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Culture of Striped Catfish *Pangasianodon hypophthalmus* through Net Cages in Carp Pond under varying Stocking Density

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ABSTRACT

This study was conducted to determine optimum stocking density of *Pangasianodon hypophthalmus* (Pangasius) for cage culture system installed in carp pond and evaluate its impact on carp pond productivity. Pangasius fingerlings (weight 5.90 ± 0.26 g; length 85.9 ± 0.45 mm) were stocked in PVC net cages of size 2 m x 2 m x 1 m using varying stocking density *viz*., T1- 80 fishes/ m^2, T2- 100 fishes/ m^2, T3- 120 fishes/ m^2 and T4-140 fishes/ m^2 in five replicates. After 180d of culture period significantly ($p<0.05$) higher final weight 613.06 ±5.684 g; length 374.8 ±3.26 mm; net gain in length 288.9±3.139 mm; ADG (Aggregate daily weight gain) 3.36 ±0.032 g was observed in T1-80 fishes/ m^2. However higher net gain in weight of 607.16 ±5.602 and SGR (specific growth rate) 2.58 ±0.009 were observed in T1- 80 fishes/m^2 but there was no significant difference ($P>0.05$) among T1, T2 and T3. Although higher FCE (Food conversion efficiency) 64.43 ±0.565 % and PER (Protein efficiency ratio) 2.15±0.019 and lower FCR (Food conversion ratio) of 1.55 ±0.014 were estimated in T1- 80 fishes/m^2 but there was no significant difference among the treatments. No significant effect was observed on survival. Significantly higher ($p<0.05$) yield of 136.26 ±1.033 kg was obtained in T4 - 140 fishes/m^2 but there was no significant difference with the yield (134.9 ±1.251) kg recorded in T3 (120 fishes m^{-2}). Significantly higher B:C ratio 1.42 ±0.013 was recorded in T3. So, looking to the growth, yield and B:C ratio stocking density T3(120 fishes/m^2) is an optimum density level for higher economic returns. As far as nutrients and primary productivity is concerned significantly higher NO3-N of 2.23 ± 0.288 mg/L, PO4-P of 0.26 ±0.032 mg/ L, GPP (Gross primary productivity) of 8.48 ±1.07 g C m^2 /d, NPP (Net primary productivity) of 5.71 ±0.776 g C m^2 /d and CR (Community respiration) of 2.76 ±0.353 g C m^2/d were recorded in carp pond when pangasius culture through net cages was carried out. Consequently, carp fish production about 2480 kg /0.4 ha with lower FCR of 1.23 and higher B:C ratio of 2.06 was recorded which is about 30.60 per cent higher than the carp production of previous years when pangasius cultured were not accompanied.

Key Words: Carp, Fish, Pond, Productivity, Stocking density.

INTRODUCTION

Pangasiadon hypophthalmus synonym *Pangasius sutchi* is familiar as *tra, swai, sutchi* catfish, striped catfish or iridescent shark belongs to family pangasidae and order siluriform. It is found in Chao Phraya River in Thailand and lower basin of Mekong River (Vidthayanon and Hogan, 2013). Now a days it is traded over 100 countries worldwide as skinless and bone less fillets, popularly along with portions, steaks, and its value-added products (Thi *et al,* 2013). Many values added products of the fish have been accepted worldwide and are having huge commercial importance (Lakshman *et al,* 2015). It grows rapidly to 1.2 to 1.3 kg within 6-8 m of culture period but usually harvested at higher sizes as per market availability (Gurung *et al,* 2016).

Pangasius was introduced in India during 1995-96 from Thailand (Ahmed and Hasan, 2007; Rao,

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2010) and now it is cultured extensively through pond culture system (Rao, 2010). Commonly, monoculture of pangasius is carried out in pond and cages with high stocking density (FAO, 2010). In pond culture system, higher yield 200-300 Mt /ha is achieved through stocking density 20-40 fish/m^2 (FAO, 2010). Cage culture is an intensive culture system operated with very high fish stocking densities (100 -150 fish /m^3) and yields around 100-120 kg/m^3 using extruded pelleted feed. (Hung and Cacot, 2000).

Although higher yield of pangasius is possible in monoculture system with high stocking density but net profit could be achieved through polyculture with silver carp (Sarkar *et al,* 2007). As a voracious feeder pangasius can establish dominancy over feeding and compete for feed with major carps in polyculture system. So pangasius culture through cages in carp pond will restrict the area of feeding for pangasius. Fecal matter and ammonia excreted by pangasius serves as manure and will have the potential to increase the natural productivity of carp pond. The primary productivity and its regulating components are very important to consider in fish culture system (Sivakumar and Karuppasamy, 2008). So, optimum stocking density of pangasius fish for net cages to be installed in carp pond and impact on carp production need to be evaluated.

MATERIALS AND METHODS

The study of pangasius culture in varying stocking density in carp pond was conducted for 180 d during August 2019 to January 2020 in the earthen carp fish pond of size 0.3 ha. and depth 7 ft. at Krishi Vigyan Kendra, Navsari Agricultural University, Navsari (Gujarat). Fingerlings of pangasius with mean weight 5.90 ± 0.26 g and length 85.9 ± 0.45 mm were stocked in fabricated PVC net cages (2m x 2m x 1m) using varying stocking density *viz*., T1- 80 fishes m^{-3}, T2- 100 fishes m^{-3}, T3- 120 fishes m^{-3} and T4-140 fishes m^{-3}. The experiment was conducted in twenty experimental cages using five replicates of each treatment following CRD statistical design for a period of 180 days in carp pond. The pond was stocked with 3000 yearlings (average size 140 ± 5.6 mm and weight 60 ± 2.80 g) of carps' fishes, Catla, Rohu, Mrigal and Grass carp with species ratio of 2:4.5:2.5:1 respectively. Initially pangasius fish were fed with standard commercial floating pelleted feed of 30% protein and 4-5% fat content at the satiation level of 8% of their body weight and subsequently the feed quantum was reduced to 0.75% of its body weight. Growth of the pangasius fish in terms of total length (mm) and weight(g) were estimated every month. Growth performance parameters *i.e.*, net weight gain, net length gain, specific growth rate (SGR), aggregate daily weight gain (ADG), food conversion ratio (FCR), feed efficiency ratio (FER) and protein efficiency ratio (PER) were calculated using following formulas (Tok *et al,* 2016; Labh *et al*, 2017).

In order to distinguish the effect of pangasius culture through cage farming on carp production previous two years data of carp fish production along with nutrients level and primary productivity of carp pond's water were used to compare the effect on carp pond productivity and production due to pangasius integration using cages. The pond was completely drained and dried before commencing the crop. Sampling and analysis for physico-chemical parameters and nutrients (Nitrate- nitrogen and Phosphates-phosphorus) content of pond water was carried out periodically on monthly basis following standard methods (Trivedi and Goel 1986; APHA, 1985). Primary productivity parameters *viz*; Gross primary productivity (GPP), Net photosynthesis productivity (NPP) and community respiration (CR) were determined through estimating dissolved oxygen using the dark-light bottle methods with 3 hr of incubation period during (10:00 a.m. -1:00 p. m.). Primary productivity was calculated based on the changing value in dissolved oxygen level in initial bottle (IB), light bottle (LB) and dark bottle (DB). The multiplication factor 0.375 was used to derive carbon value from oxygen concentration (Sreenivasan, 1964). The gross and net productions were calculated with the following equations outlined in Britton and Greeson (1987)

GPP (Gross primary productivity) (O2 mg/L/hr) = (Dissolved oxygen of light bottle – Dissolved oxygen in dark bottle) ÷ Incubation period× 0.375 = g C/ m^2 /hr.

NPP (Net primary productivity) (O2 mg/L/hr) = (Dissolved oxygen of light bottle - Dissolved oxygen of initial bottle) ÷ Incubation period × 0.375= g C/ m^2 /hr.

CR (Community respiration) (O2 mg/L/hr) = (Dissolved oxygen of initial bottle – Dissolved oxygen of dark bottle) ÷ Incubation period × 0.375 =g C/ m^2 /hr.

Statistical analysis: SPSS software version- 16 using one way ANOVA and Duncan's multiple range test (P≤0.05).

RESULTS AND DISCUSSION

Water quality parameters

Water quality parameters *viz;* DO (Dissolved oxygen), water temperature, light penetration, pH and total alkalinity ranged from 3.95 to 5.50 mg/l ; 20.5 to 28.95 °C; 22-44 cm; 7.95 -8.50 and 154.5 -221 mg/ l , respectively and presented in Table 1. There was no significant difference (p<0.05) in mean value of DO, Temperature, light penetration, pH and total alkalinity during three years. The parameters are almost observed within the range suitable for fish culture as suggested by Bhatnagar and Devi (2013) for aquaculture. Light penetration can be correlated with nutrient status and affected by algal growth and turbidity. Higher light penetration shows low primary productivity of phytoplankton and results into lower fish production from the pond (Olah *et al,* 1986)

Growth and survival of *Pangasius*

Significantly higher (p<0.05) final length of 374.8 ±3.26 mm; net gain in length of 288.9 ±3.139 mm; ADG (aggregate daily weight gain) of 3.36 ±0.032 g and SGR (specific growth rate) of 2.58 ±0.009 were recorded in T1(80 numbers/ m^3). No significant difference (p>0.05) in SGR was recorded among T_1, T2 and T3 but significantly lower (p<0.05) SGR was observed in T4. As far as weight gain is concerned higher value of 607.16±5.602g was recorded in T1 followed by 588.36 ±5.186, 586.84 ±4.883 and 525.12±3.467g in T3, T2 and T4 , respectively. However, there was no significant difference in net weight gain in T1, T2 and T3 but significantly lower (p<0.05%) net weight gain was recorded in higher stocking density T4 (140 numbers/ m^3).

Significantly lower (p<0.05%) survival rate was observed in T4. Although higher survival rate 94.58 ±0.0.228% was observed in T3 followed by 94.25 ±0.306, 93.7 ±0.436 % in T1 and T2, respectively. There was no significant difference in survival rate up to stocking density 120 numbers/m^3. Similarly, Jiwyam (2011) recorded more than 90% survival rate in *Pangasius bocourti* under the stocking density 12, 25, 50, 100 and 200 fish/ m^3 indicate that pangasius fish can tolerate crowding. With increasing stocking density *viz;* 40, 50 and up to 60 numbers/ m^3. Similar to present study Azimuddin *et al.* (1999) also did not find any significant effect of stocking density on survival of *P. sutchi.* But with too much less density of 30 numbers per cubic meter. Datta *et al* (2017) also estimated 100 percent survival rate in *Pangasius* fish up to stocking density 30 numbers/m^3. So, it may be concluded that there will be no significant difference in survival rate in stocking density up to 120 numbers/m^3. Higher weight gain, ADG and SGR in low stocking density in the present study are in agreement with Vaishnav *et al* (2017) who observed significantly higher net weight gain, SGR (specific growth rate) in *P. hypophthalmus* reared in the net cage of size 3.65 m X 3.65 m X 5.18 m with stocking density 2600 number (38 numbers/m^3) for 60 days of culture experiment conducted in reservoir.

The trend of higher SGR at low density in the present study may be comparable with Chowdhary *et al* (2020) who observed higher SGR, weight gain in cage farming installed in flood plains

Table 1. Physico-Chemical Parameters, Nutrients Status And Primary Productivity Of Carp Pond

	YEAR					
	June 2017- May 2018 (Without pangasius)		**June 2018- May 2019 (Without pangasius)**		**June 2019- May 2020 (With pangasius in cages)**	
Parameters	Mean± Sem	Range	Mean ±Sem	Range	Mean ±Sem	Range
Dissolved oxygen (mg L^{-})	$4.89^{a} \pm 0.117$	4.15 - 5.5	$4.83^{a} \pm 0.117$	3.95- 5.4	$4.89^{a} \pm 0.098$	4.30- 5.30
Temperature (°C)	$25.42^{a} \pm 0.682$	21.00 - 28.95	$25.53^{a} \pm 0.776$	20.50- 28.85	$25.71^{a} \pm 0.617$	21.5-28.00
Light penetration (cm)	$31.75^{a} \pm 1.632$	22.00 - 40.00	$32.80^{a} \pm 1.576$	24.00- 42.50	$31.38^{a} \pm 1.728$	22.00- 44.00
pH	8.27 ± 0.044	7.95 - 8.50	8.31 ± 0.031	8.15- 8.50	8.24 ±0.026	8.15-8.40
Total Alkalinity (mg L^{-})	$181.58^{a} \pm 4.853$	161 – 221	$178.54^{a} \pm 4.78$	154.5- 205	$182.17^{a} \pm 3.339$	168-209
Nitrate (mg L^{-})	$1.13^{b} \pm 0.099$	0.42 - 1.57	$1.14^{b} \pm 0.098$	0.48- 1.59	$2.23^{a} \pm 0.288$	0.39-3.35
Phosphate (mg L^{-})	$0.12^{b} \pm 0.014$	0.05 - 0.19	$0.11^{b} \pm 0.01$	0.07-0.19	$0.26^{a} \pm 0.032$	0.06-0.39
GPP g C m^{-2} day^{-}	$5.10^{b} \pm 0.561$	2.4 - 8.33	$5.62^{b} \pm 0.608$	2.48-8.85	$8.48^{a} \pm 1.074$	2.55-14.10
NPP g C m^{-2} day^{-}	$3.26^{b} \pm 0.408$	1.05 - 5.55	$3.78^{b} \pm 0.447$	1.65-6.00	$5.71^{a} \pm 0.776$	1.80-10.35
CR g g C m^{-2} day^{-}	$1.84^{b} \pm 0.177$	0.75 - 2.78	$1.85^{b} \pm 0.184$	0.68-2.85	$2.76^{a} \pm 0.353$	0.75-4.65

GPP- Gross primary productivity; NPP- Net primary productivity, CR- community respiration.
Mean ±S.E. superscript with same letters is not significantly different at $P<0.05$
Mean ±S.E. superscript with different letters is significantly different at $P<0.05$

Table 2. Pangasius fish growth performance in net cages under different stocking density

Growth parameters (Mean ±S.E.)	T_1 (80 numbers / cubic meter)	T_2 (100 numbers /cubic meter)	T_3 (120 numbers /cubic meter)	T_4 (140 numbers / cubic meter)
Initial length (mm)	85.90 ±0.20	85.90 ±0.20	85.90 ±0.20	85.90 ±0.20
Initial weight (g)	5.90±0.118	5.90 ±0.118	5.90 ±0.118	5.90 ±0.118
Final length (mm)	374.8^{a} ±3.26	363^{b} ±3.318	369.8^{ab} ±3.171	332.8^{c} ±2.518
Final weight (g)	613.06^{a} ±5.684	592.74^{b} ±4.833	594.26^{b} ±5.223	531.02^{c} ±3.421
Net gain in length (mm)	288.9^{a} ±3.139	277.1^{b} ±3.35	283.9^{ab} ±3.171	246.9^{c} ±2.643
Net gain in weight (g)	607.16^{a} ±5.602	586.84^{a} ±4.883	588.36^{a} ±5.186	525.12^{b}±3.467
ADG (g)	3.36^{a} ±0.032	3.26^{b} ±0.029	3.27^{b} ±0.029	2.92^{c} ±0.09
SGR (%)	2.58^{a} ±0.009	2.56^{a} ±0.014	2.57^{a} ±0.011	2.50^{b} ±0.013
FCR	1.55^{a} ±0.014	1.56^{a} ±0.011	1.57^{a} ±0.016	1.59^{a} ±0.012
FCE (%)	64.43^{a} ±0.565	64.07^{a} ±0.48	63.80^{a} ±0.625	62.71^{a} ±0.449
PER	2.15^{a} ±0.019	2.13^{a} ±0.008	2.14^{a} ±0.016	2.09^{a} ±0.015
Survival (%)	94.25^{a} ±0.306	93.7^{a} ±0.436	94.58^{a} ±0.0.228	91.64^{b} ±0.0.268
Fish production (kg per cage)	92.46^{c} ±1.063	111.07^{b} ±0.814	134.9^{a} ±1.251	136.26^{a} ±1.033
Yield (kg per m^{-3})	46.23^{c} ±1.063	55.54^{b} ±0.814	67.45^{a} ±1.251	68.13^{a} ±1.033
Benefit cost ratio (BCR)	1.25 $±0.013^{d}$	1.33 $±0.009^{c}$	$1.42±0.013^{a}$	1.37 $±0.09^{b}$

ADG- Aggregate daily weight gain, FCR-Food conversion ratio, FCE- Food conversion efficiency, SGR- Specific growth rate, PER- Protein efficiency ratio
Mean ±S.E. superscript with same letters or not is not significantly different at P<0.05
Mean ±S.E. superscript with different letters is significantly different at P<0.05

at low stocking density 17 and 22 numbers/m^3 than 25numbers/m^3. Azimuddin *et al* (1999) also observed significantly higher weight gain, specific growth rate in the treatment of stocking density 40 fishes/m^3. In the present study no significant difference in SGR was observed among stocking density 80,100 and 120 number of fish/m^3. Similar to present study Jiwyam (2011) did not observe any significant difference in SGR of *P. bocourti* under higher stocking densities (50, 100, and 200 fish/ m^3). But in contrast to the present study Islam *et a.* (2018) observed higher growth performance and survival of *P. hypophthalmus* fry (0.19 ±0.007g) in stocking density of 200/ m^3 in net cage (4.6 x 1.5 x 1.4 m^3).

Similar to the present study highest yield , Mehta *et al,* (2018) concluded highest yield 64.4 ton /ha in cage (5 m x 5 m x 1.25 m) culture experiment with stocking density 140000 fish/ha. but there was no significant difference in growth parameters in various stocking density from 80000 to 140000 numbers/ha.

In the present study low FCR 1.55 ±0.014 was recorded in T1 followed by 1.56 ±0.011, 1.57 ±0.016 and 1.59 ±0.012 in T2, T3 and T4 respectively. But significant influence of stocking density was not observed on FCR (Food conversion ratio), FCE (Feed conversion efficiency) and PER (Protein efficiency rate) may be due to similar content and type of feed. Whereas Azimuddin *et a.* (1999) observed significantly lower ($p<0.05$) FCR (Food conversion ratio) and higher ($p<0.05$) PER (Protein efficiency rate) in low stocking density (40 fishes/ m^3). Vaishnav *et al* (2017) also recorded the effect of stocking density over FCR and gross conversion efficiency. In India FCR varies from 1.1 to 1.3 under pond culture system of *P. hypophthalmus* (Singh and lakra, 2012).

Fish yield and benefit cost ratio

Higher fish production 136.26 ±1.033 kg per cage was recorded from T4 followed by 134.9 ±1.251, 111.07 ±0.814 and 92.46 ±1.063 kg from T3, T2 and T1 respectively (Table 2). Fish yield increases with increase in stocking density. About 20.13, 47.37 and 45.90% higher fish yield was recorded in T2 (55.54^b ±0.814 kg/m^3), T3 (67.45^a ±1.251 kg/m^3) and T4 (68.13^a ±1.033 kg/m^3) than T1 (46.23c ±1.063 kg/m^3) respectively. Thus, T3 and T4 were significantly high ($p<0.05$) yielding stocking density but there was no significant difference ($p>0.05$) between them. It may be concluded that pangasius can thrive well in crowding condition. Fish yield recorded in the present study is much higher than the yield 9.080 kg/m^3 recorded by Vaishnav *et al* (2017) in the stocking density of 44 numbers/m^3 and 15.01 ± 0.20 kg/$m^3$with stocking density 25 numbers/m^3 by Chowdhary *et al* (2020). As per Table 2 higher B:C ratio (benefit cost ratio) of 1.42±0.013 was observed in T3 followed by T4, T2 and T1 with 1.37 ±0.09, 1.33 ±0.009 and 1.25 ±0.013 respectively. There was significant difference ($p<0.05$) in B:C ratio among the treatments.

Carp pond productivity

Nutrients (Nitrate-nitrogen and Phosphate-phosphorus) level of carp pond

Monthly variations in Nitrate-nitrogen and Phosphate-phosphorus of the carp pond's water are presented in table1. Nitrate-nitrogen ranged from 0.42-1.57, 0.48- 1.59 and 0.39-3.35 mg/L in the year 2017-18, 2018-19 and 2019-20, respectively. Significantly higher ($p<0.05$) NO3-N of 2.23 ± 0.288 mg/L was estimated in the pond water during the year 2019-20 followed by 1.14 ±0.098 mg/L in 2018-19 and 1.13 ± 0.099 mg/L in 2017-18. There was no significant difference in the nitrate content during 2017-18 and 2018-19. Similarly, Phosphate-phosphorus ranged from 0.05 - 0.39 mg/L during the study period of three years with significantly higher

Table 3. Carp production in 0.30 ha. earther pond

Year	Stocking number of fish	Species ratio	Fish yield (kg)	Species wise yield (kg)				FCR	B:C ratio	GPP (g C m^{-2} day^{-1})	FP (g C m^{-2} day^{-1})	conversion efficiency (%) (FP/GPP×100)
				Catla	Rohu	Mrigal	Grass carp					
2017-18	3000	2:4.5:2.5:1	1810	260	911	435	204	1.52	2.41	5.1	0.17	3.33
2018-19	3000	2:4.5:2.5:1	1987	320	967	510	190	1.67	2.32	5.62	0.18	3.20
2019-20	3000	2:4.5:2.5:1	2480	628	1086	466	300	1.23	3.06	8.48	0.23	2.71

FCR- Food conversion ratio; B:C ratio- Benefit cost ratio; GPP- Gross primary productivity; FP- Fish production

($p<0.05$) of 0.26 ±0.032 mg/L in 2019-20. Thus, it is estimated that about 126.09% higher phosphate and 96.48% higher nitrate content were recorded during 2019-20 than average of previous two years. The increased content of nitrate and phosphate can be directly associated with cage culture activities of pangasius in carp pond during 2019-20 since pangasius eat the supplementary feed voraciously and excrete large amount of fecal and ammonia in pond water

Similarly, Sarkar *et al* (2007) observed increased level of inorganic nitrate nitrogen and phosphate-phosphorus with increase in number of pangasius catfish in polyculture system. Verma and Srivastava (2016) observed almost double quantity of nutrients in village eutrophic pond. But P:N ratio in the present study during pangasius farming is about 1:8.5 which is ideal for primary production.

Primary productivity

The data (Table 1) about GPP and NPP ranged from 2.4 to 14.10 and 1.05 to 10.35 g C /m^2 /d during June-2017 to May -2020 respectively. Significantly higher ($p<0.05$) GPP 8.48 ±1.074 g C /m^2 /d recorded in 2019-20 followed by 5.62 ±0.608 in 2018-19 and 5.10 ± 0.561 g C /m^2 /d in 2017-18. There was no significant difference in GPP in the previous two years. Similarly, higher ($p<0.05$) NPP of 5.71 ±0.776 g C /m^2 /d was estimated during 2019-20. No significant difference ($p<0.05$) in mean value of NPP in carp pond during previous two years (2017-18 & 2018-19) of pangasius cage farming was observed. Significantly higher ($p<0.05$) CR of 2.76 ±0.353 g C /m^2 /d recorded during 2019-20 of pangasius cage farming followed by 1.85 ±0.184 and 1.84 ± 0.177 g C /m^2 /d 2017-18 and 2018-19 respectively. About 58.21, 62.22 and 49.19 per cent higher GPP, NPP and CR recorded respectively of pond water during pangasius cage farming (2019-20) than the previous two years of without pangasius. Higher value of primary productivity directly associated higher value of with inorganic nutrients (Nitrate and Phosphate). It shows that Pangasius fish feeds voraciously on floating feeds and its faecal organic matter and excreta products fertilize the pond for higher productivity.

Carp fish production

As per Table 3 higher carp production 2480 kg was recorded from 0.3 ha pond in the year 2019-20 followed by 1987kg in 2018-19 and 1810 kg in 2017-18. About 30.60 per cent higher carp production was observed in 2019-20 compared to mean production of previous two years. It shows that pangasius culture system through cages in carp culture pond could certainly accelerate primary productivity. Higher primary productivity always enhances the growth of planktivorous fish. Such integration of fish farming would not only increase the carp fish production but it can also reduce FCR (Food conversion ratio) 1.23 during 2019-20 from 1.52 and 1.67 FCR of previous two years. Higher benefit cost ratio 3.06 also recorded during the year 2019-20 compare to 2.41 and 2.32 B:C ratio in 2017-18 and 2018-19 respectively. Higher conversion efficiency 3.33 per cent was estimated in 2017-18 followed by 3.20 per cent in 2018-19 and lower 2.71 per cent in 2019-20. It shows that very small portion of GPP was converted into fish production. It could be increased by stocking more numbers of carp fish when pangasius cage culture is integrated with carp culture pond. Higher production of carp was positively correlated with higher productivity and trophic level of pond. Sarkar *et al* (2007) also recorded positive correlation among inorganic nutrients (NO_3-N and PO_4-P) primary productivity and fish production in pangasius and silver carp polyculture system. They also observed that when fraction of pangasius fish is increased in polyculture system level of mean inorganic NO_3-N and PO_4-P along with primary productivity and fish production were also increased.

CONCLUSION

Stocking density 120 numbers /m^3 could be the most suitable for higher production with higher economic return. Moreover, integration of pangasius culture through cages in carp pond not only enhance carp fish production of 30.60 per cent higher but also lowers FCR up to 1.23 with higher benefit cost ratio 3.06 of carp production system. Thus, more research needs to be conducted by adding inorganic nutrients (Nitrate and phosphate) extracting Azolla algal culture component through cages or pens around or between pangasius cage culture units in carp pond for maximization of carp production and water quality management with efficient utilization of waste of one farming system. Such farming system could be familiar as integrated multi trophic aquaculture.

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