum and Gracilaria verrucosa. These two species seaweeds were cultured in tiger shrimp pond at density of 2 kg/m^3. Density of tiger shrimp was 50 juvenile /m^3. These experiments were conducted in 28 days. The shrimp productivity was evaluated from the rate of shrimp survival, final individual size, growth and biomass production. Seaweeds biomass production was also evaluated. Collected data was analyzed using one way ANOVA, continued by LSD test. Results indicated that the presence of both seaweeds tend to increase shrimp productivity, it was indicated by higher survival, individual size, growth rate and shrimp biomass production. The role of Gracilaria in increasing shrimp productivity was higher compared to Sargassum. It is recommended to use Gracilaria in integrated model with tiger shrimp.

Keywords: Tiger shrimp ; *sargassum* ; *gracilaria* ; integrated model.

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INTRODUCTION

Production of tiger shrimp in Indonesia has been decreasing due to environmental deterioration since the application of intensive farming for long period of time (Nurjana, *et al.*, 1994). As results, water quality is reduced sharply and mass mortality of 2 months old of shrimp is very common. According to Pudjianto and Ranoemihardjo (1994) this signal was started since year of 1990. It was particularly occurred in tambak that has been used for at least 4 years (Kokarkin, 1994). Martin (1998) stated that intensive shrimp farming has led to low water and sediment quality in the ponds. This was mainly caused by accumulation of unconsumed feed. According to Jones (1995) only 80% of feed is eaten by shrimp, while the rest of it was left unconsumed. Degradation of unconsumed feed will increase toxic chemical content such as ammonia and nitrite. The effluents, which consist of excess feeds and excretory products, can promote eutrophication and result in harmful algal blooms and anoxia conditions (Wu, 1995). Eventually, the survival and growth rate of shrimp was decreasing. To reduce the environmental impacts and maintain sustainability of shrimp farming, various methods have been introduced, such as integrating shrimp and seaweeds. The presence of these aquatic plants is expected to absorb excess nutrients. Several seaweeds species such as *Ulva, Porphyra* and *Gracilaria* have significant capability in reducing nutrient (Neori, *et al.*, 1996). Suharyanto (2008) have used *Gracilaria* to be integrated with *Portinus pelagicus*, *Litopenaeus vannamei* and also *Chanos chanos*. However, there is limited literature available to evaluate the effect of seaweeds species presence on shrimp performance, such as survival, growth rate and shrimp final production.

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MATERIALS AND METHODS

Materials and experimental design

Post larva tiger shrimp (30 days) at average size of 0.06g, were stocked into 1m x 1m x 1.2 m plastic enclosures. These all enclosure was placed in cement pond. The system used in this experiment consisted of twelve plastic enclosures. Three replicates of two treatments were set up in a completely randomized design. The first treatment, tiger shrimp was integrated with *Sargassum plagyophyllum*, whereas second treatment was integrated with *Gracilaria verrucosa*. Enclosures without seaweeds were served as controls. The tiger shrimp and seaweeds were stocked at densities of $50/m^3$ and 2 kg kg/m^3 respectively. The shrimp was fed according to standard method of raising procedure. The experiment was conducted for a period of 30 days. During the experiment, evaporation losses of water were compensated by the addition of fresh water to maintain the salinity level.

Analytical procedures

The shrimp size were measured and weighed weekly to obtain the data required to determine specific growth rates (SGR %) or weight gain (WG g) by using formulas:

SGR = 100 (Wt-W0)/t and WG= Wt – W0

Where: W0 = initial weight; Wt = weight at time t since the beginning.

The survival rate (SR) of the shrimp in each enclosure was also calculated using the formulas:
SR = Ntn x 100/Ni

where: Ntn: number of shrimp surviving at the time n;
Ni: number of shrimp at the beginning of the experiment

Statistical analysis

SPSS and Microsoft Excel were used for data analysis. LSD post hoc tests in
One way of ANOVA were used to determine any significant differences ($p \leq 0.05$) among treatment means.

RESULTS AND DISCUSSION

Survival rate of tiger shrimp:

In general, the range of the tiger shrimp survival rate in this experiment was between 62% to 96%. This range was relatively high compared to Bardach experiment (1972) which survival rate was only 60%. This was probably due to the shorter duration of experiment. Integrating with *Sargassum plagyophyllum* resulted in average level of survival rate was 84.66 ± 12.05%. It was slightly increased by 18.76% compared to non integrated tiger shrimp (controls). In controls, the shrimp survival rate was 71.33 ± 14.47 %.

Table 1. Growth performance of Tiger shrimp among Integrating Model

Survival rate, final shrimp sizes and biomass production			
Parameters	Integrated Model		
	Tiger Shrimp-*Sargassum*	Tiger shrimp-*Gracillaria*	Controls
Survival rate (%)	84.66 ± 12,05	88.66 ± 9.46	71.33 ± 14.47
Shrimp weight (g)	1.33 ± 0,15	1.66 ± 0.16	1.25 ± 0.23
Shrimp length (cm)	5.86 ± 0,10	6.15 ± 0.30	5.59 ± 0.48
Shrimp biomass production (kg/ha)	563.07 ± 94,85	740.17 ± 130.25	444.73 ± 115.87

Tiger shrimp that integrated with *Gracillaria verrucosa*, resulted in the highest of survival rate (88.66 ± 9.46). It was 24.3% higher than controls. Using LSD analyzes however, indicated no significant difference among treatments ($p > 0.05$). There was a tendency that the presence of seaweeds will be able to promote more survival rate of tiger shrimp.

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Further observation indicated that there was a strong correlation between shrimp survival rate with water clarity resulted by seaweeds persistence. The presence of seaweeds can also be used to maintain higher oxygen level in the water.

Mean individual size

After 30 days of experiment, mean individual weight of tiger shrimp was range between 1.02g to1.85g. The low shrimp weight was due to the short duration of experiments. In controls, tiger shrimp without seaweeds grow relatively lower, with average individual weight was 1.25g ± 0.23g, and length was 5.59 cm ± 0.48 cm . Integrating with *Sargssum plagyophyllum* produced tiger shrimp with mean individual weight was 1.33 ± 0.15 and length was 5.86 ± 0.10. This result was in similar to Mai *et al*., (2008), who reported that there was no significant differences in weight gain of western king prawn (*Penaeus latisulcatus*).The same trend also reported by Lombardi, *et al.*, (2006) when integrated culture of seaweed *Kappaphycusalvarezii*, with Pacific white prawn (*Litopenaeus vanamei*).

In controls, mean individual weight of shrimp was 1.25 ± 0.23g. Addition of seaweeds in general resulted in an increased of weight gain. When tiger shrimp was integrated with *Sargassum*, the average of final individual weight was 1.33g ± 0.15g. It was approximately 6.4% higher than controls. The average individual weight gain was resulted by addition of *Gracilaria*, (1.66g ± 0.16g). It was 32.8% higher compared to controls. Statistical analyzes indicated that there was no significant difference between integrated model ($p > 0.05$).

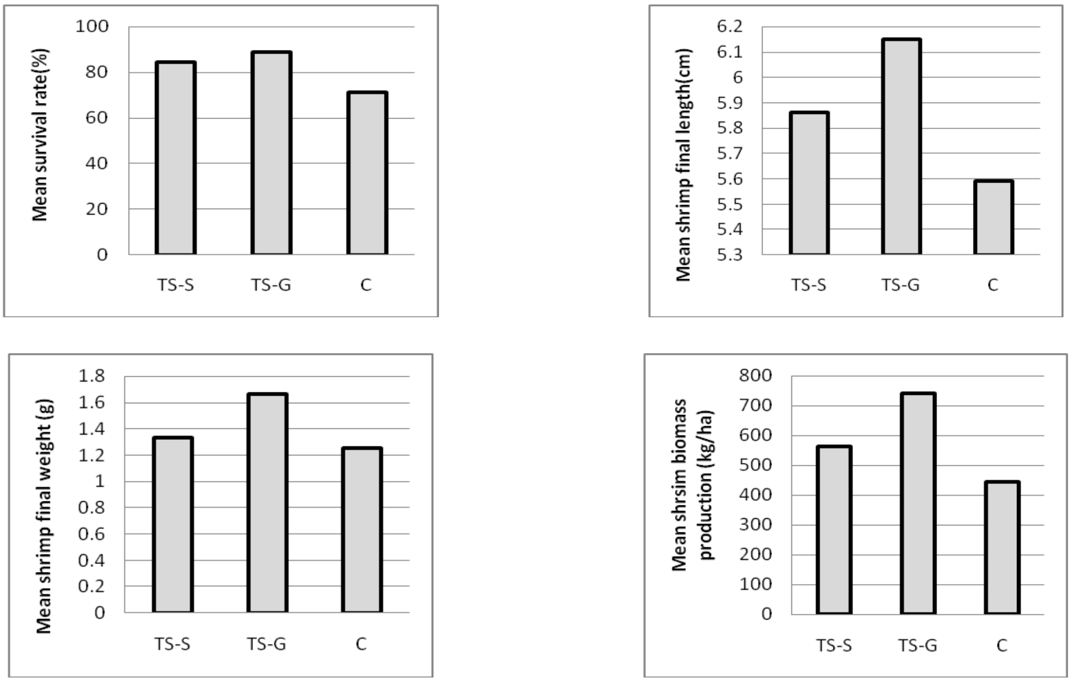

Fig. 1. Mean individual sizes of tiger shrimp in different integrated model after 30 days of experiments (TS-S: integrated model of tiger shrimp with Sargassum; TS-G: integrated model of tiger shrimp with Gracilaria; C: Control / tiger shrimp without seaweeds)

In controls, the average of individual shrimp length was 5.59cm ± 0.48cm. Integrated model with *Sargassum* resulted in average individual shrimp length was 5.86 ± 0.10. It was only 4.83% higher, whereas with *Gracilaria*, the shrimp length reached until 6.15 ± 0.30. It was 10% higher than controls. Statistical analyzes indicated no significant difference between integrated model ($p>0.05$).

Growth performance of tiger shrimp

Observation on shrimp growth performance between integrated model indicated that, in controls, mean individual weight at the age of 2

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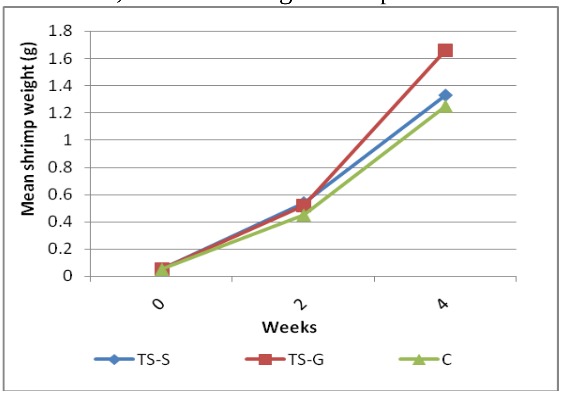
weeks was 0.45g. It was approximately 9 fold of initial weight. In the presence of *Sargassum* the average of individual weight at 2 weeks experiment was 10 fold of initial weight. If shrimp was integrated with *Gracilaria*, the individual weight was 12 time of initial weight. After 30 days of experiments (4 weeks), the average specific growth rate in controls was 11.06% per day, while in integrated with *Sargassum* was 11.77%. When tiger shrimp was integrated with *Gracilaria*, the specific growth rate was 11.85% per day. These results indicated that the presence of seaweed in general would increase the specific growth rate of tiger shrimp. *Gracilaria* was better in supporting the growth of tiger shrimp. This was probably because *Gracilaria* is the most efficient biofilter. This macoalga was capable in reducing excess of nutrient (Msuya and Neori , 2002). The excess of ammonia in the shrimp pond may the cause of lower shrimp growth rate. According to Troell *et al.*, (1999) the presence of *Gracilaria* increased the growth of fish by 40%.

Table 2. Growth performance of tiger shrimp in different integrated model

Integrated Model	**Mean Final Individual Shrimp Sizes weeks**					
	0		**2**		**4**	
	Weight ± SD (g)	Length ± SD (cm)	Weight ± SD (g)	Length ± SD (cm)	Weight ± SD (g)	Length ± SD (cm)
TS-S	0.05 ± 0,00	1.22 ± 0.00	0.50 ± 0.54	4.38 ± 0.39	1.33 ± 0.15	5.86 ± 0.10
TS-G	0.05 ± 0,00	1.22 ± 0.00	0.61 ± 0.08	4.49 ± 0.19	1.66 ± 0.16	6.15 ± 0.30
Controls	0.05 ± 0,00	1.22 ± 0.00	0.45 ± 0.11	4.33 ± 0.01	1.25 ± 0.23	5.59 ± 0.48

(TS-S: integrated model of tiger shrimp with *Sargassum*; TS-G: integrated model of tiger shrimp with *Gracilaria*; C: Control / tiger shrimp without seaweeds)



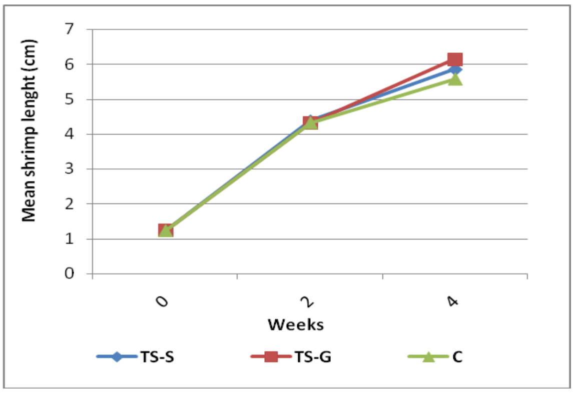


Fig 2. Growth performance of tiger shrimp in different integrated model after 30 days of experiments (TS-S: integrated model of tiger shrimp with *Sargassum*; TS-G: integrated model of tiger shrimp with *Gracilaria*; C: Control / tiger shrimp without seaweeds)

Shrimp and *seaweeds biomass production*

After 30 days of experiment (4 weeks), the specific growth rate observed from shrimp length in control was 1.92% per day, while in integrated with *Sargassum* was 2.25% per day. Integrated model with *Gracilaria* resulted in specific growth rate was 2.46% per day. This is indicated that with *Gracilaria* the growth of shrimp is the highest. Statistical analyzes however indicated no significant difference of shrimp weight and length between integrated model (p>0.05). It can be concluded that there is an indication that integrated model with seaweeds resulted in higher shrimp growth rate. Integrated with *Gracilaria* resulted in higher shrimp growth rate if compared to integrated model with *Sargassum*. This growth performance may caused by the higher growth rate of *Gracilaria* itself compared to *Sargassum*. If the growth of seaweeds was high, the role of seaweed in assisting to increase water quality was also high. It is well known that seaweeds has a good capability in increasing water quality (Neori, *et al.*, 1996).

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According to Abreu *et al.*, (2011), *Gracilaira* is the most efficient biofilter. to be used in ecological engineering application. The presence of *Gracilaria* can increase the growth of shrimp because this plant efficiently reduced nitrate in the water (Pretiwi, 2010). Beside that, the presence of *Gracilaria* also significantly reduce the content of phosphate, ammonia and ammonium in the water (Soriano *et al.*, 2009).

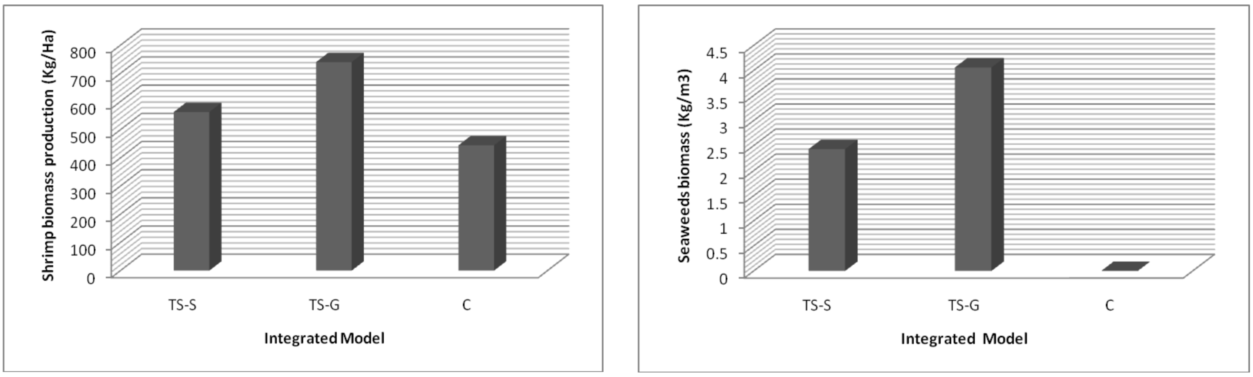

Fig. 3. Shrimp and seaweeds biomass production in different integrated model after 30 days of experiments (TS-S: integrated model of tiger shrimp with *Sargassum*; TS-G: integrated model of tiger shrimp with *Gracilaria*; C: Control / tiger shrimp without seaweeds)

Seaweeds biomass production

Mean *Sargassum* biomass production after 28 days was 2.43 ± 0.15, whereas *Gracilaria* biomass production was 4.06 ± 0.25. Biomass production of *Gracilaria* was 67% higher compared to *Sargassum*. Using t test statistical analyses indicated highly significant different of growth rate between *Sargassum* and *Gracilaria* ($p<0.05$). The growth rate of Sargassum was approximately 21.66 ± 0.54 per month, while *Gracilaria* was 103.33 ± 0.40 monthly. The growth rate of *Gracilaria* was 4.79 fold of Sargassum. This experiment indicated that there was a significant difference of growth rate between Sargassum and *Gracilaria*. According to Troell (1997), *Gracilaria* was seaweeds species that has a high growth rate compared to others. *Gracilaria* planted in farming water has growth rate of 7% per day or 210% a month.

The growth of *Gracilaria* in this experiment was lower compared to Troell (1997), it is probably due to lower sunlight that apparently will reduce the growth of *Gracilaria* (Troell, *et al.*, 1997). Besides that, the high growth rate of *Gracilaria* is also due to its high capability in absorbing nutrient such as nitrogen. According to Bird (1982), *Gracilaria* capable to sink nitrogen for 3-5%. Other seaweeds only sink nitrogen in average of 1-2%. *Gracllaria* also capable of nitrogen absorption during the dark (Neori, 1996). Besides that, *Gracllaria* also very tolerant to salinity changes. This seaweed can grow in salinity level of 15 ppt to 22 ppt. *Gracilaria* growth optimum in brackish water at salinity level (Luning, 1990).

CONCLUSIONS

Integrating *Sargassum sp.* into western king prawn culture can improve the water quality when compared to prawn monoculture systems. Although the results of this study showed that this integration had no significant effect on prawn growth, the addition of *Sargassum* did assist in the maintenance of optimum water quality and could thereby reduce the environmental impacts of the effluent on surrounding areas.

Integrating seaweeds into tiger shrimp culture resulted in much better water quality, shrimp final weight, length and production compared to shrimp monoculture systems. The addition of *Gracilaria verrucosa* can function more effectively in maintaining water quality and shrimp production compared to *Sargassum* sp.

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