Effects Of Addition Of Tilapia And Periphyton Substrates On Water Quality And Abundance Of Plankton In Freshwater Prawn Culture Ponds.

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Abstract: The research investigated the effects of addition of tilapia and periphyton substrates on water quality and abundance of plankton in freshwater prawn culture ponds. The absence and presence (0 and 0.5 individual/m^2) of tilapia were investigated in 40m^2 ponds stocked with 3 prawn juveniles (5.023 ±0.04g)/m^2 with or without added substrates for periphyton development. A locally formulated and prepared pellet feed (2mm) containing 30% protein with C/N ratio close to 10 was used. The feed was applied at the rate of the 10% body weight and gradually decreased to 3% at the end of the culture period. Water quality parameters and the abundance of plankton and periphyton biomass were measured. The abundance of plankton and periphyton biomass was significantly higher in tilapia-free ponds comparing to tilapia added ponds. The addition of substrates did not influence size at harvest but improved the survival of prawn from 54.4 to 76.9%. Substrates contributed an increase in gross and net yield of prawn by 33% and 42.5%, respectively. Addition of tilapia and periphyton substrates benefited the freshwater prawn culture through reducing toxic inorganic nitrogenous compounds in water, enhancing the utilization of natural foods and improving survival, production and economic benefit.

Keywords: Freshwater prawn, Periphyton, Plankton, Tilapia, Water quality parameter

INTRODUCTION

Freshwater prawn farming is an important aquaculture industry in many Asian countries, which together contributes over 98% of the global freshwater prawn production. The increasing demand and steadily rising price in the international market caused a silent revolution in the development of freshwater prawn farming in Bangladesh (Asaduzzaman, 2005). Introducing different substrates for periphyton development (Uddin, 2007; Tidwell and Bratvold, 2005), in freshwater prawn ponds have been found promising. Besides substrate addition of stocking tilapia was suggested to reduce underutilization of natural foods (plankton, periphyton etc) observed in monoculture ponds (Asaduzzaman et al., 2008).

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Tilapia in such system depends on natural foods in the form of plankton (Perschbacher and Lorio, 1993), periphyton (Uddin, 2007) and microbial floc (Avnimelech, 2007) In addition, tilapia driven movements and resuspension increased the bottom dissolved O_2 availability leading to better mineralized and stimulating the natural food web (Jiménez Montealegre et al., 2002). The present research was aimed to investigate the effect of tilapia addition on prawn survival and production, pond ecology, and economic performance in presence and absence of substrates for periphyton development in freshwater prawn culture ponds. Special attention was given to the effects of addition of tilapia on water and sediment quality; abundance of plankton production and economic performances of such system.

Materials And Methods

The experiment was carried out for a period of 120 days from 20th February to 20th June, 2008 at the Fisheries Field Laboratory Complex, Bangladesh Agricultural University, Mymensingh. A pond (81m×8.9m) was drained completely and portioned by galvanized iron sheets into 18 small ponds (40m^2 each) of which 12 ponds were used for this experiment. An on-station trial was conducted with a 2×2 factorial design with the absence or presence (0 or 0.5 individual/m^2) of tilapia in monoculture of freshwater prawn (3 juveniles/m^2) as first factor, and with and without substrates addition for periphyton development as second factor. The treatments without periphyton substrates are referred to as 'T_0P_0' and '$T_{0.5}P_0$', while the treatments with periphyton substrates are referred to as 'T_0P' and '$T_{0.5}P$'.

Pond Preparation and Stocking

Before beginning the experiment, ponds were renovated and cleaned of aquatic vegetation. Quicklime (CaO) was applied to the pond bottom at the rate of 250kg/ha. All ponds were fertilized with semi-decomposed cattle manure, urea and triple super phosphate (TSP) at the rates of 3000, 100 and 100kg/ha, respectively. The shelter was built by bamboo kanchi with date tree leaves. About 436 bamboo branches (locally known as kanchi) with a mean diameter of

0.05m were kept vertically into the bottom mud of each pond, excluding a one meter wide perimeter water surface from the dike. Bamboo branches increased an additional area for periphyton development equivalent to about 60% (i.e. $24m^2$) of the pond surface area. The ponds were stocked with large size juveniles of prawn and tilapia having average weight of 5±0.4g and 24.3±0.24g respectively. A locally formulated and prepared pellet feed (2mm) containing 30% protein with C/N ratio close to 10 was used. The feed was applied initially at the rate of 10% body weight and gradually decreased to 3% of the body weight. The prawn and tilapia were sampled using a cast net to adjust the feeding rate.

Water quality monitoring

Water quality parameters such as temperature (°C), dissolved oxygen (mg/l), transparency (cm), were measured weekly, total alkalinity ((mg/l), phosphate-phosphorus (mg/l), nitrate-nitrogen(mg/l), nitrite-nitrogen (mg/l), ammonia-nitrogen (mg/l) and chlorophyll-a (μg/l) were measured monthly. Water temperature was recorded in the field with the help of a celsius thermometer. The transparency of water was measured by a Secchi disc of 20 cm diameter. pH of pond water was determined by a direct reading digital pH meter in the laboratory. The dissolved oxygen was measured by using a portable digital DO meter. Ammonia-nitrogen (TAN), Nitrate-nitrogen (NO_2-N), Nitrite-nitrogen (NO_3-N), Phosphate-phosphorous (PO_4-P) were determined by using HACH Kit. Chlorophyll-a was measured using filter papers and spectrophotometer at 664 and 750 nm wave lengths. The analyses of water quality parameters were done in the Water Quality and Pond Dynamics Laboratory, Dept. of Fisheries Management, BAU, Mymensingh.

Plankton Enumeration

Collection of plankton sample and preservation

Plankton samples were collected fortnightly from each pond. Ten liters of water sample was taken from different places and depths of the pond and passed through fine (25μ) mesh plankton net. Filtered samples were taken into a measuring cylinder and carefully made up to a standard volume of 50ml. Then the collected plankton samples were preserved in 5% buffered formalin in small plastic bottles for subsequent studies.

Qualitative and quantitative study of plankton

From each 50 ml preserved sample, 1 ml sub-sample was examined using a Sedge Wick-Rafter Cell (S-R Cell) and a binocular microscope (Olympus CH-40). One ml sub sample from each sample was transferred to the cell and then all planktonic organisms present in 10 squares of the cells chosen randomly were identified and counted. The quantitative estimation of plankton was done using the following formula for quantitative estimation:

$N=(P\times C\times 100)/L$

Where N is the number of plankton cells or units per liter of original water; P, the number of plankton counted in 10 fields; C, the volume of final concentrate of the sample (ml); L, the volume (l) of the pond water sample.

Growth Sampling of Prawn

Monthly sampling was done by using a cast net to observe the growth of prawn and to adjust the feeding rate. Growth of prawn in each sampling was measured by using a digital electronic balance.

Analysis of experimental growth data

Experimental data collected during the growth trial were used to determine the growth parameters as follows:

i) weight gain (g) = Mean final weight – Mean initial weight

ii) t weight gain (%) = [(Mean final weight – Mean initial weight)/ Mean initial weight]×100%

iii) ɘngth gain (cm) = Mean final length – Mean initial length

iv) e daily gain (g) = (Mean final prawn weight– Mean initial prawn weight)/ (T_2-T_1)

v) ꞇ growth rate (%/day) = $[(Log_eW_2 - Log_eW_1) / (T_2 - T_1)]\times 100\%$

Where, W_2= Final live body weight (g) at time T_2
W_1= Initial live body weight (g) at time T_1

After 120 days culture, adult freshwater prawn were harvested and counted for total number separately from each pond to evaluate the survival rate. After direct counting, weight and length of each individual prawn juvenile was also taken. Analysis of the data was done by using the software SPSS version 11.5 significance was assigned at 5% level.

Results

Water quality parameters

All water quality parameters were more or less within the acceptable range for freshwater prawn culture. Water quality parameters in different treatments have been presented in Tables 2 and 3

Physico-chemical parameters

Temperature (^{0}C)

The water temperatures of experimental ponds were found to vary from 27.7 to 34.9^{0}C and were found to be suitable. There was no significant difference (*P>0.05*) among the treatments when ANOVA was performed.

Transparency (cm)

Water transparency ranged from 17 to 74cm with the highest (74cm) and the lowest (17cm) in treatment $T_{0.5}P_0$ and T_0P_0, respectively and significant difference (*P>0.05*) were observed between the treatments (Table 2).

pH

The pH values ranged from 6.6 to 9.5 with the highest (9.5) and the lowest (6.6) in treatments T_0P and T_0P_0, respectively. There was no significant difference (*P>0.05*) among the different treatments when ANOVA was performed.

Surface dissolved oxygen (mg/l)

The values of surface dissolved oxygen (o_2) concentration in the treatments T_0P_0, T_0P, $T_{0.5}P_0$ and $T_{0.5}P$ were 5.37±0.06, 5.43±0.065, 5.38±0.06 and 5.39±0.06mg/l respectively. There was no significant difference (*P>0.05*) found among the treatments.

Bottom dissolved oxygen (mg/l)

The ranges of bottom dissolved oxygen concentration in different treatments T_0P_0, T_0P, $T_{0.5}P_0$ and $T_{0.5}P$ were from 1.20 to 3.91, 1.49 to 4.09, 1.68 to 4.14 and 1.58 to 4.21mg/l respectively. There was no significant difference (*P>0.05*) observed among the treatments.

Chemical parameters (Nutrients)

Nitrate-nitrogen (mg/l)

The nitrate-nitrogen (NO_3-N) concentrations ranged from 0.01 to 0.14mg/l. The highest (0.14mg/l) NO_3-N was found in treatment $T_{0.5}P_0$ when the lowest (0.01mg/l) was observed in the treatment T_0P, $T_{0.5}P_0$ and $T_{0.5}P$. ANOVA showed that there was no significant difference (*P>0.05*) among the treatments accept between T_0P_0 and T_0P.

Nitrite-nitrogen (mg/l)

The nitrite-nitrogen (NO_2-N) concentration ranged from 0.01 to 0.028mg/l with the mean values of 0.0105±0.0016, 0.0072±0.0015, 0.0098±0.0013 and 0.0055±0.0011 mg/l in the treatments T_0P_0, T_0P, $T_{0.5}P_0$ and $T_{0.5}P$ respectively. There was no significant difference among the treatments T_0P_0, T_0P, $T_{0.5}P_0$ and $T_{0.5}P$ when ANOVA was performed.

Total ammonia nitrogen (mg/l)

The total ammonium-nitrogen (TAN) concentrations in ponds ranged from 0.009 to 0.142mg/l. The highest (0.142 mg/l) NH_3-N was observed in treatment T_0P_0 and $T_{0.5}P_0$ and the lowest (0.009 mg/l) was observed in treatment $T_{0.5}P$. There was no significant difference (*P>0.05*) among the treatments when ANOVA was performed.

Phosphate-phosphorus (mg/l)

The overall phosphate-phosphorus (PO_4-P) concentration ranged from 0.28 to 5.16mg/l. The highest (5.16mg/l) and the lowest (0.24mg/l) values of PO_4-P were observed in treatments T_0P_0 and in both T_0P and $T_{0.5}P_0$. There was significant difference (*P>0.05*) among the treatments when ANOVA was performed.

Chlorophyll-a (µg/l)

The concentrations of chlorophyll-a in ponds under different treatments ranged from 13.09 to 288.34µg/l. The highest (288.34µg/l) and the lowest (13.09µg/l) chlorophyll-*a* concentration were recorded in treatments T_0P_0 and $T_{0.5}P$ respectively. Significant difference (*P>0.05*) were observed between treatments when ANOVA was performed.

Effects of addition of tilapia and periphyton substrates on water quality parameters

Water quality parameters and outcomes of ANOVA are presented in Table 4. Temperature and pH of the water were similar among the treatments. The addition of tilapia increased the bottom dissolved oxygen by 6.9% compared to the treatments without tilapia. Both the addition of tilapia and periphyton substrates increased the Secchi depth and decreased the chlorophyll-a concentration of water. The chlorophyll-a concentration was always lower in tilapia and periphyton substrates added ponds compared to tilapia and substrates free ponds during the culture periods. The mean values of NH_3-N, NO_2-N, NO_3-N and PO_4-P were decreased by the addition of periphyton substrates and tilapia.

Plankton populations

The abundance of plankton in water of the experimental ponds was enumerated and identified upto genus level. The plankton communities in pond water consisted of four groups of phytoplankton and two groups of zooplankton in all treatments. Forty five genera of phytoplankton belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae were found. Among the phytoplankton group, Chlorophyceae was the most dominant group and Euglenophyceae was the least abundant group. The highest abundance of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae was found in treatment T_0P_0 when the lowest in treatment $T_{0.5}P$ respectively. There were significant difference (*P>0.05*) in the treatments when ANOVA was performed. Ten genera of zooplankton, including five genera of Rotifera and five genera of Crustacea were also identified. The mean abundance (×10^3cells/l) of Rotifera were found 5.10, 3.97, 4.87,4.57 in treatments T_0P_0, T_0P, $T_{0.5}P_0$ and $T_{0.5}P$ respectively (Table 5). These values were not significantly different (*P*>0.05) among the treatments. Among Crustacea, *Diaptomus, Cyclops,* and nauplius were the most commonly found zooplankton. The highest abundance (5.5×10^3cells/l) of crustacea was found in treatment T_0P_0. These values were not significantly different (*P*>0.05) among the treatments. Mean abundance of phytoplankton and zooplankton with their different groups are shown in Table 5.

Effects of addition of periphyton substrates and tilapia on the abundance of plankton

Effects of addition of periphyton substrates and tilapia on the abundance of plankton are presented in Table 6. The addition of periphyton substrates and tilapia decreased the Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae phytoplankton group compared to the treatments without periphyton substrates and tilapia. Among zooplankton the addition of periphyton substrates decreased Rotifera but increased crustacea. On the other hand Crustacea decreased and Rotifera increased by the addition of tilapia.

Effects on growth and yield parameters of freshwater prawn and tilapia

Effects of addition of periphyton substrates and tilapia, and their interactions on yield parameters of freshwater prawn are given in Table 7. The addition of periphyton substrates increased survival of prawn by 41.4% compared to the treatment without substrates addition. The specific growth rate of prawn (SGR) was decreased by addition of substrates for periphyton development. Gross and net yield of prawn was higher in ponds provided with substrates than in ponds without substrates. On average, substrates contributed 33% higher gross yield and 42.5% higher net yield of freshwater prawn. The addition of tilapia decreased the gross and net yield of prawn by 11% and 14.1%, respectively. Both substrates and tilapia had significant effects on FCR of freshwater prawn. Substrates decreased FCR by 13.5% whereas tilapia increased it by 16.1%. Gross and net yields of prawn under different treatments are statistically significant (Table 7)

Discussion

Water quality parameters

In the present study, temperature was found to vary from 27.7 to 34.9°C in the ponds which were within the recommended suitable temperature range (21.9^0C–33.5^0C) for prawn culture (Fair and Foftner, 1981). Optimum temperature for prawn ranges from 27 to 31^0C (Sandifer *et al.,* 1983). Water transparency grossly indicates the presence or absence of natural food particles of fish as well as productivity of a waterbody. In the present study, the water transparencies were found to vary from 17 to 74cm which was more or less similar to the study of Ahsan *et al*. (2013) and Kohinoor (2000). Boyd (1982) suggested a transparency between15-40cm is good for fish culture. the pH were found to vary from 6.6 to 9.5 which were more or less similar to the findings of Boyd (2000) who reported that the ideal environment for nursing of prawn post-larvae should have pH values of 7-8.5. In the present study, the ranges of surface oxygen concentration in different ponds varied from 4.47 to 6.6mg/l and the bottom oxygen concentration varied from 1.20 to 4.21mg/l. Hossain *et al*. (2004) reported the dissolved oxygen content of 3.0 to 6.1 mg/l in earthen ponds in *M. rosenbergii* monoculture. The ranges of NO_3-N were found to vary from 0.12 to 0.03, 0.13 to 0.01, 0.14 to 0.01 and 0.12 to 0.01 mg/l in treatments T_0P_0, T_0P, $T_{0.5}P_0$, and $T_{0.5}P$ respectively, which are more or less similar to the finding of Asaduzzaman *et al*. (2005). The present study showed that the nitrite-nitrogen (NO_2-N) concentration ranged from 0.01 to 0.028mg/l. Nitrites at concentration of 1.8 mg/l have caused serious problems in hatcheries, but there is no definitive information as to the toxicity of nitrite in prawn nursery and growout periods of prawn (D'Abramo and Brunson, 1996). In the present study, the values of phosphate-phosphorous (mg/l) were found to vary from 1.24 to 5.16, 0.28 to 3.23, 0.28 to 3.12 and 0.29 to 4.23 mg/l. The findings more or less agree with the findings of Wahab *et al.* (1995) who found phosphate-phosphorus range from 0.09 to 5.2mg/l. Now a days, study of chlorophyll-a of any waterbody is widely used as an indicator of productivity instead of phytoplankton study. Ahmed (2005) found a negative relationship between chlorophyll-a and water transparency. Chlorophyll-a values ranged from 13.0 to 288.34µg/l in the study. The values of chlorophyll-a indicated that all ponds under three treatments were highly productive and suitable for fish culture. Rahman (2000) and Kohinoor (2000) have recorded more or less similar chlorophyll-a values.

Plankton production

Fish and crustacean culture depends largely upon natural foods. There is a highly positive correlation between the level of primary productivity and aquacultural production. The abundance of total phytoplankton and total zooplankton were from $31.5.0\times10^3$ to 241.0×10^3cells/l and from 2.5×10^3 to 14.5×10^3cells/l respectively which were higher than those observed by Kohinoor *et al.* (1998) who recorded from 22.50×10^3 to 27.83×10^3cells/l in case of phytoplankton population and from 5.20×10^3 to 6.34×10^3 cells/l in case of zooplankton population and Wahab *et al.* (1994) who recorded phytoplankton population ranging from 2.0×10^3 to 320×10^3cells/l which was more or less similar to that of the present study.

Effects on growth and yield parameters of freshwater prawn and tilapia

The highest net and gross yields of freshwater prawn were recorded in ponds provided with periphyton substrates. On average, substrates contributed an increase in gross and net yield of prawn by 33% and 42.5%, respectively. This increase in gross and net yield was mainly due to the increased survival since periphyton substrates did not have an effect on individual weight at harvest. Addition of substrates minimized territoriality of freshwater prawn, thereby, increasing survival (Asaduzzaman et al., 2008). It provides additional shelter and natural food in the form of periphyton colonized on bamboo *kanchi* substrates along with improvements of environmental conditions through a range of ecological and biological process (van Dam et al., 2002; Milstein et al., 2006). The net yield of freshwater prawn was significantly higher with no tilapia than with tilapia, indicating that inter-specific competition between tilapia and prawn decreased the net yield of prawn when tilapia was present. Although, Uddin (2007) reported that tilapia addition might affect prawn survival during molting but the similar survival revealed that addition of substrates might have minimized the territoriality effect of tilapia on prawns. The FCR calculated based on prawn biomass increased significantly with the addition of tilapia because part of the feed was eaten by the tilapia whereas, substrates decreased the FCR value by 13%. Uddin (2007) reported that FCR was 13% lower in fed-periphyton-based ponds compared to substrate free fed ponds. In case of tilapia, substrates addition increased the gross and net yield, indicating that substrates provide additional natural food (Uddin, 2007).

The economic analysis revealed that prawn-tilapia polyculture with stocking density 3 prawns and 0.5 tilapia/ m^2 in periphyton based system would be a very profitable business.

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REFERENCES

[1]. Ahsan, M.E., Wahab, M.A., Siddik, M.A.B., Alam, M.A., Sharker, M.R., and Nahar, A. Impacts of inclusion of column Feeder rohu (*Labeo rohita*) at different stocking densities growth, production and environment in freshwater prawn-carp-mola polyculture system. Internaional Journal of Biological Research;1(2):48-54.

[2]. Asaduzzaman, M., Wahab, M.A., Verdegem, M.C.J., Azim, M.E., Haque, S., Salam, M.A., 2008. C/N ratio control and substrate addition for

periphyton development jointly enhance freshwater prawn (*Macrobrachium rosenbergii*) production in ponds. Aquaculture 280: 117-123

[3]. Asaduzzaman, M. 2005. The potentials of organic farming of freshwater prawn (*Macrobrachium rosenbergii*) in Bangladesh. M.S. dissertation, Dept. of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 125 p.

[4]. Azim, M.E., Talukder, G.S., Wahab, M.A., and Haque, M.M. 1995. Effect of liming and maintenance of total hardness levels on fish production in fertilized ponds. Progress. Agril., 6(2): 7-14.

[5]. Avnimelech,Y. 2007. Feeding with microbial flocs by tilapia inminimal discharge bio-flocs technology ponds. Aquaculture 264, 140–147.

[6]. Boyd, C.E. 1982. Water quality management for pond fish culture. Elsevier Sci. Publ. Co. Amsterdam-Oxford-New York. 318 p.

[7]. D'Abramo, L.R. and Brunson, M.W. 1996. Production of Freshwater prawn in ponds. Southern Regional Aquaculture Center (SARC), USA. Publication no. 484.

[8]. Fair, P.H. and Foftner, A.R. 1981. The role of formulated feeds on natural productivity in culture of the *Macrobrachium rosenbergii*. Aquaculture. 24: 233-243.

[9]. Hussain, M.G. 2004. Farming of tilapia: Breeding plans, mass seed production and aquaculture techniques. Momin offset press, Dhaka, Bangladesh. pp.149.

[10]. Jiménez-Montealegre, R., Verdegem, M., Zamora, J.E., Verreth, J., 2002. Organic matter sedimentation and resuspension in tilapia (*Oreochromis niloticus*) ponds during a production cycle. Aquacult. Eng. 26, 1-12.

[11]. Kohinoor, A.H.M. 2000. Development of culture technology of small indigenous fish- mola (*Amblypharyngodon mola*), punti (*Puntius sophore*) and chela (*Chela cachius*) with notes on some aspects of their biology. Ph.D. dissertation, Dept. of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 363 p.

[12]. Kohinoor, A.H.M., Islam, M.L. Wahab, M. A. and Thilsted S. H. 1998. Effect of mola (*Amblypharyngodon mola*) on the growth and production of carps in polyculture. Bangladesh J. Fish. Res., 2(2): 119-126.

[13]. Milstein, A., Ahmed, A.F. Masud, O.A. Kadir A. and Wahab, M.A. 2006. Effects of the filter feeder silver carp and the bottom feeders mrigal and common carp on small indigenous fish species (SIS) and pond ecology. Aquaculture, 258: 439-451.

[14]. Perschbacher, P.W. and. Lorio, W.J. 1993. Filtration rates of catfish pond phytoplankton by Nile tilapia *Oreochromis niloticus* Journal World Aquaculture Society 24(3):434- 437.

[15]. Rahman, M.M. 2000. Effect of addition of calbaush (*Labeo calbasu*) in the periphyton based aquaculture system of rohu and catla. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 82 p.

[16]. Sandifer, P.A., Smith T.I.J., Jenkins W.W. and Stokes A.D. 1983. Seasonal culture of freshwater prawns in South Carolina. In: McVey, J.P. and J.R. Moore (eds), CRC Handbook of Mariculture, Vol.1: Crustacean Aquaculture, CRC Press, Boca Raton. pp. 189-204.

[17]. Tidwell, J.H., Bratvold, D. 2005. Utility of added substrates in shrimp culture. In: Azim, M.E., Verdegem, M.C.J., van Dam, A.A., Beveridge, M.C.M. (Eds.), Periphyton:Ecology, Exploitation and Management. CABI Publishing, Wallingford, UK, pp. 247-268.

[18]. Uddin, M.S., 2007. Mixed culture of tilapia (*Oreochromis niloticus*) and freshwater prawn (*Macrobrachium rosenbergii*) in periphyton-based ponds. Ph.D. Thesis. Fish Culture and Fisheries Group, Wageningen University, The Netherlands, 208 pp.

[19]. van Dam, A.A., Beveridge, M.C.M., Azim M.E., Verdegem, M.C.J., 2002. The potential of fish production based on periphyton. Rev. Fish Biol. Fish. 12, 1-31.

[20]. Wahab, M.A., Ahmed Z.F., Islam, M.A. and Rahmatullah, S. M. 1995. Effects of introduction of common carp, *Cyprinus carpio* on the pond ecology and growth of fish in polyculture, Aquacult. Res., 26(9); 619-628.

[21]. Wahab, M.A., Ahmed, Z.F. 1994. Compatibility of silver carp in polyculture of cyprinid fishes. Progress. Agric., 5(2): 221-227.

Table 1. Experimental design

Properties	Treatments			
	T_0P	T_0P_0	$T_{0.5}P$	$T_{0.5}P_0$
Prawn	120 nos. (3 juveniles/m^2)	120 nos. (3 juveniles/m^2)	120 nos. (3 juveniles/m^2)	120 nos. (3 juveniles/m^2)
Tilapia	Nil	Nil	20 nos. (0.5 individual/m^2)	20 nos. (0.5 individual/m^2)
Periphyton substrates	Present	Absent	Present	Absent

Table 2. Mean values of weekly water quality parameters of the ponds under different treatments.

Parameter (M±SE)	Treatment			
	T_0P_0	T_0P	$T_{0.5}P_0$	$T_{0.5}P$
Temperature (^{0}C)	30.79±0.27^a	30.69±0.23^a	30.68±0.25^a	30.76±0.24^a
Transparency (cm)	27.65±0.82^{b*}	27.15±0.55^b	42.80±1.48^a	43.69±1.26^a
pH	7.91±0.08^a	7.89±0.06^a	8.08±0.08^a	9.59±1.52^a
Surface-DO (mg/l)	5.37±0.06^a	5.43±0.06^a	5.38±0.06^a	5.39±0.06^a
Bottom-DO (mg/l)	2.84±0.09^a	2.90±0.09^a	3.13±0.09^a	3.13±0.09^a

(M±SE) = (Mean±Standard Error); *Mean values with different superscripts in the rows were significantly different (*P<0.05*)

Table 3. Mean values of monthly water quality parameters of the ponds under different treatments.

Parameter (M±SE)	Treatment			
	T_0P_0	T_0P	$T_{0.5}P_0$	$T_{0.5}P$
NH_3 –N (mg/l)	0.0613±0.0099^a	0.0396±0.0077^a	0.0563±0.0098^a	0.0368±0.0087^a
NO_2-N (mg/l)	0.0105±0.0016^a	0.0072±0.0015^a	0.0098±0.0013^a	0.0055±0.0011^a
NO_3-N (mg/l)	0.090±0.0069^{a*}	0.053±0.0087^b	0.060±0.0109^{ab}	0.0427±0.0081^b
PO_4-P (mg/l)	2.32±0.2428^a	1.36±0.2024^b	1.41±0.1779^b	1.19±0.2408^b
Chlorophyll-a (µg/l)	187.096±12.48^a	156.40±11.88^{ab}	118.96±12.29^{bc}	86.89±10.19^c

(M±SE) = (Mean±Standard Error); *Mean values with different superscripts in the rows were significantly different (*P<0.05*)

Table 4. Effects of addition of tilapia and periphyton substrates on water quality parameters per factor based on two-way ANOVA. P = periphyton substrates; T = tilapia addition; P×T = interaction of addition of periphyton substrates and tilapia.

Variables	Means (Tukey test)				ANOVA significance (*P* Value)		
	Periphyton substrate		Tilapia				
	With	Without	With	Without	P	T	P×T
Water quality parameters							
Temperature (°C)	30.7	30.7	30.7	30.7	NS	NS	NS
Surface DO (mg/l)	5.3	5.4	5.4	5.3	NS	NS	NS
Bottom DO (mg/l)	3.0	3.0	3.1^a	2.9^b	NS	**	NS
pH range	7.7-9.8	6.9-9.1	7.7-9.9	6.8-9.0	-	-	-
Transparency (cm)	38.7^a	35.2^b	44.2^a	29.7^b	**	***	NS
Total Alkalinity (mg/l)	141.5	146.7	145.9	142.2	NS	NS	NS
Chlorophyll-a (µg/l)	121.6^b	153.0^a	102.9^b	171.8^a	*	***	NS
NH_3-N (mg/l)	0.038^b	0.059^a	0.047	0.050	*	NS	NS
NO_2-N (mg/l)	0.006^b	0.010^a	0.008	0.009	*	NS	NS
NO_3-N (mg/l)	0.044^b	0.075^a	0.051	0.068	**	NS	NS
PO_4-P (mg/l)	1.27^b	1.87^a	1.30^b	1.84^a	**	*	NS

The mean values with no superscript letter in common per factor indicate significant difference at 0.05; * *P*<0.05; ** *P*<0.01; *** *P*<0.001; NS, not significant.

Table 5. Mean abundance of phytoplankton and zooplankton in pond water under different treatments.

Plankton Groups (M±SE)	Treatments			
	T_0P_0	T_0P	$T_{0.5}P_0$	$T_{0.5}P$
Plankton (×10^3cells/l)				
Bacillariophyceae	50.33±7.62^{a*}	35.97±5.90^{ab}	24.97±5.53^{b}	21.73±6.57^{b}
Chlorophyceae	89.20±6.23^{a}	59.73±4.45^{b}	43.00±4.13^{bc}	29.27±3.26^{c}
Cyanophyceae	15.33±1.88^{a}	11.67±1.57^{ab}	11.03±1.92^{ab}	8.03±0.99^{b}
Euglenophyceae	14.50±1.74^{a}	9.63±1.48^{ab}	8.50±1.15^{b}	6.47±0.81^{b}
Total phytoplankton	169.37±11.35^{a}	117.0±9.68^{b}	87.50±9.14^{bc}	65.50±7.92^{c}
Rotifera	5.10±0.87^{a}	3.97±0.65^{a}	4.87±0.63^{a}	4.57±0.95^{a}
Crustacea	1.77±0.36^{a}	1.83±0.27^{a}	1.70±0.41^{a}	1.80±0.23^{a}
Total zooplankton	6.87±0.90^{a}	5.80±0.72^{a}	6.57±0.65^{a}	6.37±0.98^{a}
Total plankton	176.23±11.31^{a}	122.80±9.79^{b}	94.07±9.08^{bc}	71.87±7.92^{c}

(M±SE) = (Mean±Standard Error);* Mean values with different superscripts were significantly different ($P< 0.05$).

Table 6. Effects of addition of periphyton substrates and tilapia on the abundance of plankton, per factor based on two-way ANOVA.

Variables	Means (Tukey test)				ANOVA significance (P Value)		
	Periphyton substrate		Tilapia				
	With	Without	With	Without	P	T	P×T
Plankton (×10^3cells/l)							
Bacillariophyceae	28.85	37.65	23.35^{b}	43.15^{a}	NS	**	NS
Chlorophyceae	44.50^{b}	66.10^{a}	36.13^{b}	74.47^{a}	***	***	NS
Cyanophyceae	9.85^{b}	13.18^{a}	9.53^{b}	13.5^{a}	*	*	NS
Euglenophyce	8.05^{b}	11.50^{a}	7.48^{b}	12.07^{a}	*	**	NS
Total phytoplankton	91.25^{b}	128.43^{a}	76.50^{b}	143.18^{a}	***	***	NS
Rotifera	4.27	4.98	4.72	4.53	NS	NS	NS
Crustacea	1.82	1.73	1.75	1.80	NS	NS	NS
Total zooplankton	6.08	6.72	6.46	6.33	NS	NS	NS
Total plankton	97.33^{b}	135.15^{a}	82.97^{b}	149.52^{a}	***	***	NS

The mean values with no superscript letter in common per factor indicate significant difference at 0.05; * P<0.05; ** P<0.01; *** P<0.001; NS, not significant.

Table 7. Effects of addition of periphyton substrates and tilapia on growth and yield parameters of freshwater prawn per factor based on two-way ANOVA.

Variables	Means (Tukey test)				ANOVA significance (P Value)		
	Periphyton substrate		Tilapia				
	with	Without	with	Without	P	T	P×T
Initial Stocking weight (g)	5.0	4.9	5.0	4.9	NS	NS	NS
Initial harvesting weight (g)	35.2	37.2	35.2	37.2	NS	NS	NS
Initial weight gain (g)	30.2	32.3	30.2	32.3	NS	NS	NS
SGR (%)	1.63^{b}	1.70^{a}	1.63	1.68	*	NS	NS
Food conversion ratio	2.05^{b}	2.37^{a}	2.38^{a}	2.05^{b}	**	**	NS
Survival rate (%)	76.9^{a}	54.4^{b}	63.6	67.8	***	NS	NS
Gross yield (kg/ha)	810^{a}	609^{b}	668^{b}	751^{a}	***	**	*
Net yield (kg/ha 120)	660^{a}	463^{b}	519^{b}	604^{a}	***	**	*

The mean values with no superscript letter in common per factor indicate significant difference at 0.05; * P<0.05; ** P<0.01; *** P<0.001; NS, not significant.