THE OPTIMAL RATIO OF NILE TILAPIA (*Oreochromis niloticus*) AND COMMON CARP (*Cyprinus carpio*) FOR IMPROVING PRODUCTIVITY ON DEEP WATER POND

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ABSTRACT

Pond productivity can be increased by applied polyculture system in the deep pond. The purpose of this experiment is to examine the optimal ratio between nile tilapia and common carp, in order to increase the productivity. Nine concrete tanks (15 m^2) with water depth of 2.2 m and were completed by water inlet, water outlet, and aeration. Both of nile tilapia and common carp with size ranging of 5-8 cm in total length were used. Stock density was 150 ind./m^2. The difference ratio of both fish tilapia and carp of fish stocked as a treatment. The fish ratio this experiment were as followed: A) 100%; B) 80%:20%; C) 60%:40%. Fish fed by pellet until at ad libitum. The duration of experiment was 100 days. Parameters such as survival, growth, and productivity were observed every ten days during the experiment period. Water quality parameters were also periodically observed. The results showed that survival of nile tilapia among the treatments were not significantly different ($P>0.05$) where survival of common carp at B treatment was better than C treatment ($P<0.05$). The highest of growth of absolute weight (94.86±2.85 g) and total length (14.71±1 cm) of nile tilapia at B treatment was found ($P<0.05$) where the best of growth of absolute weight (106.52±10.47 g) and total length (11.57±1.78 cm) of common carp was also found at B treatment ($P<0.05$). Biomass productivity at B treatment was the highest compared with A treatment ($P<0.05$). Combination between polyculture and the deep water pond technology could increase productivity. The polyculture system and the deep water pond technology would be able to keep constant water quality within in the threshold accordance with the regulation for fish culture.

KEYWORDS: polyculture, nile tilapia, common carp, deep water pond

INTRODUCTION

Nile tilapia (*Orechromis niloticus*) is one of the important freshwater fish in 21 century and being culturing since 100 countries, especially in Southeast Asia. Nile tilapia is national commodity and has high moderate economic value in Indonesia. On the other hand, common carp (*Cyprinus carpio*) has also an importance freshwater fish in Indonesia and other Asian countries such as China, India, Bangladesh, and Cambodia. Both of these fishes have been cultivated in almost area in Indonesia. The fish demand of nile tilapia and common carp has increased with increasing human population but the fish yield from culture has uncovered yet (FAO, 2007).

Some efforts have been made to fulfill the target production in order to meet of demand as protein source for human consumption. There are some technologies culture systems have been applied such as semi intensive and intensive culture. However, the fish production is still insufficient and it always under the target due to poor of water quality (Setiadi &

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Setijaningsih, 2011). Therefore, innovation technology to improve productivity and optimize in land utility should be done.

One solution of technology that can be applied is the combination between the intensive polyculture and the deep water pond technology. Polyculture technique can increase pond productivity and use worldwide (Khan *et al.*, 2009; Danaher *et al.*, 2007; Marceli *et al.*, 2002). Polyculture of nile tilapia and common carp in the deep water pond were applied in Thailand but the productivity was not satisfied due to poor of water quality during the culture period (Lin & Diana, 2000). However, intensive polyculture in the deep water pond has not been studied in detail. The combination between intensive polyculture and the deep water pond technology with the innovation of the design both of water inflow and outflow for the purpose to increase pond productivity, improving water quality, and optimize land utility are need to be studied and evaluate.

Using deep water pond on freshwater fish culture shows very effective in term of increase pond productivity and land utility because fish production is higher than that of shallow water pond. Stocking density of nile tilapia in intensive culture is only 50-75 ind./m^2 in the shallow water pond (Carman & Sucipto, 2002) while in the deep water pond can be increased up to 150 ind./m^2 or equal to 150% (Taufik *et al.*, 2011). Stocking density of gouramy culture before using deep water pond was 200 kg of seeds (250-300 g in body weight per individual) and the production was 450 kg while stocking density increases up to 300 kg of seeds and the production was 800 kg (Agung, 2010). The deep water pond would be able to contribute more space than that of shallow water pond because the increasing water depth would lead to increase the water volume in the same area.

Intensive culture of nile tilapia in 1.5 m water depth, however, there is still remain the empty space at the bottom of water column because nile tilapia is one of the surface active fish (pelagic fish). Therefore, to utilize the bottom of water column, the intensive polyculture technique with the along with which species has an activity in the bottom pond is possible to be applied. Common carp is a bottom feeder (Wahab *et al.*, 2002). This species is suitable for culturing with nile tilapia in the polyculture system. The polyculture between nile tilapia and common carp is efficient in commercial food waste due to common carp will take the commercial food at the bottom of pond (Bocek, 1999). Polyculture system technique is fish culture containing two or more difference fish species in the same pond. This technique is emphasized to utilize the different ratio of stocking densities and water column for food efficiency, increase in productivity, and optimize in land use.

The objectives of this experiment are to examine the optimal ratio between nile tilapia and common carp to increase production and to evaluate the design construction of deep water pond in relation to water quality on intensive polyculture system, especially, in the area where activity of aquaculture having a problem in term of productivity with limitation of land factor.

MATERIAL AND METHOD

Nine concrete tanks (3 m wide x 5 m long x 2.2 m depth) were used. The design construction of deep water pond (Figure 1) was as

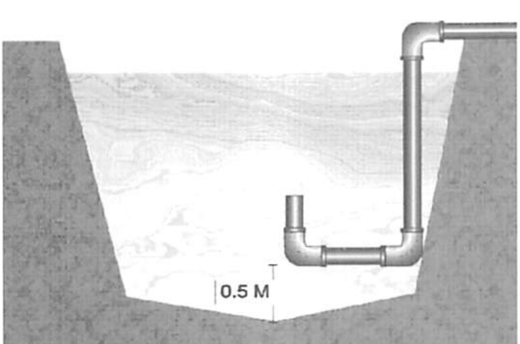

Figure 1. Water inlet on the deep pond (side view)

follow: at the bottom center was deeper and it was function as a bottom drain. From the center (bottom drain) of the pond bottom to the tip of edge of wall pond was made slightly rise with an angle of ± 20˚. The PVC pipe with 3 inch diameter was used as water inlet and it was in pairs upside down like "goose neck" with the tip of pipe placed at 0.5 m from the pond bottom.

Outflow water such as "monniek" system using PVC pipe with diameter of 3 inch was used and then it was covered by PVC pipe with diameter of 6 inch. Some of the holes at the bottom of PVC pipe with diameter of 6 inch were made (Figure 2). Four points of aeration with installed 0.5 m from the pond bottom were set up for each pond.

Nile tilapia and common carp with size ranging of 5-8 cm in total length (Figure 3) were used in this experiment. Stocking density at each pond was 150 individuals per m^3. The different of ratio between nile tilapia and common carp as a treatment in this experiment was as followed:

A. 100% of nile tilapia
B. 80% of nile tilapia and 20% of common carp
C. 60% of nile tilapia and 40% of common carp

Pellet as feed containing 28% protein was used as food the fish was fed once daily until satiation. The duration of experimental was three months. Parameters such as survival rate, absolute growth rate, daily growth rate, and productivity were observed. To measure the gain in term of total length and body weight, fish sample (10% of total population at each pond) was taken every ten days.

Statistical analysis using group randomize design with three replicates were performed. To determine the differences among the treatments, multiple comparisons using Duncan test were performed.

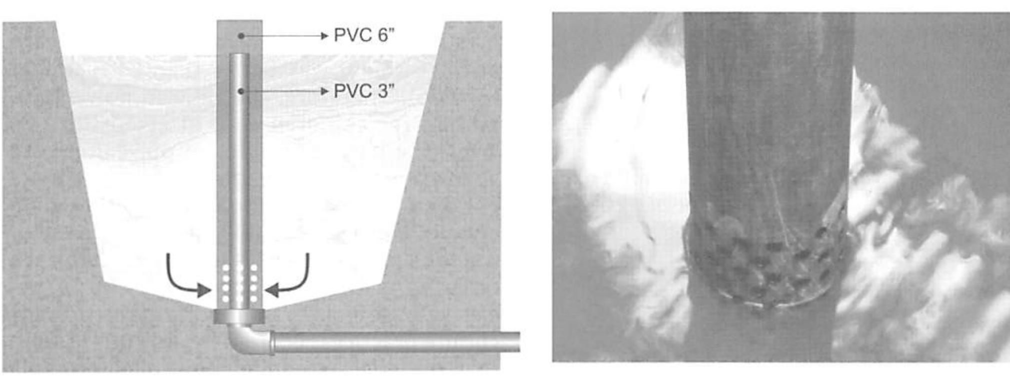

Figure 2. Water outlet of *monniek* system on the deep water pond (side view)

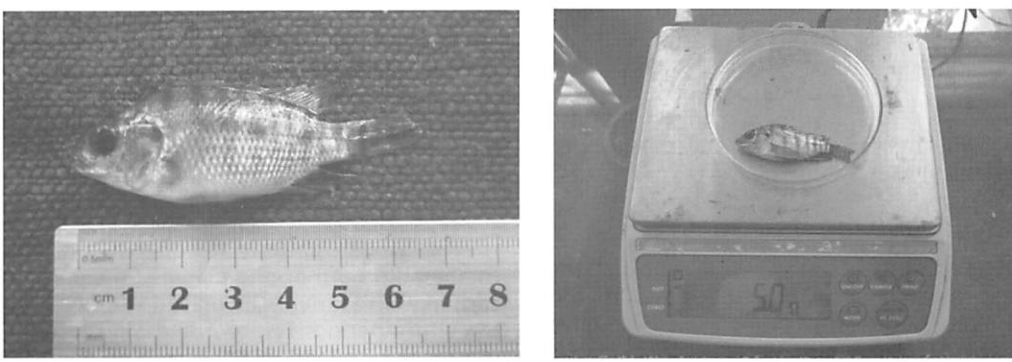

Figure 3. Average of length and weight of nile tilapia used at the beginning of the experiment

Survival rate is ratio between the number of fish at the end of experiment and the number of fish at the beginning of experiment which is expressed in the percentage.

Survival rate was calculated using the following formula (Solomon & Boro, 2010):

$$S = (Nt/No) \times 100\%$$

where:

S = survival rate
Nt = the number of fish at the end of the experiment
No = the number of fish at the beginning of the experiment

Specific growth rate was calculated using the following formula (Solomon & Boro, 2010):

$$G = (\ln Wt - \ln Wo)/\Delta t \times 100\%$$

where:

G = specific growth
Wt = weight of fish at the end of the experiment
Wo = weight of the fish at the beginning of the experiment
Δt = time

Biomass productivity was calculated using the following formula (Kumar *et al.*, 2005):

$$P = (Wt - Wo)/\Delta t$$

where:

P = productivity
Wt = weight of the biomass at the end of the experiment (Kg/day)
Wo = weight of the biomass at the beginning of the experiment (kg/day)
Δt = time

Water quality parameters such as temperature, pH, dissolved oxygen (DO), CO_2, ammonia (TAN), nitrite, alkalinity, and hardness during the experimental period were periodically analyzed.

RESULTS AND DISCUSSION

Carman & Sucipto (2009) reported that deep water pond made either by earthen or concrete ponds which constructed the range of 1.5-2.0 m in depth. The advantages of deep water pond are more space in the water column and keep stability of water temperature compare to shallow pond. Moreover, deep water pond technology is adopted from net cage culture system.

Survival Rate

Generally, the mortality of both nile tilapia and common carp occurred on seven days after stocking. The mortality occurred most probably caused by handling stress and adaptation in new environment. The clinical symptom such as very slowly swimming at the water surface, lesion on the tip of the fin, opaque eye, and the dark black fish color. Thereafter, fish became easy to be attacked by parasite or bacterial diseases and in the following day the fish would be died.

The survival rates of nile tilapia (Table 1) at all treatments were found more than 60%. Based on analyzed statistic, the different of ratio percentages of nile tilapia among the treatments revealed that no significantly different ($P>0.05$) in the survival rate. This indicated that the different ratio percentage between nile tilapia and common carp with stocking density of 150 individuals/m^3 was no effect on survival. The survival rate of common carp at B treatment was better than C treatment ($P<0.05$). Therefore, the ratio in polyculture system for common carp affected the survival. The basic principles of polyculture are species of different feeding habits which are cultured in the same pond to avoid feeding competition and best utilization of different of water column strata without any harm to each other's (Azad *et al.*, 2004). Therefore, species selection plays an important role for any culture practices. Bilard & Berni (2004) stated that the species composition of nile tilapia and common carps are suitable, because nile tilapia has feeding habit at the surface layer while common carp is usually at the bottom. Thus, we suspected that the different survival of common carp was due to is not suitable ratio. Similarly, stocking ratio affects the survival and growth performance of catfish and nile tilapia (Solomon & Boro, 2010; Ferdoushi & Haque, 2006; Kumar *et al.*, 2005).

Growth Rate

The growth pattern of body weight and total length both of nile tilapia and common carp at all treatments increased with leading to culture period (Figure 4 and 5). The high of growth of nile tilapia occurred on days 30 at B (80%:20%) and C (60%:40%) treatments were found while at A treatment was low.

Table 1. Survival rate of nile tilapia and common carp (%) at the end of the experiment

Treatments	Fish species	Initial number (ind.)	Final number (Ind.)	Survival (%)		
				Nile tilapia	Common carp	Biomass
A	Nile tilapia	2,250	1,488.00	66,13^a± 6.75		
	Common carp	-	-		-	
	Biomass	2,250	1,488.00			66,13^a
B	Nile tilapia	1,800	1,201.67	66,76^a±6.04		
	Common carp	450	335.67		74.59b±9.92	
	Biomass	2,250	1,537.34			68,34^a
C	Nile tilapia	1,350	876.67	64,94^a±2.84		
	Common carp	900	546.67		60,74b±2.56	
	Biomass	2,250	1,423.34			63,25^a

Remarks: The value in the same column followed the same superscript letter revealed not significantly different (P>0.05)

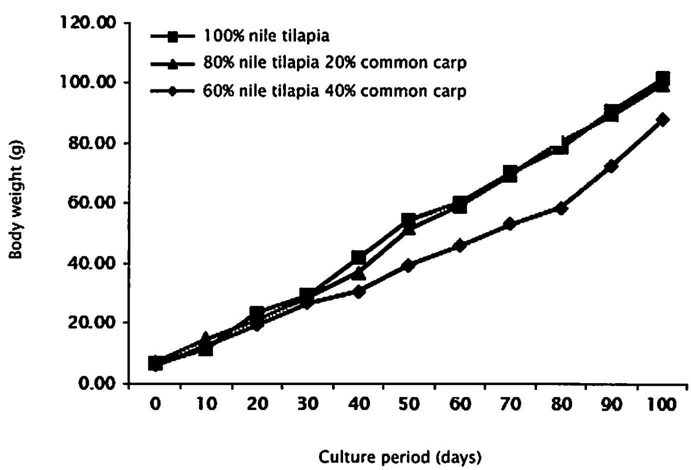

Figure 4. Growth body weight of nile tilapia at each treatment during culture period of 100 days

The growth pattern of total length and body weight of common carp cultured at B treatment (80%:20%) was higher than that of common carp cultured at C treatment (60%:40%). The growth pattern of total length of common carp at B teatment was high on days 50 where the growth of body weight was on days 70 but at C treatment was low and relaitve constant. (Figure 6 and 7). It can be stated that the B treatment (80%:20%) was better compared to the others in term of fish growth. We suspected that the differrence of growth of nile tilapia and common carp in polyculture systems might be related to ratio, tolerance in adaptation process, and behavior between them such as feeding habit and locomotion activities in relation to water column utility whether used by nile tilapia or common carp. Kumar *et al.* (2005) reported that the ratio between two species almost the equal in number would be easier to adapt and to utilize water column by fishes while the wide ratio is harder to interaction, adaptation process and water column utilize by fish resluts in fish need more energy for locomotion, thus, it affects growth. Shahin *et al.* (2011) stated that introducing stock addition of nile tilapia in the polyculture system affect the growth rate significantly. In contrats, the present result showed that even the ration at B treatment was bigger than C treatment but the growth was better. This may be due to synergistic of adaptation prosses between nile tilapia and common carp. Shrestha & Bhujel (1999) reported that the polyculture of nile tilapia and common carp (1:1) was the optimal ratio. Whereas, 5:1 stocking ratio was most suitable for fish growth (Yang *et al.*, 1990).

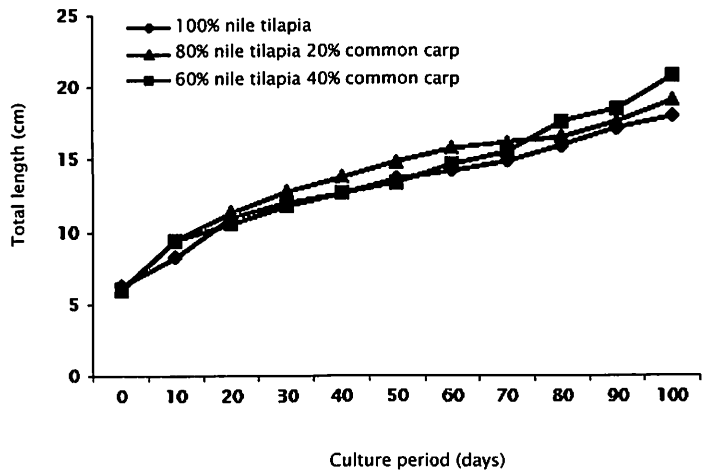

Figure 5. Growth total length of nile tilapia at each treatment during culture period of 100 days

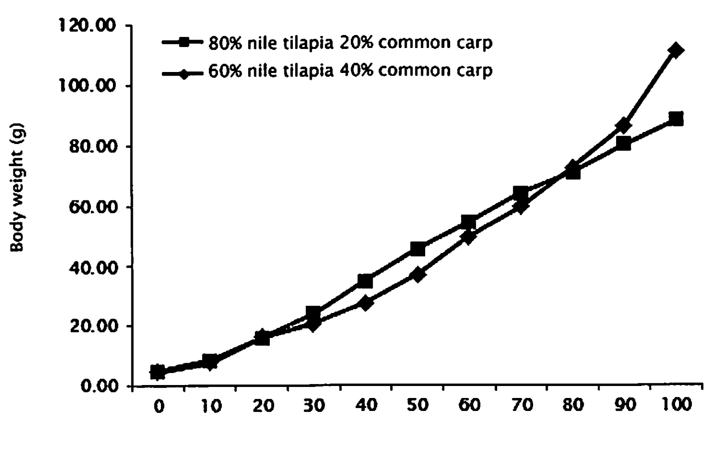

Figure 6. Growth body weight of common carp at each treatment during culture period of 100 days

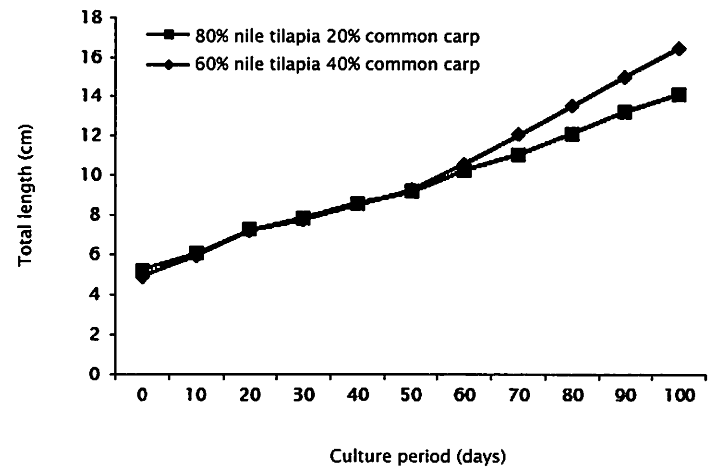

Figure 7. Growth total length of common carp at each treatment during culture period of 100 days

The absolute growth of body weight of nile tilapia (Table 2) at B treatment (94.86±2.85 g) was the highest, followed by C treatment (92.82±5.26 g) and A treatment (82.07±8.61 g). Absolute growth in total length of nile tilapia (Table 3) at B treatment (14.71±1.52 cm) was the highest compared to C treatment (13.17±0.60 cm) and A treatment (11.74±0.59 cm). Statistical analyses revealed that the absolute growth of body weight and total length at B treatment was better than the others ($P<0.05$). Thus, it can be stated that the ratio in polyculture system affects the fish growth. Survival and growth of fish are influenced by ratio and fish species on the polyculture system (Solomon & Boro, 2010; Chaudhary *et al.*, 2008).

Based on growth pattern of fish on policulture system at the present experiment was better than monoculture (Figure 4 and 5). The same result have been reported by Chaudary *et al.* (2008), fish culture in the polyculture system is higher compare to monoculture in term of growth. This condition might be due to food competition level is lower in polyculture compare to monoculture. In addition, one species might be as a triger to another species in relation to feeding activity. On the other hand, there is difference in specific space (water column) utility by one species to the others. According to the observation, when the fish fed by pellet have shown that the dominan fish at the water surface was nile tilapia while common carp position was under nile tilapia.

Table 2. The growth of nile tilapia and common carp with polyculture system on the deep water pond

Treatments	Absolute weight (g)		Absolute length (cm)	
	Nile tilapia	Common carp	Nile tilapia	Common carp
A	82.07±8.61^{A}	-	11.74±0.59^{a}	-
B	94.86±2.85^{B}	106.52±10.47^{A}	14.71±1.52^{b}	11.57±1.78^{a}
C	92.82±5.26A^{B}	83.32±6.37^{B}	13.17±0.60^{ab}	8.91± 2.21^{b}

Remarks: The value in the same column followed by the same superscript letter revealed not significantly different ($P>0.05$)

This condition is very important in polyculture because such condition might be correlated with food efficiency and competition, thus, uneaten food or food that throughout of nile tilapia to pond bottom could be utilized by common carp. Wahab *et al.* (2002) reported that common carp is fish species as a bottom feeder while nile tilapia have feeding habit and behavior activities is more concentrate at the water surface (Marcel *et al.*, 2002). Bocek (1999) stated that stocking bottom feeding fish such as common carp prevents sinking foods from being wasted.

Productivity

Productivity of polyculture nile tilapia and common carp are presented in Table 3.

Productivity at the end of the experiment (Table 3) showed that at B treatment (1.45 kg/day) was the highest, followed by C treatment (1.22 kg/day), and A treatment (1.18 kg/day). Analyzed statistic revealed that biomass productivity at B treatment was better than the others ($P<0.05$).

Productivity at B treatment was higher than A treatment. It can be stated that the ratio of nile tilapia and common carp (80%:20%) is the optimal ratio. The present experiment suggested that the optimal ratio is related to water column utility, feeding activity, and locomotion of both fishes. This condition may be stimulated fish growth and survival. Base on the observation, even though the artificial food used sinking type but the respone of nile tilapia was still aggresive near the wáter surface layer where common carp would be able to feeding at the bottom or beneath of nile tilapia at the same time. Therefore, such condition would be advantaged in related to food efficiency. Polyculture system could increase the productivity (Anil *et al.*, 2010; Danaher *et al.*, 2007; Kumar *et al.*, 2005) and food efficiency (Solomon & Boro, 2010; Wahab *et al.*, 2002).

Water Quality Parameters in Relation to Design Construction of Deep Water Pond

Water quality is the main factor as an external factor which is very important on fish culture for survival and growth. This factor can be fluctuated and sometimes find extreme condition and easy to change in daily or season that affects aquatic life such as physiological process, behavior, resistance, growth and survival (Affandi & Tang, 2002).

Even if the range of water quality analysis values (Table 4) on each treatment is within the threshold but at B treatment showed better than A and C treatments. Thus, it can be stated that polyculture system with optimal ratio is not only increase on survival, growth, and productivity but it would be able to keep water quality. Therefore, we suggested that both of nile tilapia and common carp are suitable in term of feeding competition and utilization of water column. On the other hand, we suspected that this condition is also related to the design construction of deep water pond.

Table 3. Productivity of fish biomass (kg/day) at the end of the experiment

Treatments	Fish species	Initial of weight biomass (kg)	Final of weight biomass (kg)	Productivity (kg/day)
A	Nile tilapia	13.46	130.98	
	Common carp	-	-	-
	Biomass	13.46	130.98	1.18[a]
B	Nile tilapia	11.80	121.73	
	Common carp	2.12	37.04	
	Biomass	13.91	158.77	1.45[b]
C	Nile tilapia	9.44	87.49	
	Common carp	4.43	48.27	
	Biomass	13.86	135.76	1.22[ab]

Remarks: The value in the same column followed by the same superscript letter revealed not significantly different ($P>0.05$)

Table 4. The range of water quality value during the experimental period

Parameters	Unit	Treatments			Thresholds
		A	B	C	
Temperature	°C	24.8-27.0	25.4-26.9	25.0-27.3	25-30[1)]
pH	-	7.08-8.50	6.95-8.50	7.04-8.50	5.5-8.5[1)]
Dissolved oxygen	mg/L	2.26-5.68	2.36-4.91	2.30-4.95	> 2[1)]
TAN (ammonia)	mg/L	0.068-0.300	0.070-0.257	0.137-0.299	< 0.3[4)]
TNN (nitrite)	mg/L	0.002-0.025	0.001-0.011	0.003-0.010	< 1[1)]
Ortho-Phosphate	mg/L PO_4-P	0.026-0.110	0.029-0.389	0.066-0.409	
Alkalinity	mg/L $CaCO_3$	82.86-138.10	116.00-143.62	93.92-176.8	100-150[3)]
TOM	mg/L	17.70-135.68	19.59-101.12	14.54-97.96	
CO_2	mg/L	0.00-5.45	0.00-8.16	0.00-4.08	< 15[2)]
Nitrate	mg/L	0.81-2.31	0.48-1.35	0.87-1.63	< 90[5)]

Remarks: Sources [1)]Anonym (2009); [2)]Carman & Sucipto (2009); [3)]Wedermeyer (1996); [4)]Anonym (2004); [5)]EPA (1986)

The design construction of water inlet (Figure 1) and water outlet (Figure 2) showed that water turbulent occurred properly. Therefore, we assumed that there is no stratification of temperature and dissolved oxygen (DO) between surface and bottom layers. The design constructions (Figure 1 and 2) have also ability to eliminate uneaten feed and faeces that concentrate in the bottom is easy to wash out in the pond.

Water quality such as water temperature, pH, DO, nitrite, nitrate, TAN, alkalinity, total organic matter, phosphate, and CO_2 play an important role that affect survival, growth, and productivity of fish culture (Setiadi & Setijaningsih, 2011; Efendi, 2003).

Water temperature during the experiment at each treatment was relatively stable the value is ranging of 24.8°C-27.3°C. Anonym (2009) reported that the range of water temperature of 25°C-30°C are optimal conditions for nile tilapia and common carp culture. Suggested that deep water pond technology could be kept water temperature stable. Carman & Sucipto (2009) stated that fluctuation of water temperature due to change in the air temperature and sunlight penetration. Moreover, water has ability to keep temperature stable via heat content system that obtained from environment. This capability depends on water volume of a basin.

Ammonia is end product of protein metabolism. Ammonia exist in the natural water with different forms i.e., ionized (NH_4^+) and unionized (NH_3). Carman & Sucipto (2009) reported that ammonia toxicity is correlated with pH where pH value is high most of total amonia will change to un-ionized form that toxic for aquatic life. For instance, total unionized ammonia > 1% at pH 7, total unionized ammonia 5%-9% at pH 8, total unionized ammonia 30%-50% at pH 9, and total unionized ammonia 80%-90% at pH 10. However, ours result showed that the value of total unionized ammonia (TAN) at each treatment (Table 4) was under the maximum values for fish culture namely < 0.3 mg/L. The toxic of unionized ammonia for common carp was 0.95 mg/L (Abbas, 2006) while for nile tilapia was 1.009±0.02 mg/L for larvae and 7.40±0.01 mg/L for fingerlings (Benlu & Koksal, 2005). However, the result of the present study showed that the value of unionized ammonia during the experiment at all treatments (Table 4) were within the threshold for fish culture.

Alkalinity is sum of dissolved anions in the water with equal to $CaCO_3$. Anions involving H^+, CO_3^-, and OH^- while hardness measurement is cations of Ca^{2+} and Mg^{2+} with equal to $CaCO_3$ (Piper *et al.*, 1982 in Affandi & Tang, 2002). The main function of alkalinity is pH buffer. If the water had alkalinity value was high so the buffer capacity was very strong to keep the pH fluctuation. Optimal alkalinity for fish culture was ranged of 100-150 mg/L (Wedermeyer, 1996). Based on the alkalinity value (Table 4) could be stated that all alkainity at each treatment was proper for fish life.

Nitrite is more toxic compare to nitrate on fish (Voslarova *et al.*, 2008). Nitrate is not toxic to fish if the concentration under 90 mg/L (EPA, 1986). Shimura *et al.* (2004) reported that the nitrate concentration of 100 mg/L was toxic to fish and the mortality occured up to 60%. According to ours result (Table 4), both of nitrite and nitrate were still within the threshold for fish culture.

CONCLUSION

Based on the reslut of this experiment in order to maximize the productivity of polyculture system, the best ratio of nile tilapia and common carp in intensive polyculutre is 80%:20%. The design construction of deep water pond technology was able to keep water quality whitin the threshold for fish culture.

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