Polyculture in Deep Ponds

Interim Work Plan, Thailand Study 3

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Introduction

Fish ponds constructed in rain-fed areas of Northeast Thailand normally have a depth ranging from 2 to 3 meters. Those small ponds are filled with rain water during the wet season, and depth reduces gradually over the dry period. Small tropical ponds with a water depth greater than 1.5 m normally exhibit persistent thermal stratification (Szyper and Lin, 1990). Consequently, nutrient inputs from fertilization and regeneration to stimulate phytoplankton production probably accumulate in the hypolimnion. Stratification can also result in a severe oxygen deficit in the bottom water, especially in highly productive ponds systems. Because Nile tilapia is primarily a plankton feeder, its low efficiency in utilizing detrital material from the pond bottom often results in wasting resources for fish production. Addition of a large-sized bottom feeder such as the common carp to tilapia culture ponds may facilitate mixing of hypolimnetic water, nutrient upwelling, and increased fish production.

The objective of this experiment was to assess the effect of carp-tilapia polyculture on water quality and fish yield in deep, rain-fed ponds.

Materials and Methods

The experiment was conducted in twelve 800 m^2 ponds at the Department of Fisheries (DOF)-Udorn Thani Station, Thailand. Four experimental treatments conducted in triplicate were as follows:

- (T1) ponds stocked with Nile tilapia at 2 fish/m^2;
- (T2) ponds stocked with Nile tilapia at 2 fish/m^2 and common carp at a rate of 1000 carp/ha;
- (T3) ponds stocked with Nile tilapia at 2 fish/m^2 and common carp at 2000 carp/ha; and
- (T4) ponds stocked with Nile tilapia at 2 fish/m^2 and common carp at 3000 carp/ha.

All treatments were completely randomized. Sex-reversed, all-male Nile tilapia with an average weight of 4-5 g and common carp with an average weight of 450-500 g were stocked on August 2, 1995. All ponds were fertilized weekly with chicken manure at 250 (dry matter) kg/ha/week supplemented with urea and TSP to adjust the loading rate at 24 kg N/ha/week and 7 kg P/ha/week. At the beginning, ponds were filled up to a water level of 3 m, and then for the remaining period of the experiment, no water was added except through rainfall.

Fish growth was measured monthly by sampling 50 fish from each pond. Individual weight and length were taken. The chemical and physical conditions of pond water were also monitored according to standard CRSP protocols stated in Work Plan Seven. Fish were harvested on February 3, 1996, after 186 days of culture.

Table 1. Mean water quality paramenters of experimental period in different treatments.

Variables	T1	T2	T3	T4
DO (mg/l, 0600 h)	1.9 ± 0.3	2.0 ± 0.3	2.0 ± 0.2	2.2 ± 0.2
DO (mg/l, 1800 h)	5.8 ± 0.2	4.4 ± 0.6	5.2 ± 0.5	5.0 ± 0.5
Temperature Range (°C)	23.4 ± 33.2	23.3 ± 32.7	23.5 ± 33.2	23.7 ± 32.6
pH Range	8.2 ± 10.0	8.3 ± 9.9	7.9 ± 9.8	7.6 ± 9.8
Alkalinity (mg/l)	94.5 ± 8.1	113.9 ± 13.8	100.4 ± 8.2	116.4 ± 11.8
TAN (mg/l)	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.2	0.3 ± 0.1
NO_2-N (mg/l)	1.0 ± 0.3	1.4 ± 0.5	0.8 ± 0.2	0.7 ± 0.3
TKN (mg/l)	6.0 ± 2.2	6.1 ± 1.7	6.0 ± 2.1	4.6 ± 1.1
TP (mg/l)	1.1 ± 0.1	1.1 ± 0.1	2.1 ± 0.9	1.0 ± 0.1
SRP (mg/l)	0.7 ± 0.1	0.7 ± 0.1	0.7 ± 0.1	0.7 ± 0.1
Chlorophyll-*a* (µg/l)	294.6 ± 109.9	321.7 ± 137.0	214.9 ± 53.3	250.9 ± 72.1
TSS (mg/l)	54.6 ± 5.8	67.1 ± 6.8	65.3 ± 5.6	61.5 ± 7.2
TVS (mg/l)	27.98 ± 7.6	21.6 ± 2.1	24.3 ± 4.7	50.6 ± 26.8

Values are means ± S.E. (n = 3 for each treatment) for each pond's water quality.

One-way analysis of variance was used to sort out the effect of treatment on water quality and fish yield. Differences were considered significant at an alpha level of 0.05.

Results

Water Quality

Pond water temperature and dissolved oxygen (DO) concentration between surface and bottom water for the monthly data were not significantly different ($p > 0.05$) among the treatments. Among pond water quality parameters measured (Table 1), DO values in all treatments were most variable, ranging from 1.1-13.3 mg/l with occasional drops below 0.5 mg/l towards the end of the culture period in some ponds. The mean total alkalinity value in all treatments ranged between 94.5-116.4 mg/l $CaCO_3$ with a peak at the end of the culture period. Mean TKN and chlorophyll-*a* concentration in all the treatments showed increase towards the end of culture period (Figures 2 and 5).

Mean TAN in all treatments remained in the acceptable range (Table 1) and fluctuated throughout the experimental period with a decline towards the end of culture (Figure 1). Statistical analysis showed that there were no significant differences ($p > 0.05$) for TAN, TKN, TP and chlorophyll-*a* concentrations among the treatments. The results of the experiment showed that the introduction of common carp in polyculture with Nile tilapia did not significantly affect major water quality parameters.

Fish Production

Fish growth performance of Nile tilapia was not significantly different ($p > 0.05$) among monocultured and polycultured treatments (Table 2). The maximum mean final weight of tilapia ranged from 123.9 to 164.9 g/fish and of common carp from 301.0 to 422.5 g/fish, and they were not significantly different ($p > 0.05$) among treatments. Results of the experiment showed that in all polycultured treatments, common carp lost weight during the experimental period. The total net yields (Table 2) were also not significantly different ($p > 0.05$) among treatments. This shows that the introduction of common carp for polyculture with Nile tilapia could not increase the net biological yield when compared to the monoculture of tilapia.

Discussion

Rain-fed ponds are usually built deep to maintain the water level during dry season. In small tropical ponds with greater depth density stratification, oxygen depletion in the hypolimnion is more likely (Szyper and Lin, 1990; Szyper, 1995). Mechanical mixing or bioturbation of pond water are usually suggested to overcome the problems of stratification

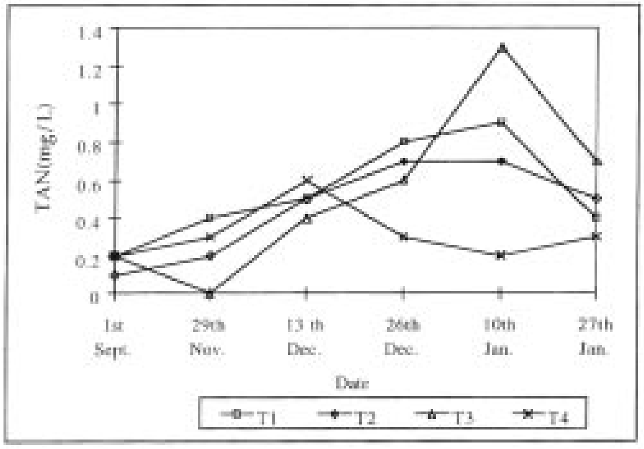

Figure 1. Mean total ammonia nitrogen (TAN) (mg/l) measured at different dates in different treatments.

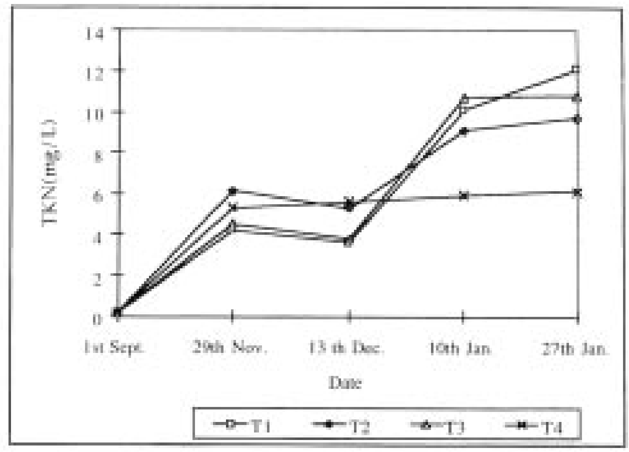

Figure 2. Mean total kjeldahl nitrogen (TKN) (mg/l) measured at different dates in different treatments.

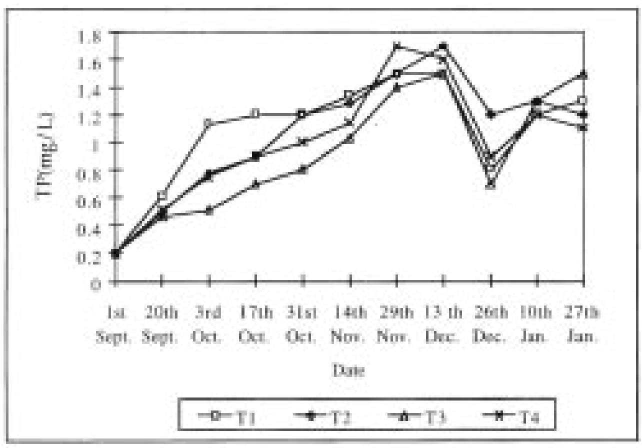

Figure 3. Mean total phosphorus (TP) (mg/l) measured at different dates in different treatments.

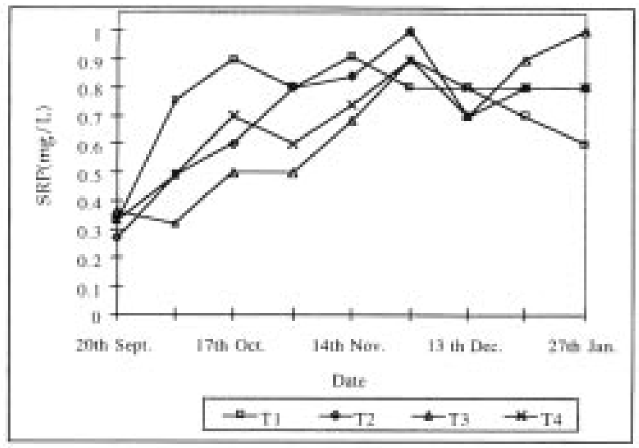

Figure 4. Mean soluble reactive phosphorus (SRP) (mg/l) measured at different dates in different treatments.

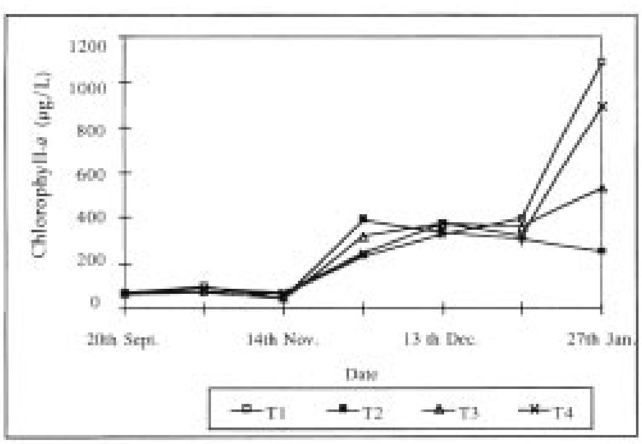

Figure 5. Mean chlorophyll-*a* concentration (µg/l) measured at different dates in different treatments.

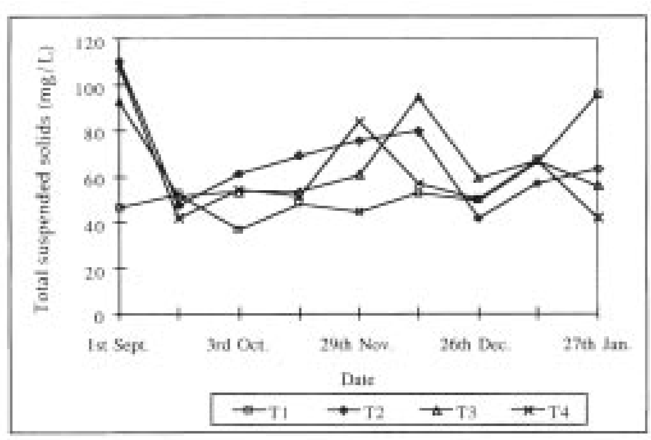

Figure 6. Mean total suspended solids (mg/l) measured at different dates in different treatments.

Table 2. Growth performance and net fish yield in different treatments.

Variable	T1	T2	T3	T4
STOCKING				
Tilapia				
Density (fish/m^2)	2	2	2	2
Total No.	1600	1600	1600	1600
Mean Weight (g/fish)	6.7 ± 0.0	4.6 ± 0.3	4.7 ± 0.2	4.4 ± 0.1
Total Weight (kg/pond)	10.7 ± 0.0	7.4 ± 0.5	7.5 ± 0.3	7.0 ± 0.2
Common Carp				
Density (fish/m^2)	0	1000	2000	3000
Total No.	0	80	160	240
Mean Weight (g/fish)	439.7 ± 8.8	-	461.7 ± 30.2	470.0 ± 22.9
Total Weight (kg/pond)	-	36.9 ± 2.4	75.2 ± 3.6	105.5 ± 2.2
HARVEST				
Tilapia				
Total No.	1433 ± 58	1444 ± 22	1142 ± 199	1536 ± 33
Survival	89.6 ± 3.6	90.3 ± 1.4	71.4 ± 12.4	96.0 ± 2.0
Mean Weight (g/fish)	140.4 ± 10.1	142.6 ± 9.4	148.3 ± 8.6	143.9 ± 15.9
Total Weight (kg/pond)	203.0 ± 5.8	214.3 ± 13.6	170.5 ± 44.4	214.7 ± 16.5
Common Carp				
Total No.	0	58 ± 18	124 ± 31	151 ± 57
Survival	-	75.1 ± 22.3	77.3 ± 19.6	63.1 ± 23.7
Mean Weight (g/fish)	330.3 ± 1.2	-	353.4 ± 35.6	326.4 ± 29.7
Total Weight (kg/pond)	-	20.8 ± 7.3	40.8 ± 11.6	51.6 ± 3.8
Net Yield (t/ha/crop) (Tilapia + Common Carp)	1.92 ± 0.73	2.41 ± 0.07	2.39 ± 0.23	1.61 ± 0.66
REPRODUCTION				
Tilapia				
Total No.	3215 ± 3208	0	50 ± 44	87 ± 69
Survival	72.4 ± 68.0	14.5 ± 9.9	-	19.6 ± 15.4
Mean Weight (g/fish)	32.7 ± 32.4	-	0.6 ± 0.4	3.2 ± 2.2
Common Carp				
Total No.	0	573 ± 164	106 ± 47	506 ± 41
Survival	23.5 ± 4.8	-	28.4 ± 9.5	24.2 ± 5.7
Mean Weight (g/fish)	-	14.5 ± 3.3	3.0 ± 1.4	11.5 ± 1.6

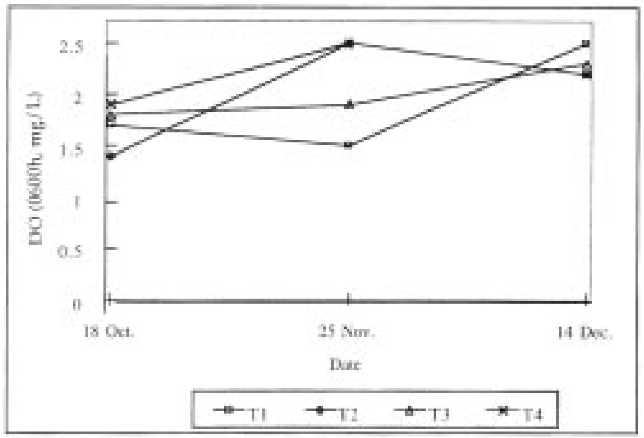

Figure 7. Mean dissolved oxygen (DO) concentration (mg/l) at 0600 h measured at different dates in different treatments.

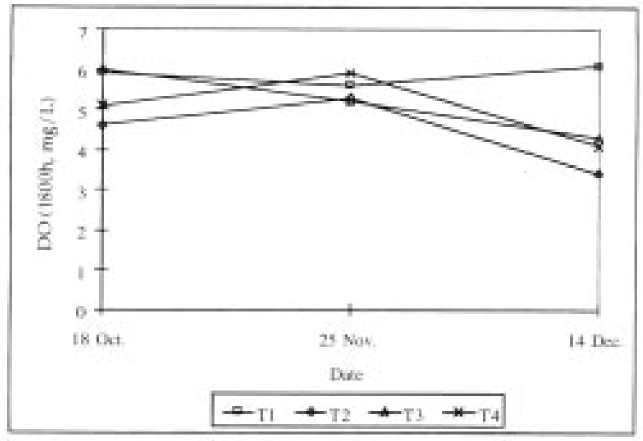

Figure 8. Mean dissolved oxygen (DO) concentration (mg/l) at 1800 h measured at different dates in different treatments.

in such types of pond. Moreover, fish such as common carp, which forage in bottom sediment for food, may facilitate mixing of hypolimnetic water and increase fish production utilizing under-utilized resources when cultured with plankton-feeding fish. However, experimental results did not show differences in net fish yield between the monoculture of Nile tilapia and polyculture with common carp in different densities. Results clearly showed that in all polycultured ponds, common carp lost weight during the experimental period. The loss of weight of common carp in deep ponds might have occurred due to an undesirable feeding environment. Common carp is a bottom-feeding fish and needs to forage in the pond sediment. Accumulation of organic matter in the bottom of deep ponds can lead to oxygen deficit and to the production of reduced substances, e.g., nitrite, ammonia, hydrogen sulfide, and methane (Boyd, 1992), which are toxic to benthic organisms (Clifford, 1992). Anaerobic conditions in pond bottoms are undesirable (Avnimelech and Zohar, 1986) because common carp may have to avoid their feeding ground, therefore resulting in an underfed condition and weight loss. The experiment could not monitor the DO differential between monoculture and polyculture of Nile tilapia with common carp as stated by Szyper (1995).

Acknowledgments

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