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Original article

Effects of C/N controlled periphyton based organic farming of freshwater prawn on water quality parameters and biotic factors

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Abstract

The effects of C:N controlled periphyton based organic farming of freshwater prawn on water quality parameters and biotic factors were investigated. The experiment had two treatments: T_1 and T_2 each with three replications. Stocking density was maintained at 20,000 juveniles ha^{-1}. In T_1, only commercially available prawn feed was applied and in T_2, a locally formulated and prepared feed containing 24% crude protein with C:N ratio close to 20 was used, and maize flour and bamboo side shoots were provided for maintaining C:N ratio 20. Mean values of water quality parameters did not vary significantly ($P>0.05$) between treatments. Periphytic biomass in terms of dry matter, ash free dry matter (AFDM) and chlorophyll *a* showed significant difference ($P<0.05$) among different sampling months. Individual harvesting weight, individual weight gain, specific growth rates, gross and net yields of prawn were significantly higher ($P<0.05$) in T_2 than T_1. Therefore, it was concluded that freshwater prawn might consume periphyton biomass in C:N controlled periphyton based organic farming practices resulted a significantly ($P<0.05$) higher production of freshwater prawn than traditional farming.

Keywords: Production, freshwater prawn, *Macrobrachium rosenbergii*, C:N ratio, periphyton, organic farming

INTRODUCTION

Freshwater prawn (*Macrobrachium rosenbergii)* is indigenous to South and South-East Asia, together with the northern Australia and the western Pacific islands (New 1988). It is an important aquaculture industry in many Asian countries, which together contributes over 98% of the global freshwater prawn production (Asaduzzaman *et al.* 2009a, 2009b). The global production of all freshwater prawn groups increased from 82,089 to 458,564 tons between 1998 and 2007 of which only freshwater prawn contributed to 48.23% (FAO 2009). In Bangladesh, freshwater prawn farming areas increased from just 2200 ha in 1991 to 7,82,559 ha in 2013 (DoF 2014). This species is very popular in Bangladesh for its attractive look, good taste and growth (Uddin 2007). The growing demand and steadily rising price in global markets, particularly in the USA, Europe and Japan, and high price in local market have caused a silent revolution of freshwater prawn farming in Bangladesh (Asaduzzaman *et al.* 2009a, 2009b). In 2012-2013, the total production of shrimp and prawn was 2,06,235 mt (DoF 2014). Therefore, it is playing a vital role in the national economy of Bangladesh, and its development has attracted substantial attention during the last two decades due to its high export potential (Ahmed 2010). On the other hand, shrimp farming is more vulnerable than that of prawn in view of coastal environmental degradation and disease outbreak like white spot disease which is not found in prawn. However, shrimp is still

contributing the major part of total export earning in the fisheries sector.

There is a great potential for further development of freshwater prawn farming in ponds and extensive low lying agricultural lands throughout the country. On average, yields from extensive ponds are in the range of 300-600 $kgha^{-1}year^{-1}$ (Asaduzzaman *et al*. 2006), which are very low compared to other neighboring prawn producing countries (Haque *et al.* 2013).

Operation of intensive aquaculture also demands high investment and technical expertise which are not affordable by resource-poor farmers of Bangladesh. Efforts are needed to intensify aquaculture by using the resources derived from other agricultural systems and manipulating natural food thereby maximizing overall nutrient retention (Azim and Little 2006).

Organic aquaculture is very much a work-in-progress and, for many reasons, an endeavor has marked by controversy. Members of both the organic and the aquaculture communities disagree on how, or even if, aquatic animal and plant production systems can qualify as "organic" as the term is commonly used. Moreover, many consumers can be confused or skeptical about organically labeled product due to conflicting or misleading standards around the world. However, it has an ambition and a special potential in relation to nature. It is based on holistic production management system which promotes and enhances health of agro-ecosystem including biodiversity, biological cycle and biological activity. The goals are to meet the use of cultural, biological and mechanical methods, as opposed to using synthetic materials and to fulfill specific functions within the system. Organic farming protects the health of consumers by reducing the overall exposure to toxic chemicals from pesticides that can accumulate in the ground, air, water and food supply. Various methods and complementary processes are being investigated for organic aquaculture, most notably Integrated Multi-Trophic Aquaculture (IMTA) and Aquaponics (a land-based outgrowth of aquaculture in many places). Prawn farming in an organic way may be an important option of moving towards the goal of sustainability. Organic prawn can contribute to increase export and domestic market earnings by supplying a particular market niche with a product perceived as high quality by environmentally aware consumers.

Introducing substrates for periphyton development (Uddin 2007, Tidewell and Bratvold 2005) and manipulation of C:N ratio (Crab *et al.* 2007, Avnimelech 2007) in freshwater finfish and prawn production in extensive ponds and combination of both C:N ratio and periphyton substrates in freshwater prawn and finfish (Asaduzzaman *et al*. 2008, 2009a, 2009b, 2010) in ponds as an approach of organic farming have showed great potential. These techniques require to setup of hard substrates and appliance of cheap carbohydrates, resources which could potentially be produced within the farmers' traditional agricultural systems. Significantly higher survival and growth of freshwater prawn were observed due to provision of substrates as compared to traditional production system having no substrates (Tidewell and Bratvold 2005, Uddin *et al.* 2006). In periphyton-based ponds, periphyton are used as additional natural food, substrate as shelter to minimize territorial effects and improved water quality through trapping suspended solids, organic matter breakdown and enhanced nitrification. On the other, prawn is fed with a specially formulated organic food which contains no drugs and has locally available low cost raw materials free from antibiotics and artificial chemicals and a high C:N ratio is maintained by using low cost maize flour. Production of heterotrophic single cell protein (bio-floc) by controlling microbial water quality through manipulation of C:N ratio are rapidly expanding in both active suspension ponds (ASP) and extensive ponds, especially in producing penaeid shrimp (Crab *et al.* 2007, Avnimelech 2007).

In view of the above facts, the present study has been undertaken to compare the performance of organic farming with the traditional farming of freshwater prawn in respect of water quality and biotic production of pond. The ultimate goal of this research is to increase the pond productivity and enhance the environmental and economic sustainability.

METHODOLOGY

Study area, period and pond facilities: The experiment was carried out at the pond facilities of the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh for a period of 90 days from September to November 2009. Six rectangular earthen ponds with an area of 130 m^2 and an average depth of 1.2 m each was used for this research. The ponds were rain-fed, well exposed to prevailing sunlight and being used for research over last 15 years.

Experimental design: The trial was conducted in a completely randomized design into two different treatments (T_1 and T_2) with three replications for each selected as randomly. Stocking density of prawn juvenile was same (20,000 ha^{-1}) in both treatments. The difference between two treatments was in the management practices. Feed for prawn was supplied in both treatments. In T_1, only commercially available prawn feed (30% protein) was applied and in T_2, a locally formulated

and prepared feed containing 24% crude protein with C:N ratio close to 20 was used and maize flour and bamboo side shoot were provided for maintaining C:N ratio 20 and developing periphyton, respectively.

Pond preparation: Before commencing the experiment, pond dikes and other parts were repaired properly using the excavated bottom soils and ponds were manually cleaned of aquatic vegetation. All unwanted fishes and other aquatic organisms were eradicated properly from all ponds by using rotenone at the rate of 7.5 $kgha^{-1}ft^{-1}$. After one week, ponds were limed at the rate of 250 kg ha^{-1}. Ponds were fertilized with urea and triple super phosphate (TSP) at the rate of 100 and 100 $kgha^{-1}$, respectively after 3 days of lime application. Then the ponds were left for 10 days to promote algal development.

***Stocking and pond management*:** In all ponds, post larvae (PL) of freshwater prawn (individual weight 5.47±0.02 g) procured from a nearby commercial hatchery was stocked according to the experimental design (2 prawns m^{-2}). After stocking, a commercially available prawn feed (Saudi-Bangla feed) containing 28% protein (% wet weight basis) was applied in T_1. A locally formulated and prepared pellet feed (2 mm) containing above 24% protein with a C:N ratio close to 10 was used in T_2. The both feeds were applied considering the body weight of prawn at a daily feeding rate of 10% body weight at the beginning of the experiment (up to 30 days), and assuming 80% survival, feed application was gradually reduced to 5% body weight at the end of the culture period. Feed was distributed evenly over the pond's surface twice daily at 07:00 and 18:00 hours. Individual weights of minimum 10% of initially stocked prawn in numbers were recorded monthly to estimate the biomass and adjust the feeding rate. The prawns were sampled using cast net after removing some bamboo side shoots *(kanchi)* from substrate added treatment ponds. After sampling, bamboo side shoots were set back to their original positions.

Locally purchased maize flour was used as carbohydrate source for manipulating the C:N ratio. The pre-weighed maize flour were mixed in a beaker with pond water and uniformly distributed over the ponds' surface directly after the feed application in T_2. The analyzed proximate composition of feed and maize flour is given in Table 1.

Determination of water quality parameters: Water samples were collected using a horizontal water sampler from three locations of each pond and pooled before analysis. Water quality parameters, temperature (Celsius thermometer), dissolved oxygen (HACH Sension 8), pH (CORNING 445 pH meter) and transparency (Secchi disc) were monitored in situ between 0900 to 1000 h on a weekly basis. Total alkalinity (tirimetric method) and NO_2-N, NO_3-N, NH_3-N and PO_4-P concentrations (HACH kit model DR 2010) in the filtrate were measured in the late morning (between 0900 to 1000 h) at monthly interval (APHA 1992). Before nutrient analysis, water samples were filtered through a glass microfiber filter paper (Whatman GF/C, Whatman International, Maidstone, England) using a vacuum pressure air pump. The filtered water was used for nutrient analysis. The filter papers were preserved in 10 ml acetone in a test tube and the paper were ground by using a glass rod and kept in refrigerator for 24 hours. Then it centrifuged (Denlay centrifuge, model BS-400) for 10 minutes at 3,000 RPM and made ready for the analysis of chlorophyll-*a*. Later, chlorophyll *a* was determined using spectrophotometer (Spectronic® Genesys™5, model 336001) at 664 and 750 nm wave lengths, following Boyd (1979).

Table 1: Proximate composition of the feed and maize flour (the percentages are given on a wet weight basis)

Component	*Moisture (%)*	*Protein (%)*	*Lipid (%)*	*Fiber (%)*	*Ash (%)*	*NFE* (%)*
Prepared feed	8.69	24.27	10.0	6.15	20.61	30.28
Maize flour	11.08	7.72	4.64	5.40	1.14	70.02
Saudi-Bangla feed	12.0	28.0	5.0	6.5	16.0	32.5

**NFE = Nitrogen free extract = 100 – (moisture + protein + lipid + crude fiber + ash)*

Assessment of plankton population: Plankton samples were collected monthly by pooling 10 L of water from five locations in each pond and passing it through a plankton net (mesh size 45 µm). The concentrated samples were preserved in small plastic bottles with 5% buffered formalin. Plankton numbers were estimated using a Sedgewick-Rafter (S-R) cell and was left to stand for 15 minutes to allow plankton to settle. Then, the planktons on 10 randomly selected fields of the chamber were counted under a binocular microscope (Swift, M-4000). Taxa were identified to genus level using keys from Bellinger (1992). Plankton abundance was calculated using the following formula-

$$N = (P \times C \times 100) / L \text{ (Azim } et\ al. \text{ 2001)}$$

Where, N = 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); and L= the volume (l) of the pond water sample.

Assessment of benthic macroinvertebrates: The benthic macroinvertebrate samples were collected monthly with an Ekman dredge (covering an area of lower month 225 cm^2). In each pond, bottom mud samples were collected from 3 different locations and washed through a 250 µm mesh size sieve. Benthic macroinvertebrates remaining on the sieve were preserved in a plastic vial containing a 10% buffered formalin solution and pooled together. Identification keys used for benthic macroinvertebrates were from Pinder and Reiss (1983). Benthic macroinvertebrates density (individuals/m^2) was calculated using the following-

N = Y x 10000 / 3A (Asaduzzman *et al.* 2010)

Where, N = number of benthic organisms (number m^{-2}); Y = total number of benthic organisms counted in 3 samples; A = area of Ekman dredge (cm^2).

Study of the biomass of periphyton: From each pond, three poles were selected randomly and two 2×2 cm samples of periphyton were taken at three depths (25, 50 and 75 cm below the water surface) per pole on a monthly basis starting after 15 days of substrate installation. Half of the 2x2 cm samples from three poles and three depths per pond per sampling day were pooled for dry matter (DM), ash and ash free dry matter (AFDM) analysis. The other half of the 2x2 pooled samples from three poles and three depths per pond per sampling day were used to determine chlorophyll *a* concentration following standard methods (APHA 1992).

Harvesting of prawn and estimation of yield parameters: Prawns were harvested after draining the ponds. Individual length (wooden measuring board; precision 0.1cm) and individual weight (Denver-xp-3000; precision=0.1g) were recorded. Specific growth rate (SGR), feed conversion ratio (FCR) and net yields were calculated as follows:

SGR (% bw day^{-1}) = [(ln final weight – ln initial weight) x 100]/ Culture periods (days)

FCR = Feed applied (dry weight) /Live weight gain

Net yield = Total biomass at harvest – Total biomass at stocking

Statistical analysis: Independent samples T-Test was performed for comparing water quality parameters, plankton, benthic macorinvertibrates data, and growth and production of prawn between the treatments. Survival and percent data were analyzed using arcsine-transformed data, but percent values were reported. Temporal effects of periphyton data in T_2 were analyzed using one-way ANOVA based on Duncan's Test. The assumptions of normal distribution and homogeneity of variances were checked before analysis. All statistical tests were carried out at a 5% significance level using SPSS (Statistical Package for Social Science) version11.5.

RESULTS AND DISCUSSIONS

Water quality parameters: In fish culture, water quality is usually defined as the suitability of water for the survival and growth of fish. Mean values of water quality parameters did not differ significantly (P>0.05) between two treatments (Table 2).

Table 2: Mean(±SE) values of measured water quality parameters

Parameters	*Treatments*		*Level of signifi-cance*
	T_1	T_2	
Temperature surface (^oC)	27.48±0.51	27.33±0.52	NS
Temperature bottom (^oC)	26.20±0.40	26.14±0.40	NS
Transparency (cm)	43.31±1.15	42.02±1.61	NS
pH	7.37±0.05	7.28±0.04	NS
Dissolved oxygen (mgl^{-1})	4.66±0.21	4.52±0.22	NS
Total Alkalinity ($mg\ l^{-1}$)	102.0±2.66	99.42±3.21	NS
Total NH_3-N ($mg\ l^{-1}$)	0.16±0.04	0.19±0.04	NS
NO_3-N (mgl^{-1})	0.018±0.003	0.018±0.004	NS
NO_2-N (mgl^{-1})	0.004±0.005	0.003±0.006	NS
PO_4-P (mgl^{-1})	0.43±0.06	0.33±0.04	NS
Chlorophyll *a* ($\mu g\ l^{-1}$)	36.57±6.62	22.72±2.40	NS

The mean values of water temperature were more or less close to the 27°C in each treatment. The recommended suitable range of temperature for prawn culture is 21.9°C to 33.5°C (Fair and Foftner 1981). Water transparency indicating sestonic food abundance found to be ranged from 23 to 61 cm in two treatments which were more or less similar with the findings of Kohinoor *et al*. (2001) and Uddin (2002) who recorded values ranging from 15 to 58 cm and 11 to 63.5 cm. The ranges of dissolved oxygen concentration (2.30 to 9.20 mgl^{-1}) in two treatments exceeded the upper limit of the findings of Haque *et al.* (2013) who recorded DO concentration 1.60 to 8.60 mgl^{-1}. Wulff (1982) reported that juveniles of freshwater prawn could tolerate minimum oxygen levels of 1.0 to 1.5 mgl^{-1} and suggested not to allow the prawns at such levels for long time. The mean values of pH were 7.37±0.05 and 7.28±0.04 in treatments T_1 and T_2, respectively which was more or less similar to the findings of Boyd and Zimmermann (2000), who reported that the ideal environment for nursing of prawn post-larvae should have pH values of 7 to 8.5. It is also reported that pH ranged from 6.8 to 8.4 is suitable for *M. rosenbergii*

culture (Hossain *et al*. 2000). Water bodies having total alkalinity 40 ppm or more are considered more productive than water bodies of lower alkalinity (Mairs 1966). According to Boyd (1982) total alkalinity should be more than 20 ppm in fertilized ponds. Total alkalinity in the present study ranged from 74.00 to 120.00 mgl^{-1} in both treatments, indicating a suitable range for prawn culture. The mean(±SE) values of chlorophyll *a* were more or less identical to the findings of Haque *et al.* (2013) but were lower compared to the findings of other authors in this region (Rahman *et al.* 2010, Kunda *et al.* 2008) might be due to lower values of total nitrogen limiting the algal biomass (Maclean *et al*. 1994). The values of NH_3-N in treatment T_1 and T_2 were 0.08 to 1.03 mgl^{-1} and 0.01 to 0.56 mgl^{-1} which are more or less similar to Rahman (2005) and Asaduzzaman *et al.* (2006) who recorded ammonia-nitrogen value ranged from 0.01 to 0.82 and 0.203 to 0.569 mgl^{-1}, respectively. The ranges of NO_3-N were found to vary from 0.010 to 0.06 mgl^{-1} and 0.020 to 0.06 mgl^{-1} in T_1 and T_2 treatments, respectively which are more or less similar to the finding of Asaduzzaman (2005) and Haque *et al.* (2013). The mean(±SE) values of NO_2-N concentration were 0.004±0.005 mgl^{-1} and 0.003±0.005 mgl^{-1} in T_1 and T_2 treatments, respectively which are comparable to the findings of Haque *et al.* (2013) and Wahab *et al*. (1995). Phosphate-phosphorous (mgl^{-1}) were found to vary from 0.17 to 0.89 mgl^{-1} and 0.13 to 0.59 mgl^{-1} during the experiment in T_1 and T_2 treatments, respectively which are more or less agree with the findings of Wahab *et al.* (1995), Uddin (2002) and Alim (2005) who recorded phosphate-phosphorus values ranging from 0.09 to 5.2 mgl^{-1}, 0.03 to 4.46 $mgl^{-1}$and 0 to 1.80 mgl^{-1}, respectively. The concentration of chlorophyll *a* was found to vary from 7.14-82.85 μgl^{-1} to 11.90-43.70 μgl^{-1} during the experiment in T_1 and T_2 treatments, respectively which were more or less similar to Hasan (1998) and Paul (1998) who found chlorophyll *a* in pond waters ranged from 10 to 200 μgl^{-1}.

***Abundance of plankton and benthic macroinvertebrates*:** The abundance of plankton population (phytoplankton and zooplankton) and their different groups did not vary significantly (*P>0.05*) between the treatments (Table 3).

Haque *et al.* (2013) found similar result in their C/N ratio controlled periphyton-based study. The plankton communities in pond water consisted of four major groups of phytoplankton and two groups of zooplankton in both treatments. Thirty eight genera of phytoplankton belonging to Chlorophyceae (19), Bacillariophyceae (10), Cyanophyceae (7) and Euglenophyceae (2) were found. Chlorophyceae followed by the Bacillariophyceae was the most dominant group in terms of number of genera and abundance (cells or colonies l^{-1}) among phytoplankton in both treatments. Seventeen genera of zooplankton belonging to Crustacea (9) and Rotifera (8) were found. Crustaceans was the most dominant group in terms of number of genera and abundance (cells or colonies l^{-1}) than Rotifers in both treatments. The phytoplankton and zooplankton species composition were the representative of that found in Bangladesh prawn/fish ponds and in rice fields (Kunda *et al.* 2008, Asaduzzaman *et al*. 2009b, Haque *et al.* 2013). Benthic organisms are very important food items for freshwater prawn. The benthic macro-invertebrates were divided into Chironomidae, Oligochaeta, Mollusca and Miscellaneous groups. The mean abundance of total benthic population was 1098.93±62.90 and 1195.88±66.02 individual per m^2 in T_1 and T_2, respectively (Table 3). Chironomidae followed by Oligochaeta was the most dominant group among benthos in two treatments which is agreed to the findings of Haque *et al.* (2013) and Pinder and Reiss (1983). The steady decrease in total benthos after the first month until the end of the experiment might be due to increased grazing pressure by increased biomass of prawn (Asaduzzaman *et al*. 2009b). There is evidence that prawns prefer to forage on animals like trochopterans, chironomids, oligochaetes, nematodes, gastropods and zooplankton in their natural habitats (Coyle *et al*. 1996, Tidwell *et al*. 1997).

Table 3: Abundance of plankton and benthos (mean±SE, N=12) with their different groups recorded in two treatments

Variables	*Treatments*		*Level of significance*
	T_1	T_2	
Plankton ($x10^3$ cells or colonies)			
Bacillariophyceae	23.58±1.39	31.38 ±2.05	NS
Chlorophyceae	47.42±2.34	53.00±2.21	NS
Cyanophyceae	29.42±2.37	24.92±3.11	NS
Euglenophyceae	2.42±0.58	2.42±0.46	NS
Total phytoplankton	102.83±4.01	111.70 ± 2.73	NS
Rotifera	3.33±0.56	3.04 ± 0.31	NS
Crustacea	1.04 ± 0.22	0.75 ± 0.14	NS
Cladocera	6.21 ± 0.77	3.38 ± 0.53	NS
Total zooplankton	12.96 ± 0.97	9.08 ± 0.65	NS
Total plankton	115.79 ± 4.30	120.79 ± 2.47	NS
Benthos (Individual m^{-2})			
Chironomidae	619.36±35.74	682.80±28.89	NS
Oligochaeta	225.80±17.89	258.90±23.69	NS
Mollusca	185.90±10.85	199.73±19.43	NS
Miscellaneous	68.70±7.75	53.59±5.03	NS
Total	1098.93±62.9	1195.88±66.02	NS

Periphyton composition and biomass: The periphyton composition per unit substrate and surface area and the outcomes of ANOVA are presented in Table 4.

Table 4: Abundance and biomass of periphyton (SD, N=12) over sampling periods

Variables	*Sampling periods*			
	Initial	*Period 1*	*Period 2*	*Period 3*
Periphytic abundance (x10^{3}cells or colonies cm^{-2})				
Bacillariophyceae	13.87±88.19	15.75±381.88	13.26±150.11	17.47±260.34
Chlorophyceae	28.50±321.46	29.98±252.0	27.20±140.20	32.92±730.40
Cyanophyceae	11.30±152.75	12.08±44.10	11.21±150.70	13.67±88.19
Euglenophyceae	0.34±66.67	0.49±20.82	0.34±7.64	0.61±5.77
Total phytoperiphyton	54.00±152.75	58.00±264.56	52.00±360.56	64.67±417.67
Rotifera	0.50±25.17	0.37±14.53	0.61±59.25	0.58±15.27
Crustacea	0.30±17.32	0.13± 28.48	0.19±8.82	0.12±11.54
Total zooperiphyton	0.80±40.41	0.50±15.28	0.80±55.68	0.70±26.46
Total Periphyton	54.80±193.13	58.50±277.91	52.80±416.05	65.37±392.19
Quantitative biomass				
Dry matter (mg cm^{-2})	2.10±0.06	2.15±0.03	1.99±0.06	1.77±0.05
Ash free dry matter (mg cm^{-2})	1.40±0.05	1.45±0.02	1.37±0.03	1.29±0.02
Chlorophyll-a (µg cm^{-2})	9.03±0.02	9.45±0.03	8.09±0.04	7.00±0.04

The periphyton community constitutes a major component of aquatic biological systems (Biggs 1987). Periphyton includes both the phyto-periphyton and zoo-periphyton, and sometime aquatic insects (Biggs 1987, Wetzel 1983). In the present study, phyto-periphyton and zoo-periphyton were only recorded as periphyton. About 40 genera of phyto-periphyton belonging to Bacillariophyceae (10), Chlorophyceae (21), Cyanophyceae (7) and Euglenophyceae (2) and 6 genera of zoo-periphyton belonging to Rotifer (5) and Crustacea (1) were also identified as periphytic communities in the substrate treatment during the experiment. The periphyton species composition and the mean values were the approximate representative of that found in Bangladesh prawn/fish ponds (Asaduzzaman *et al*. 2009b, Haque *et al*. 2013). The periphyton biomass in terms of dry matter (DM), Ash free dry matter (AFDM) and chlorophyll *a* varied significantly (*P<0.05*) among different sampling dates and a continuous decreasing trend except first month until the end of the experiment (Figure 1, 2 and 3). This confirms the utilization of periphyton by cultured prawn. This was also reflected by a decreasing trend of zoo-periphyton in the present study. However, the numbers of periphyton remained same over the experimental period indicating the qualitative change of the composition due to grazing. The low biomass of prawn initially exerted low grazing pressure allowing periphyton to grow. As prawn grew its increased grazing pressure led to reduced periphyton biomass. Uddin *et al.* (2006) reported that freshwater prawns may feed selectively on periphyton. It may have picked preferentially on animal portion and detrital aggregates rather than picking up the mixed biomass.

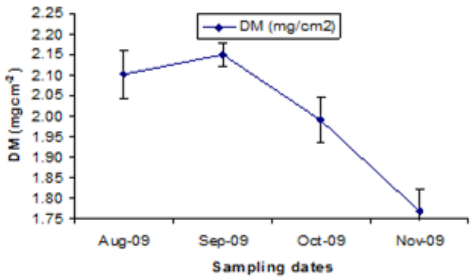

Figure 1: Monthly variations of DM content in T_2

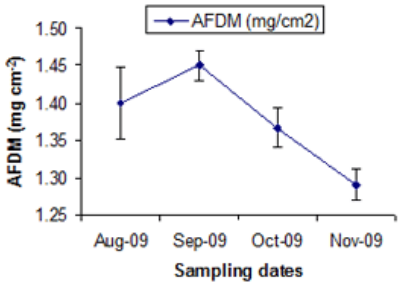

Figure 2: Monthly variations of AFDM content in T_2

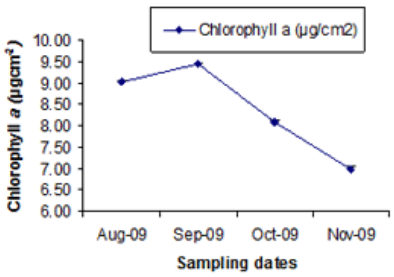

Figure 3: Monthly variations of Chlorophyll *a* content in T_2

Growth and yield parameters of prawn: Growth and yield parameters of freshwater prawn are given in Table 5. There was no significant difference (*P*>0.05) in the mean survival rate of prawn between T_1 and T_2. Therefore, it may be concluded that substrate and organic feed with high carbohydrate content has no effects on the survival rate of prawn. This may be agreed with the findings of Tidwell *et al.* (2002) who reported that substrate had no significant (*P*>0.05) impact on prawn survival. The gross and net yields of prawn were significantly higher (*P*<0.05) in treatment T_2 than treatment T_1. This might be due to addition of substrates

for periphyton development and controlling a high C:N ratio (20) for preparing organic feed through maize flour which has been reflected in the higher weight gain of prawn in T_2. It has been reported that combination of both periphyton substrates and C:N ratio in freshwater prawn and finfish (Asaduzzaman *et al.* 2008, 2009a, 2009b, 2010; Haque *et al.* 2013) ponds have showed great potential. This is mainly because of additional shelter and natural food in the form of periphyton colonized on bamboo substrates along with improvements of environmental conditions through a range of ecological and biological processes (Tidwell *et al.* 2002, Milstein *et al.* 2003). On the other, production of heterotrophic single cell protein (bio-floc) by controlling microbial water quality through manipulation of C:N ratio are rapidly expanding in both active suspension ponds (ASP) and extensive ponds, especially in producing penaeid shrimp (Crab *et al.* 2007, Avnimelech 2007). Therefore, the findings of the present study agree with the above authors.

Table 5: Growth performance (Mean±SE) of prawn

Variables	*Treatments*	
	T_1	T_2
Individual stocking weight (g)	5.54±0.02[a]	5.43±0.01[b]
Individual harvesting weight(g)	29.98±0.21[b]	33.67±0.44[a]
Individual weight gain (g)	24.44±0.19[b]	28.02±0.43[a]
Specific growth rate (% bw d^{-1})	1.50±0[b]	1.63±0.01[a]
Feed conversion ratio	0.40±0.02	0.36±0.01
Survival (%)	71.15±1.11	76.41±1.68
Gross yield (kgha^{-1} 90d^{-1})		
Large (≥50g)	395.70±5.93[b]	469.07±16.99[a]
Medium (33.3-49.9 g)	22.18±2.32	31.97±5.48
Small (≤33.2 g)	8.69±1.17	10.38±1.00
Total	426.57±6.84[b]	511.41±12.72[a]
Net yield (kg ha^{-1} 90 d^{-1})	347.77±5.69[b]	428.32±11.29[a]

Mean values with different superscripts indicates a significant different P<0.05 based on Duncan's Test

CONCLUSION

From the findings of the present research, it is found that all the water quality parameters, qualitative and quantitative abundance of phytoplankton, benthic macroinvertebrates showed no significant differences (P>0.05) and were more or less within the suitable ranges for prawn culture in both treatments. The periphyton biomass in terms of dry matter (DM), Ash free dry matter (AFDM) and chlorophyll *a* varied significantly ($P<0.05$) among different sampling dates and a continuous decreasing trend was observed except first month until the end of the experiment in T_2. Therefore, it is hypothesized that the periphyton grown on bamboo surface may enhance the growth and production of freshwater prawn in C:N controlled periphyton based organic farming treated prawn ponds. In the present study, it was not possible to estimate the contribution of artificial feed and different types of natural food in the form of phytoplankton, periphyton and herterotrophic bacteria on the growth of freshwater prawn. Therefore, a further research is necessary to estimate the contribution of artificial and natural food as well as heterotrophic bacteria on the growth of freshwater prawn. It is also necessary to compare the production and economic performance of freshwater prawn by using other low cost feed ingredients and carbohydrate sources and cheaper periphyton substrates for the sustainability of organic farming of freshwater prawn.

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