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Effects of Stocking Biomass on Growth, Survival, and Production of the two Sizes of Clam *Meretrix lyrata* Cultured in the Intertidal Areas

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Abstract

The triplicate experiment had been conducted in 50 m² plots randomly placed in the intertidal areas to evaluate the effects of stocking biomass on survival, growth performance, and quality of clam *Meretrix lyrata*. The two stocking sizes (Mean $\pm$ SD, cm) at shell length of 1.0 ± 0.2 and 1.7 ± 0.1 were scattered at different biomass: 0.05, 0.1, 0.2, 0.3 kg.m⁻² and 0.34, 0.68, 1.36, 2.03 kg.m⁻² and named as T1, T2, T3, T4 and T5, T6, T7, T8, respectively. Results show that meat ratio of the clam were similar regardless of different stocking biomass. The fatty acids were rich in highly unsaturated fatty acids especially docosahexaenoic acid but were variable. In contrast, growth and survival of the clam were strongly affected by the stocking biomass in which the lower stocking biomass resulted in higher specific growth rate (SGR) and survival rate. The biomass gained therefore reduced accordingly with increase in the stocking biomass, although the increase of final production was evident. However, SGR and survival of the treatments T1, T2, and T3 were not significantly different, suggesting the highest net profit and investment return of the treatment T3. Therefore, the stocking biomass of 0.2 kg.m² was recommended to maximize profit of the clam cultivation.

Introduction

The mollusk production has been increasing steadily during the last two decades (Gibbs 2004) and has reached the total production of 13.25 mmt, which accounts for 23.3% of total world aquaculture production in 2004 (Tacon & Halwart 2006). Among mollusk species, the bivalve shellfish are not only the favorable seafood but also are regarded as the most ecologically efficient forms of aquaculture because these are low trophic-level animals. Besides, bivalve shellfish are filter feeders, which can also be used as biofilter for improvement of water quality (Shpigel & Blaylock 1991; Shpigel et al. 1993; Shpigel et al. 1997; Mazzola & Sara 2001) and thus contribute to the sustainable aquaculture development.

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Clams belong to bivalve shellfish but they are different from the others by dwelling on the bottom. Researches have been carried out on the production of various clam species (Shpigel & Spencer 1996; Cigarría & Fernandez 2000; Zhang & Yan 2006) and the use of clam for improvement of water quality (Shpigel & Fridman 1990; Jara-Jara et al. 1997). In Vietnam, the endogenous brackish water clam *Meretrix lyrata* (*M. lyrata*) is an emerging cultured species for coastal aquaculture because this is favorable seafood in the national and international markets. *M. lyrata* distributes naturally in the intertidal of southern coast and known as “Ngheu Ben Tre” because the exploited production mostly comes from Ben Tre province, south of Vietnam. Recently, due to high consumption demand, *M. lyrata* is being cultivated and expanded to the northern coastal provinces such as in Nam Dinh, Thanh Hoa, Nghe An, and Ha Tinh. However, the clam production still is very unstable and unpredictable due to poor management. The technical information on clam culture still is very limited. Therefore, it is necessary to study the establishment of a standard protocol to enhance the production and profit of clam culture.

Among the factors that affect growth and production, feed and feeding of clam have been regarded as the most important factors. Researches recently have revealed that feed clearance rate have positive relationship with body size, and within a range of food concentration, their feeding can be strongly affected by substrata (Zhuang & Wang 2004) and by salinity or diurnal rhythm (Zhuang 2006). For maximizing production and profit, Zhang & Yan (2006) described a new three-phase culture method for Manila clam farming in China. In this method, the seed was artificially produced indoor during winter and the grow-out phase was conducted in the intertidal with appropriate stocking size, stocking density, and substrate. In the intertidal areas where the feed are naturally dependent, uncontrollable, and variable, stocking biomass becomes an important factor to increase the growth and production. The objective of this research was to evaluate the effect of stocking biomass of the two sizes of *M. lyrata* on growth performance and survival to enhance the production and profit of cultivation. The other parameters within the culture system cannot be altered as it is a natural ecosystem highly connected to capture fisheries, which is one of the key industries for the fishery community.

Materials and Methods

The experiment had been conducted in the intertidal areas that belong to Hau Loc District, Thanh Hoa Province. There were 24 plots of 50 m² each, separated by plastic mesh and randomly allocated for eight treatments (three replicates each). The small clam seeds at shell length of 1.0 ± 0.2 cm were scattered at four different biomass: 0.05, 0.10, 0.20, and 0.30 kg.m⁻² and named as T1, T2, T3, and T4, respectively. The bigger size of clam seed at a shell length of 1.7 ± 0.1 cm was stocked at 4 different stocking biomass: 0.34, 0.68, 1.36, and 2.03 kg.m² and named as T5, T6, T7, and T8, respectively. This experiment was terminated after 165 days of rearing. Environment factors such as temperature (thermal meter), DO, pH (Oxyguard), turbidity (Secchi disk), and salinity

(Refractometer) of water in the experiment site were daily monitored at 3 designated points within the experimental area.

Growth of clam, expressed in mean of shell length (cm) and mean of live weight (g), was determined by random sampling ($n = 30$) and was measured every fortnight. The daily specific growth rate (SGR) was calculated using the following formula (Jara-Jara et al. 1997):

$$\text{SGR}(\%.\text{day}^{-1}) = 100 * (\text{Ln}W_f - \text{Ln}W_i) / t.$$

Where W_i and W_f are mean of initial weight and final weight, respectively, and t is number of experiment days. Size variation of the clam was evaluated according to Wang et al. (1998) in which the mean of three replicates of the coefficient of variation (CV) was used to examine the inter-individual variation among the clam in each treatment: $\text{CV}(\%) = 100 * \text{SD} / M$, where M is mean of live weight, and SD is standard deviation of the clam in each treatment. The meat ratio (% of meat weight: total live weight) of clam was conducted by separating the meat content of random samples ($n = 20$). The excess water was removed by placing the sample on tissue paper.

At the end of experiment, clam was randomly sampled and preserved in Liquid Nitrogen Biological Container (YDS-3, -196°C) for the analysis of fatty acids. The fatty acids content expressed in mg.g^{-1} dry weight was first extracted by placing the clam in a 35-mL glass tube with a teflon lined screw caps and 5 mL of methanol/toluene mixture (3:2 v/v) was added; then, 0.1 mL of internal standard solution containing 4.78 mg.mL^{-1} 20:2(n-6) fatty acid dissolved in iso-octane was added. The freshly prepared acetylchloride/methanol mixture (1:20 v/v) then was added as the esterification reagent. The tube was flushed with nitrogen gas and closed tightly before carefully shaking and was placed in a boiling water bath (100°C). After one hour, the tube was cooled, 5 mL of distilled water and 5 mL of hexane were added, and the upper layer was separated by centrifugation. The combined hexane phase was dried by filtration process carried out in a flask using the anhydrous sodium sulphate filter, and the FAMES were finally dissolved in 0.5 mL iso-octane and transferred in a 2-mL glass vial for injection in Finnigan Trace GC untra with capillary column BP-70 ($50\text{m} \times 0.32\text{mm} \times 0.25\mu\text{m}$). All data of the treatments were tested for significant differences ($p < 0.05$) using One-way ANOVA followed by Turkey test for multiple comparisons of means. The data are expressed as Average $\pm$ SD, and the statistical analysis was carried out using GraphPad Prism version 4.0 and Microsoft Office EXCEL for Window.

Results and Discussion

Environment conditions of the experiments

The experiment site situated the intertidal areas near the estuary where the clams

have been already cultivated for recent years. The environment factors such as DO, water temperature, pH, and salinity (Table 1) were regarded as the best conditions for clam development. The high levels of salinity fluctuation are typical for estuary ecological conditions. The average water temperature was $23.59 \pm 2.40^\circ\text{C}$, relatively low compared with the normal water temperature in the south of Vietnam, where *M. lyrata* is naturally distributed. This mean clam is not affected by the marked variation and good growth and survival rate were noticed. However, low water temperature might affect growth performance, and the growth and survival of *M. lyrata* might be not as high as the ones cultivated in the south of Vietnam. As Soudanta et al. (2004) has described, in the Manila clam cultured in four rearing sites that were selected for their varied ecological characteristics, it was observed that the environmental conditions influenced the physiological and immunological parameters.”

Table 1. Environment conditions in the experiment site

Parameters	DO (ppm)	Water temperature ($^\circ\text{C}$)	pH	Salinity (ppt)	Turbidity (cm)
Average $\pm$ SD	6.25 ± 0.42	23.59 ± 2.40		25.65 ± 2.84	9.05 ± 3.13
Maximum	7.66	31.00	8.99	31.00	20.00
Minimum	5.50	19.50	7.21	20.00	5.00

Growth performance

The growth performance of the two stocking sizes of *M. lyrata* at different stocking biomass expressed in specific growth rate, final shell length, and final live weight as well as size variation are shown in Tables 2 and 3.

Table 2. Growth performance of clam at stocking size of 1.0 cm

Treatments	T1	T2	T3	T4
SGR	1.25 ± 0.05^a	1.13 ± 0.05^a	1.08 ± 0.10^{ab}	0.94 ± 0.37^b
Final length (cm)	2.04 ± 0.13^a	2.01 ± 0.09^{ab}	1.95 ± 0.10^b	1.95 ± 0.11^b
Final weight (g)	5.92 ± 1.08^a	5.76 ± 0.81^{ab}	5.46 ± 0.76^{ab}	5.30 ± 0.85^b
% of meat:total weight	15.87 ± 1.00^a	15.48 ± 2.72^a	15.53 ± 1.02^a	15.15 ± 5.47^a
CV% (weight)	28.72 ± 2.55^a	23.07 ± 0.24^b	23.73 ± 1.55^b	27.78 ± 2.11^{ab}

Value (Mean $\pm$ SD) followed by different superscript letters within a row are significantly different ($P < 0.05$). T1, T2, T3, and T4 are treatments of clam cultured at 0.05, 0.1, 0.2, and 0.3 kg.m⁻², respectively. SGR = daily specific growth rate; CV = coefficient of variation

Table 3. Growth performance of clam at stocking size of 1.7 cm

Treatments	T5	T6	T7	T8
SGR	0.62 ± 0.04 ^a	0.46 ± 0.03 ^b	0.33 ± 0.02 ^c	0.32 ± 0.02 ^{cd}
Final length (mm)	2.36 ± 0.17 ^{ab}	2.40 ± 0.10	2.32 ± 0.11 ^{bc}	2.27 ± 0.10 ^c
Final weight (g)	9.24 ± 1.20 ^a	9.33 ± 0.95 ^a	8.90 ± 1.12 ^a	8.21 ± 1.01 ^b
% of meat:total weight	14.53 ± 1.89 ^a	15.78 ± 2.35 ^a	16.53 ± 0.62 ^a	15.48 ± 1.31 ^a
CV% (weight)	22.3 ± 0.45 ^a	19.05 ± 5.16 ^a	18.69 ± 3.36 ^a	22.73 ± 4.16 ^a

Value (Mean ± SD) followed by different superscript letters within a row are significantly different ($p < 0.05$). T5, T6, T7, and T8 are treatments of clam cultured at 0.34, 0.68, 1.36, and 2.06 kg.m⁻², respectively. SGR = daily specific growth rate; CV = coefficient of variation.

For the small-size group, there was no significant difference in specific growth rate and final weight among T1, T2, and T3 treatments (Table 2), indicating that growth of the clams were not affected by the stocking biomass below 0.2 kg.m⁻². The final size of *M. lyrata* was more variable at low (T1) and high (T4) stocking density compared with the medium (T2 and T3) ones. The meat yield expressed in percentage of meat per total weight, which is regarded as the most valuable part of the clams, was not significantly different ($p > 0.05$) in all treatments

The growth of *M. lyrata* at stocking size of 1.7 cm significantly reduced with an increase in the stocking biomass (Table 3). At high stocking biomass (T7 and T8), the SGRs were relatively low and were not significantly different. The final length and final weight of the treatment T8 were significantly smaller compared with others. However, the size variation was not affected by different stocking biomass.

In general, at younger stage, the animal has better growth rate. In the case of clam, at the same stocking biomass, the small-size clam (1.0 cm) grew much better than the large-size clam (1.7 cm). In the intertidal areas, the natural feed and environmental factors are uncontrollable and are dependent of nature. Dynamics of tide, wave, and current create the availability of algae, organic matter that is regarded as feed for clam. However, because clam is filter feeder and passively dwells on the bottom, the amount of biomass decreases beyond certain level and hence the natural feed might not be enough for its growth. Moreover, in treatments of the same size organisms, increasing biomass led to the increase in the competition of other environmental conditions such as habitat, DO, and increased accumulation of metabolic wastes, that is feces, which is regarded as a detriment for the growth of clam (Yan et al. 2006). It was also observed that at the same temperature, the clearance rate and ingestion rate of clam increased exponentially with an increase in the size (Zhuang and Wang, 2004). Results of the

growth performance (Table 3) indicated that at high stocking biomass (more than 0.3 kg.m⁻²), the growth could be inhibited, and the growth rate significantly reduced with an increase in the biomass. In addition, it was noted that winter is not an appropriate culture period because the water temperature is normally low and does not support the growth of *M. lyrata*, the tropical species.

Survival

The stocking biomass influenced the survival rate in both the sizes of clam. Survival was very high in the low stocking biomass treatment (T1) and was almost similar in the treatments T2 and T3. As seen in figure 1 the treatment T1 was significantly different ($p < 0.05$) from the treatment T4.

In the larger stocking groups, survival of the treatment T5 was highest followed by the treatment T6. Survival of the treatment T7 and treatment T8 were very low and were not significantly different (Fig 2). On the other hand, the results presented in figures 1 and 2 also indicate that the clam survival is not only affected by the stocking biomass but also affected by the stocking density. The environmental condition and food availability could be explained as the main reasons for the impact of the stocking biomass on survival rate.

Stocking size had been detected to affect survival of the Manila clam in which the small-size group showed higher mortality; however, substrata or predators are

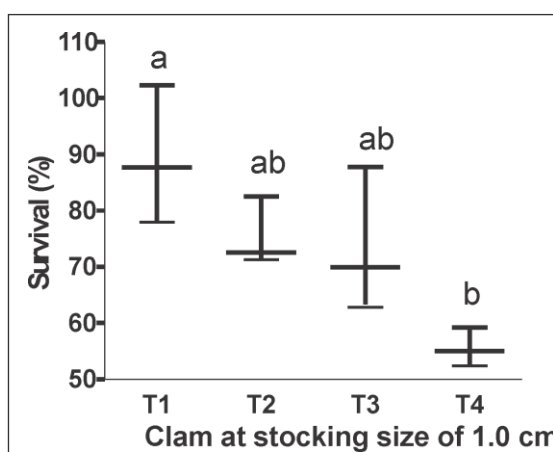


Figure 1. Survival of clam size 1.0 cm rearing at different stocking biomass. (Value (Average $\pm$ SD) followed by different superscript letters are significantly different ($p < 0.05$). T1, T2, T3, and T4 are treatments of clam cultured at 0.05, 0.1, 0.2, and 0.3 kg.m⁻², respectively).

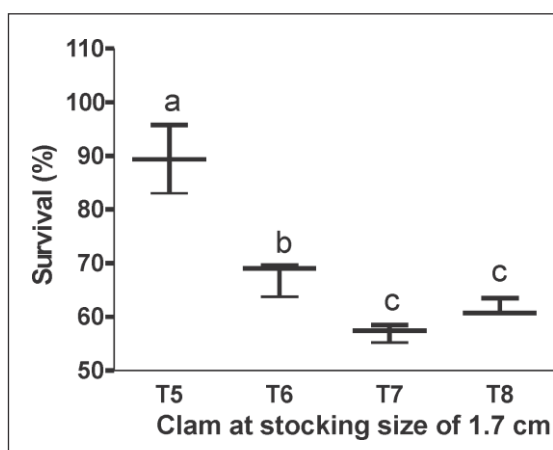


Figure 2. Survival of clam size 1.7 cm rearing at different stocking biomass. (Value (Average $\pm$ SD) followed by different superscript letters are significantly different ($P < 0.05$). T5, T6, T7 and T8 are treatments of clam size 1.7cm cultured at 0.34, 0.68, 1.36 and 2.06 kg.m⁻² respectively).

not the only reason for this high mortality rate (Cigarría & Fernandez 2000), and the normal stocking size of this species for intertidal cultivation was 1.0 cm (Zhang & Yan 2006). In our trial, at same stocking biomass (0.30 and 0.34 kg.m⁻²), survival rate of treatment T4 (1.0 cm) was very low (55%) compared with survival rate of 90% of the treatment T5 (1.7 cm). Within the same size 1.7 cm, the treatment T7 and T8 had relatively low survival rate compared with the treatment T5 and T6, suggesting that those stocking biomass were too high for the development of clam.

Production and quality

Both growth and survival was considered for the estimation of the production of clam. There was a positive relationship between the clam production and stocking biomass, although the growth and survival were negatively affected. Among the small stocking size group, the final production increased accordingly with the gain in biomass and no significant difference ($p > 0.05$) was detected between T1 and T2 and T3 and T4 (Table 4). The percentage of biomass gained, in contrast, showed a decreasing trend as the stocking biomass increased. No significant difference was detected between T1 and T4. This is due the fact that the increase in biomass negatively affected the growth and survival of the clams.

Table 4. Biomass production of clam at stocking size of 1.0 cm

Treatments	T1	T2	T3	T4
Final production (ton.ha ⁻¹)	4.14 ± 0.57 ^a	6.82 ± 0.56 ^a	12.62 ± 2.16 ^b	14.84 ± 0.91 ^b
Biomass gained (ton.ha ⁻¹)	3.62 ± 0.57 ^a	5.78 ± 0.56 ^a	10.54 ± 2.16 ^b	11.72 ± 0.91 ^b
% of biomass gained	697.1 ± 109.4 ^a	555.8 ± 53.6 ^{ab}	506.9 ± 104.0 ^{ab}	375.8 ± 29.3 ^b

Value (Mean ± SD) followed by different superscript letters within a row are significantly different ($p < 0.05$). T1, T2, T3, and T4 are treatments of clam cultured at 0.05, 0.1, 0.2, and 0.3 kg.m⁻², respectively

In the larger stocking size (1.7 cm), the final production of the clam significantly increased with an increase in the stocking biomass ($p < 0.05$). The percentage of biomass gained, in contrast, decreased with an increase in the stocking biomass in T5, T6, and T7 (Table 5). However, no significant difference ($p > 0.05$) was observed in the biomass gained in the treatment T5 and T6 and percentage of biomass gained in the treatments

T7 and T8. In both size groups, the increase in biomass certainly had a negative impact on the net production.

Table 5. Biomass production of clam at stocking size of 1.7 cm

Treatments	T5	T6	T7	T8
Final production (ton.ha ⁻¹)	9.49 ± 0.68 ^a	14.46 ± 0.69 ^b	23.58 ± 0.68 ^c	34.80 ± 1.00 ^d
Biomass gained (ton.ha ⁻¹)	6.10 ± 0.68 ^a	7.68 ± 0.69 ^a	10.02 ± 0.69 ^b	14.46 ± 0.99 ^c
% of biomass gained	180.0 ± 20.0 ^a	113.3 ± 10.1 ^b	73.9 ± 5.1 ^c	71.1 ± 4.8 ^c

Value (Mean ± SD) followed by different superscript letters within a row are significantly different ($p < 0.05$). T5, T6, T7, and T8 are treatments of clam cultured at 0.34, 0.68, 1.36, and 2.06 kg.m⁻², respectively.

The high value of percentage of biomass gained confirmed that the stocking biomass was barrier for the development of clam. However, the increase in the biomass gained as well as final production indicated that the determination of appropriate stocking biomass is important for the production of clam. The economic calculation therefore is vital to optimize investment benefit.

Fatty acid profile

There was difference in the fatty acid profiles between treatments regardless of different stocking biomass. The total FAME varies from 134.4 to 193.7 mg.g⁻¹ dry weight (Table 6). However, the presence of high content of HUFA especially DHA content (29.00 to 62.77 mg.g⁻¹ dry weight) indicated the value of clam as seafood product. The variation observed in the amount of fatty acids in clam may be attributed to the development of ovary and/or growing development stage when the fatty acids normally accumulate. Our result confirmed the variation in the amount of fatty acid of clam *Ruditapes decussatus* reared in sea water and effluent from a fish farm in Galicia (Jara-Jara et al. 1997). The variation in the amount of fatty acid and the factors affecting this variation need a further research.

Economic evaluation

The estimation of the economic benefit of clam cultured in the intertidal areas is shown in Table 7. The net profit is calculated based on the output cost, input cost, and price of the clam.

Table 6. Fatty acids of clam cultured at different stocking sizes and different stocking biomass

Fatty Acids	T1	T2	T3	T4	T5	T6	T7	T8
14:00	0.58	-	-	1.07	-	0.59	2.52	6.35
16:00	44.26	42.67	78.27	21.63	47.07	84.63	33.54	33.94
16:1(n-7)	9.85	-	3.53	7.88	-	0.75	10.94	11.71
17:00	0.19	-	-	0.89	-	-	1.94	1.22
17:1(n-7)	-	-	-	-	-	-	3.39	7.71
18:00	4.63	15.63	22	23.98	16.82	7.84	10.08	10.72
18:1(n-9)	63.02	39.79	26.83	29.68	49.38	33.41	27.18	31.94
18:1(n-7)	-	-	-	5.31	6.33	-	-	-
18:2(n-6)t	0.41	8.19	-	1.06	-	-	2.35	13.74
18:3(n-3)	-	-	-	0.54	-	-	1.1	5.16
20:1(n-9)	-	7.83	-	0.52	8.18	-	-	-
20:4(n-6)	1.11	-	7.72	2.98	5.06	2.72	3.54	8.9
20:4(n-3)	-	-	-	0.31	-	-	-	-
20:5(n-3)	4.45	3.11	-	5.95	6.2	0.97	7.96	3.29
24:00:00	-	-	-	1.17	-	-	-	-
22:5(n-6)	-	-	-	-	-	-	1.56	-
22:5(n-3)	-	3	4.96	1.85	-	-	2.46	-
22:6(n-3)	45.78	29	33.62	29.65	27.58	62.77	30.4	30.0
Sum (n-3)	50.23	35.11	38.58	37.76	33.78	63.74	40.82	30.29
Sum (n-6)	0.11	0	7.72	2.98	5.06	2.72	5.1	8.9
Sum HUFA	50.34	35.11	46.3	40.74	38.84	66.46	45.92	42.19
Total FAME	174.3	149.2	176.9	134.4	166.6	193.7	139	166.1

Value = mg.g⁻¹ dry weight; T1, T2, T3 and T4 are treatments of clam cultured at 0.05, 0.1, 0.2 and 0.3 kg.m⁻² respectively; T5, T6, T7 and T8 are treatments of clam size 1.7cm cultured at 0.34, 0.68, 1.36 and 2.06 kg.m⁻² respectively.

Table 7. Economical evaluation of the two stocking size of clam rearing at different stocking biomass

Stocking size	Shell length 1.0 cm				Shell length 1.7 cm			
Treatments	T1	T2	T3	T4	T5	T6	T7	T8
Stocking biomass (ton.ha ⁻¹)	0.50	1.00	2.00	3.00	3.40	6.80	13.60	20.40
Final production (ton.ha ⁻¹)	4.14	6.82	12.62	14.84	9.49	14.46	23.58	34.80
<i>Input (* mill VND.ha⁻¹)</i>								
Cost for seed (1)	17.50	35.00	70.00	105.00	61.20	122.40	244.80	367.20
Mesh and fencing	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
Labor cost	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20
Hut for daily monitoring	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Land lease	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Harvesting cost (B*2%)	0.99	1.64	3.03	3.56	2.28	3.47	5.66	8.35
Total input (A)	37.99	56.14	92.53	128.06	82.98	145.37	269.96	395.05
<i>Output (* mill VND.ha⁻¹ with assumption price of 12 mill VND.ton⁻¹ for all harvested clam)</i>								
Total output (B)	49.72	81.82	151.44	178.08	113.90	173.52	282.96	417.60
Net profit (A - B)	11.72	25.68	58.91	50.02	30.93	28.15	13.00	22.55
Rate of investment return (%)	30.85	45.75	63.67	39.06	37.27	19.36	4.82	5.71

(1) The seed cost was 0.035 mill VND.kg⁻¹ size 1.0 cm and 0.018 mill VND.kg⁻¹ size 1.7 cm

The main cost in *M. lyrata* cultivation was the expense in seed purchase. Cost of seed ranged between 46% and 81% in small-size seed (1.0 cm) for the four treatments (T1, T2, T3, and T4). As all other costs are fixed, the increase in stocking biomass increased the total cost invested. Although total production increased with the increase in stocking biomass, the economic analysis clearly indicated that the net profit decreased beyond the level of 2 ton.ha⁻¹ stocking biomass (T3). The treatment T4 with the stocking density of 3 ton.ha⁻¹ yielded lesser net profit compared with the treatment T3. This can be explained by the higher proportion of seed cost while the biomass gained was lower due to less growth and survival. Therefore, the stocking biomass of 2 ton.ha⁻¹ is recommended for *M. lyrata* at stocking size of 1.0 cm.

For the treatment T5, T6, T7, and T8, cost of seed increased from 73.8% to 92.9%. Because the price of seed was higher than the price of harvested clam, while the biomass gained reduced accordingly with increase in stocking biomass, the net profit was reduced and relatively lower compared with the 1-cm seed stocking treatments. We suggested that the clam size more than 1.7 cm should not be cultured at stocking biomass more than 6.8 ton.ha⁻¹.

Conclusions

The result of this experiment indicated that *M. lyrata* grow very well in the intertidal areas in north coast of Vietnam during winter at water temperature of $23.59 \pm 2.40^{\circ}\text{C}$. The stocking biomass had strong effect on growth performance and survival of clam. For the stocking seed at shell length of 1.7 cm, among 4 different stocking biomass 0.34, 0.68, 1.36, and 2.04 kg.m^{-2} , the higher biomass, the lower growth performance as well as the lower survival, which eventually resulted in reduction in the net profit even the final biomass were increasing. For the small seed at shell length of 1.0 cm, among stocking biomass of 0.05, 0.1, 0.2, and 0.3 kg.m^{-2} , the lower stocking biomass resulted in better growth performance. The survival rate of the stocking biomass of 0.3 kg.m^{-2} , however, was significantly lower than the others, and therefore, the highest net profit as well as investment return was obtained at the stocking biomass of 0.2 kg.m^{-2} . We recommend using this stocking biomass to maximize the profit of the cultivation.

Quality of the clam expressed as the meat ratio of clam was similar regardless of different stocking size or stocking biomass. In addition, the fatty acids of clam were rich in HUFAs especially DHA and EPA but also were showed differences between the treatments. This might be related to the natural feed availability or the different development stages of maturation; further research on this issue need to be addressed.

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