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EFFECTS OF FISH POPULATION DENSITIES ON GROWTH AND PRODUCTION OF FISHES

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ABSTRACT

The experiment was carried out under three treatments each with two replications. Fish population density was 80 fish per decimal (silver carp 32, tilapia 32 and mrigal 16) under treatment-1, 120 fish per decimal (silver carp 48, tilapia 48 and mrigal 24) under treatment-2 and 160 fish per decimal (silver carp 64, tilapia 64 and mrigal 32) under treatment-3. The average initial length and weight of the fingerlings of silver carp, tilapia and mrigal were 7.49, 5.12, and 5.56 cm and 8.00, 2.00 and 1.50 g respectively. The ponds were fertilized fortnightly with cowdung, urea and TSP (triple super phosphate) at the rates of 5 kg, 60 g, and 90 g per decimal, respectively. During the experimental period, the range of water temperature (30.20 to 32.90^{0}C), transparency (28 to 38 cm), dissolved oxygen (8.20 to 10.60 mg/L), pH (6.90 to 7.90), total alkalinity (92.00 to 127.00 mg/L), free CO_2 (1.00 to 1.60 mg/L), phosphate-phosphorus (1.00 to 1.90 mg/L), and nitrate-nitrogen (1.90 to 3.90 mg/L) were within the productive range and more or less similar in all the ponds under three treatments. There were 25 genera of phytoplankton under five major groups and 10 genera of zooplankton under three major groups in the experimental ponds. The calculated net fish production of the ponds under treatment-1 was 2.62 ton/ha/yr and that of the ponds under treatment-2 was 4.42 ton/ha/yr and that of the ponds under treatment-3 was 5.18 ton/ha/yr. The net fish production under treatment-2 and treatment -3 were 195.58% and 229.20% higher than that of treatment-1, taking net fish production under treatment-1 for 100%. According to profit-cost analysis the ratios of net profit and total cost under treatments 1, 2, and 3 were 1:0.25, 1:0.45, and 1:0.44. According to growth and production treatment-3 is the best, and according to the profit-cost analysis, treatment-2 (ratio 1:0.45) is the best but it is almost same to that of treatment-3. So, the population density of 160 fish per decimal (under treatment-3) might be considered best. It seems that proper determination of stocking density of different fishes in polyculture is very important to increase fish production.

Key Words: Fish population density, Polyculture, fertilization, Water quality parameters

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INTRODUCTION

For successful aquaculture, knowledge on several factors is very important among which stocking density of different fish species also plays a vital role in growth of fish. Higher density of a species may affect the growth of another species; similarly lower density of a species may reduce the overall production. So the better utilization of different strata and zones of a pond three or more species with proper density and ratio must be stocked.

Polyculture is based on the relationships between organisms at different levels of food chain in the pond ecosystem. That is why natural food utilization is efficient and thus increases fish yields per unit of area (Tang, 1970). Synergism and antagonism between ecologically different species depend on stocking density beyond the optimum level and for which competition for food and space would be started. As a result fish cannot use natural food efficiently and production slows down. Thus the relationships between different fish groups must be understood in order to maintain appropriate stocking densities for each species (Milstein, 1990; Yashouv, 1968 and Hepher *et al.*, 1989).

Most of the fish farmers may believe that higher density will give more production. So they release fish fingerlings or fry in very higher density and for this reason various abnormal situation occur in the pond including very low growth and production of fishes. On the other hand, if the fish population density is low, then it may bring loss to farmers. It is hoped that the present experiment may be helpful in determining the optimum fish population density.

MATERIALS AND METHODS

Experimental ponds

All the experimental ponds were arbitrarily numbered as pond no. 1(p_1), ponds No. 2 (p_2) … and pond no. 6 (p_6). In the experiment work Pond 1 and 2 were considered as treatment No. 1, pond 3 and pond 4 as treatment No. 2 and pond 5 and 6 as treatment No. 3.

The experiment was conducted under three treatments and each treatment had two ponds (Table 1). Three species of fish, silver carp (*Hypophthalmichthys molitrix*), tilapia (*Oreochromis niloticus*) and *mrigal* (*Cirrhinus cirrhosus*) were used.

Table 1. Layout of the experiment

Treatment No.	Replication	Fish population density	Fish species & ratio	Fertilization
1	2 (2 ponds)	80 fish per decimal	Silver carp: Tilapia : Mrigal = 4 : 4:2	Urea 60g, TSP 90g, Cow dung 5 kg per decimal fortnightly
2	do	120 fish per decimal	do	do
3	do	160 fish per decimal	do	do

Water supply

Ponds were supplied with water regularly after 7 days of liming from a deep tube-well water supply system; rainfall was also a source of water supply to the ponds.

Fertilization of the ponds

Fertilization of ponds was done fortnightly with cowdung (5 kg/decimal), urea (60 g/decimal) and triple super phosphate (90 g/decimal).

Study of water quality parameters

Different water quality parameters were estimated and recorded fortnightly throughout the experimental period. Water quality measurement and sample collection were made between 8.00 a.m. and 12 noon. Physical parameters such as air temperature (^oC), water temperature (^oC), transparency (cm), and water depth (m) were measured at the pond site on every sampling day. Chemical parameters such as pH, dissolved oxygen (mg/L) free carbon dioxide (mg/L), total alkalinity (mg/L), PO_4-P (mg/L), NO_3-N (mg/L) and biological parameters such as phytoplankton density (cells/L), zooplankton density (cells/L) were done in the Limnology Laboratory of the Department of Fisheries Management.

Harvesting of fish

At the end of the experiment the water of the ponds were pumped out and all the fishes were harvested.

Estimation of survival rate, growth and production of fish

(i) The survival rate was calculated by the following formula
Survival rate (%) = (No. of harvested fishes/Initial No. of fishes) × 100
(ii) Specific growth rate (SGR %) was calculated by the following formula:

$$\text{SGR (\% per day)} = \frac{\text{Loge } W_2 - \text{loge } W_1}{T_2 - T_1} \times 100$$

Where,

W_1= Initial live body weight (g) at time T_1
W_2 = Final live body weight (g) at time T_2
(iii) Calculation of gross fish production (ton/ha/yr)

$$= \frac{\text{Gross weight (kg) of fish per decimal per month} \times 250 \times 12}{100}$$

(iv) Calculation of net fish production (ton/ha/yr)

$$= \frac{\text{Net weight (kg) of fish per decimal per month} \times 250 \times 12}{100}$$

Here,
One ha = 250 decimal; 1year = 12 months

RESULTS

Physical parameters

The mean values of average water depth (m), transparency (cm), water temperature (°C), and air temperature (°C) of the ponds under treatments 1,2, and 3 were 0.895 ± 0.03, 0.86 ± 0.03, and 0.89 ± 0.03m; 32.83 ± 1.83, 31.67 ± 1.03 and 30.92 ± 1.88 cm; 31.43 ± 0.59, 31.37 ± 0.59 and 31.50 ± 0.42 (°C); and 32.12 ± 0.67(°C) respectively (Table 2).

Table 2. Fortnightly mean value of data of physical parameters of six samplings days of the ponds under treatment 1, 2, and 3 during the experimental period

Parameters	Treatment					
	1		2		3	
	Pond No.	Mean ± S.D	Pond No.	Mean ± S.D	Pond No.	Mean ± S.D
Average water depth (m)	P_1	0.93 ± 0.03	P_3	0.83 ± 0.03	P_5	0.94 ± 0.04
	P_2	0.86 ± 0.03	P_4	0.89 ± 0.05	P_6	0.87 ± 0.03
	Mean	0.895 ± 0.03	Mean	0.86 ± 0.03	Mean	0.89 ± 0.03
Transparency (cm)	P_1	33.33 ± 3.14	P	31.83 ± 2.32	P_5	31.00 ± 2.81
	P_2	32.33 ± 2.73	P_4	31.50 ± 2.74	P_6	30.83 ± 3.00
	Mean	32.83 ± 1.83	Mean	31.67 ± 1.03	Mean	30.92 ± 1.88
Water temperature (°C)	P_1	31.50 ± 0.49	P_3	31.43 ± 0.60	P_5	31.42 ± 0.50
	P_2	31.52 ± 0.61	P_4	31.30 ± 0.64	P_6	31.58 ± 0.37
	Mean	31.43 ± 0.59	Mean	31.37 ± 0.59	Mean	31.50 ± 0.42
Air temperature (°C)	-	32.12 ± 0.67	-	32.12 ± 0.67		32.12 ± 0.67

Chemical parameters

The mean values of average dissolved oxygen (mg/L), free CO_2 (mg/L), pH , total alkalinity (mg/L), PO_4-P(mg/L), and NO_3-N (mg/L) of the ponds under treatments 1, 2, and 3 were 9.52 ± 0.67, 9.65 ± 0.32 and 10.08 ± 0.39 (mg/L); 1.18 ± 0.18, 1.13 ± 0.06 and 1.18 ± 0.16(mg/L); 7.22 ± 0.07, 7.29 ± 0.04 and 7.44 ± 0.28; 108.50 ± 5.43, 104.08 ± 2.94 and 112.42 ± 6.39(mg/L); 1.47 ± 0.32,1.32 ± 0.18 and 1.44 ± 0.03(mg/L); 2.90 ± 0.16, 3.33 ± 0.30 and 2.76 ± 0.32(mg/L) respectively (Table 3).

Fish production

The calculated gross and net fish productions of the ponds under treatments 1, 2, and 3were 2.96, 4.90 and 6.30 ton/ha/yr and 2.62, 4.42, and 5.18 ton/ha/yr respectively. Percent increase of net fish productions under treatments 2 and 3 over treatment-1 (taking it for 100%) have been found were 195.58% and 229.20% respectively (Tables 4, 5 and Figs. 1 and 2).

The total cost, gross return and net profit per hectare per year in Taka under treatments 1, 2 and 3 are Tk. 237,680, Tk. 296,000, Tk. 58,320; Tk. 337,680, Tk. 490,000, Tk. 152,320; and Tk. 437,680, Tk. 630,000, Tk. 192,320 respectively (Fig. 3).

Table 3. Fortnightly mean values of data of chemical parameters of six sampling days of the ponds under treatments 1, 2, and 3 during the experimental period

Parameters	Treatment					
	1		2		3	
	Pond no.	Mean ± S.D	Pond no.	Mean ± S.D	Pond no.	Mean ± S.D
Dissolved oxygen(mg/L)	P_1	9.42 ± 0.95	P_3	9.67 ± 0.53	P_5	10.08 ± 0.57
	P_2	9.62 ± 0.50	P_4	9.63 ± 0.18	P_6	10.08 ± 0.35
	Mean	9.52 ± 0.67	Mean	9.65 ± 0.32	Mean	10.08 ± 0.39
Free CO_2(mg/L)	P_1	1.27 ± 0.25	P_3	1.15 ± 0.12	P_5	1.22 ± 0.19
	P_2	1.10 ± 0.13	P_4	1.12 ± 0.09	P_6	1.13 ± 0.15
	Mean	1.18 ± 0.18	Mean	1.13 ± 0.06	Mean	1.18 ± 0.16
pH	P_1	7.40 ± 0.28	P_3	7.23 ± 0.40	P_5	7.37 ± 0.38
	P_2	7.30 ± 0.29	P_4	7.35 ± 0.10	P_6	7.52 ± 0.26
	Mean	7.22 ± 0.07	Mean	7.29 ± 0.04	Mean	7.44 ± 0.28
Total alkalinity(mg/L)	P_1	107.00 ± 8.92	P_3	106.5 ± 3.83	P_5	112.83 ± 8.33
	P_2	110.00 ± 8.85	P_4	101.67 ± 3.44	P_6	112.00 ± 9.19
	Mean	108.50 ± 5.43	Mean	104.08 ± 2.94	Mean	112.42 ± 6.39
PO_4-P (mg/L)	P_1	1.52 ± 0.36	P_3	1.45 ± 0.34	P_5	1.43 ± 0.23
	P_2	1.42 ± 0.29	P_4	1.18 ± 0.31	P_6	1.45 ± 0.26
	Mean	1.47 ± 0.32	Mean	1.32 ± 0.18	Mean	1.44 ± 0.03
NO_3-N (mg/L)	P_1	2.70 ± 0.41	P_3	3.32 ± 0.33	P_5	2.77 ± 0.21
	P_2	3.10 ± 0.30	P_4	3.35 ± 0.35	P_6	2.75 ± 0.46
	Mean	2.90 ± 0.16	Mean	3.33 ± 0.30	Mean	2.76 ± 0.32

Table 4. Gross and net productions of fish of the ponds under treatments 1, 2, and 3

Treatment (Fish population density)	Production				
	Kg/deci/yr		Ton/ha/yr		*Percent increase of net production
	Gross	Net	Gross	Net	
T-1 (80 fish/decimal)	11.84	10.48	2.96	2.62	100%
T-2 (120 fish/decimal)	19.58	17.66	4.90	4.42	195.58%
T-3 (160 fish/decimal)	25.20	20.72	6.30	5.18	229.20%

*Percent increase of net productions of treatment-2 and treatment-3 over treatment-1 which has been taken for 100%

Table 5. Total survival rate, growth and production (gross and net) of fishes under treatments 1, 2, and 3

Treatment	Total survival rate (%)	Final total wt (kg/deci/ 3months)	Initial total wt(kg/deci)	Specific growth rate (SGR% per day)	production (kg/deci/yr)	
					Gross	Net
T-1	90.11	2.96	0.34	2.94%	11.84	10.48
T-2	88.54	4.895	0.48	3.07%	19.58	17.66
T-3	88.80	6.30	1.12	3.02%	25.20	20.72

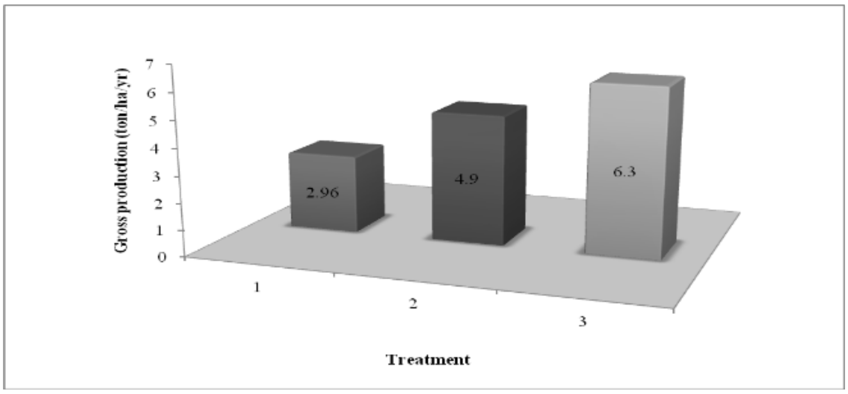

Fig. 1. Gross productions of the fishes under treatments 1, 2, and 3

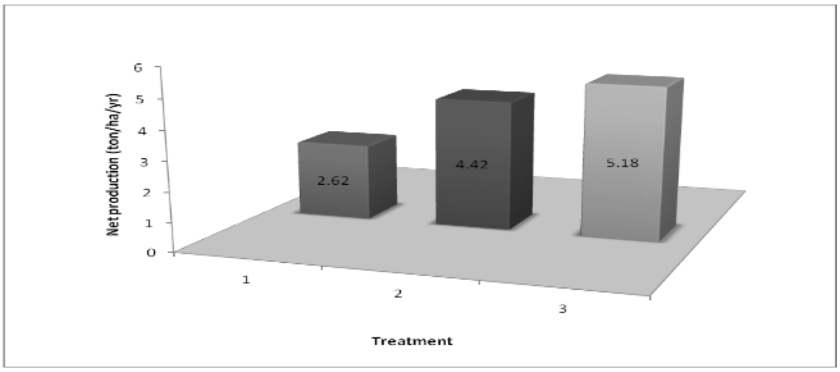

Fig. 2. Net productions of the fishes under treatments 1, 2, and 3

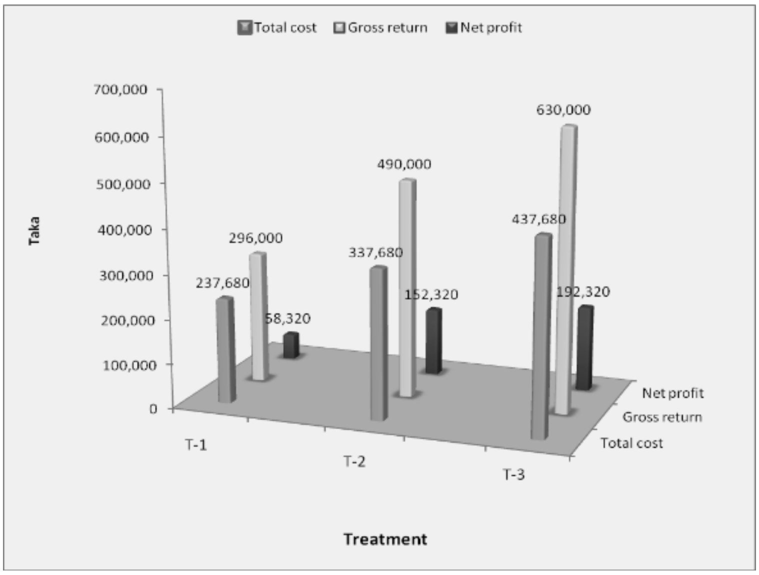

Fig. 3. Total cost, gross return and net profit per hectare per year in Taka under treatments 1, 2, and 3

DISCUSSION

Physical parameters

Water depth: Fortnightly data of water depth of the ponds were from 0.79 to 0.99 m. The mean values of water depth under treatments 1, 2 and 3 were 0.895 ± 0.03 m, 0.86 ± 0.03 m and 0.89 ± 0.03 m respectively. Rahman (1992) stated that pond should not be shallower than 1 m and deeper than 5 m and optimum depth should be 2 m.

Transparency: Fortnightly variation of water transparency of the ponds during the experimental period were from 27.00 to 36.00 cm. The mean values of water transparency of the ponds under treatments 1, 2 and 3 were 32.83 ± 1.83, 31.67 ± 1.03 and 30.92 ± 1.88 cm respectively. Rahman and Rahman (1999); Rahman *et al.* (1999); Rahman and Haque (1998); Rahman *et al.*(1997); Uddin *et al.*(2007); Chowdhary *et al.* (2008); Kabir *et al.*(2009) and Rahman and Sarker (2007) recorded almost similar transparency values of pond water in their experiments.

Water temperature: In the present experiment the water temperature fluctuated from 30 to 32°C. The water temperature remains more or less similar due to rainy season. Ali *et al.* (1998) found water temperature of ponds 20.50 to 36.50°C which was favourable for fish culture.

Air temperature: Air temperature was same for all the experimental ponds on each sampling day. Throughout the experimental period, the air temperature was found to vary from 31.00 to 33.00°C. Islam and Mendes (1976) reported that the water temperature is always less than the surrounding air temperature and varied with 3°C.

Chemical parameters

Dissolved oxygen (DO): During the experimental period dissolved oxygen content of the ponds were found from 7.00 to 10.00 mg/L. The mean values of dissolved oxygen content recorded in the present experiment under treatments 1, 2 and 3 were 9.52 ± 0.67, 9.65 ± 0.32 and 10.08 ± 0.39 mg/L respectively. Rahman and Rahman (1999); Rahman *et al.* (1999); Rahman and Haque (1998); Uddin *et al.* (2007); Chowdhary *et al.* (2008); Kabir *et al.*(2009); and Rahman and Sarker (2007) found more or less similar results.

Free carbondioxide (mg/L): The fluctuation of free carbondioxide during the experimental period ranged from 1.00 to 2.00 mg/L. The mean values of free CO_2 content recorded in the present experiment under treatments 1, 2 and 3 were 1.18 ± 0.16, 1.13 ± 0.06, 1.18 ± 0.18 mg/L respectively. These are more or less similar to the results of Rahman and Rahman (1999); Rahman *et al.* (1999); Rahman and Haque (1998); Uddin *et al.* (2007); Chowdhury *et al.* (2008); Kabir *et al.* (2009); Rahman and Sarker (2007) and Mazid (2009).

pH (hydrogen ion concentration): The fluctuation of pH during the experimental period ranged from 6.90 to 7.80. The mean values of pH recorded in the present experiment under treatments 1, 2 and 3 were 7.22 ± 0.07, 7.29 ± 0.04, 7.44 ± 0.28 respectively. These are more or less similar to the results of Rahman and Rahman (1999); Rahman *et al.* (1999); Rahman and Haque (1998); Uddin *et al.* (2007); Chowdhury *et al.* (2008); Kabir *et al.* (2009); Rahman and Sarker (2007) and Mazid (2009).

Total alkalinity (mg/L): Fortnightly fluctuation of total alkalinity in the experimental ponds ranged from 96.00 to 127.00 mg/L. The mean values of alkalinity recorded in the present experiment under treatments 1, 2 and 3 were 112.42 ± 6.39, 104.08 ± 2.94 and 108.5 ± 5.43 (mg/L) respectively. Rahman and Rahman (1999); Rahman *et al.* (1999); Rahman and Haque (1998); Uddin *et al.* (2007); Chowdhary *et al.* (2008); Kabir *et al.* (2009); Rahman and Sarker (2007) and Mazid (2009) found more or less similar results.

Phosphate- phosphorous (PO_4-P) (mg/L): The content of phosphate- phosphorous (PO_4-P) in the experimental ponds ranged from 6.60 to 8.10 mg/L. The average values of PO_4-P of the experimental ponds under treatments 1, 2 and 3 were 1.47 ± 0.32; 1.32 ± 0.18 and 1.44 ± 0.03 mg/L respectively. Aminul (1996) observed almost similar results. Wahab *et al.* (1995) found the higher concentration of phosphate-phosphorous (0.09 to 5.20 mg/L) in nine experimental ponds.

Nitrate-nitrogen (NO_3-N) (mg/L): The content of nitrate-nitrogen (NO_3-N) in the experimental ponds ranged from 1.90 to 3.90 mg/L. The average values of NO_3-N of the experimental ponds under treatments 1, 2 and 3 were 2.9 ± 0.16, 3.33 ± 0.30 and 2.76 ± 0.32 mg/L respectively. The range of nitrate-nitrogen values recorded by Das (2002) ranged from 1.60 to 3.22 mg/L were more or less similar to the values of the present study. In a study, Dewan *et al.* (1991) observed 0.20 to 3.00 mg/L of nitrate-nitrogen.

Survival rate (%): The survival rates in treatments 1, 2 and 3 were 90.11%, 88.54% and 88.80% respectively. The fry were transported carefully, released with great care. The similar type of survival rates were observed by Haque (2005) who recorded the survival rates of 89.50% and 90% under treatment-1 and treatment-2 respectively. Kohinoor *et al.* (2000) obtained survival rates of 86 to 94% in the monoculture of Thai sarpunti.

Specific growth rate (SGR% per day): The specific growth rates (SGR% per day) of fishes in different treatments were different. The specific growth rates in treatments 1, 2 and 3 were 2.94%, 3.07% and 3.02% respectively. Subir (2010) obtained specific growth rates (SGR, % per day) 1.13%, 1.03% and 0.80% under treatments 1, 2 and 3.

Production of fish: In the present experiment, calculated gross productions of fish of the ponds under treatments 1, 2, and 3 were 2.96, 4.90 and 6.30 ton/ha/yr respectively (Table 4 and Fig. 1). The calculated net productions of fish of the ponds under treatments 1, 2 and 3 were 2.62, 4.42 and 5.18 ton/ha/yr respectively (Table 4 and Fig. 2). Productions of fish of treatments 2 and 3 were significantly higher than that of treatment-1 and these were 195.58% and 229.20% higher than that of treatment-1 which was taken for 100% (Table 4).

Mazid (2009) conducted a research work on the impacts of fish population density on the growth and production of carps in polyculture system. In that study it was found that higher fish population density (100 fish per decimal) in polyculture of sarpunti and mrigal under treatment-1 did not affect fish growth and production compared to lower fish population density (50 fish per decimal) under treatment-2 and it was found that growth and production of fish under treatment-1 was significantly higher.

Subir (2010) conducted a research work to determine the impacts of fish population density on the growth and production of fishes (sarpunti, mrigal and tilapia) in polyculture system for a period of 90 days. The experiment was carried out under three treatments each with two replications. Fish population density was 50 fish per decimal (sarpunti 20, mrigal 20 and tilapia 10) under treatment-1, 75 per decimal (sarpunti 30, mrigal 30 and tilapia 15) under treatment-2 and 150 fish per decimal (sarpunti 60, mrigal 60 and tilapia 30) under treatment-3. In that experiment it was found that in treatment-1, the growth rate of fish was high but the net fish production was comparatively lower than the other two treatments. He concluded that 75 fish per decimal is the best sstocking density for the culture of sarpunti, mrigal and tilapia in polyculture system.

Production and cost-return analysis: The calculated average per hectare total cost per year was Tk. 237,680, Tk. 337,680 and Tk. 437,680 for the treatments 1, 2, and 3 respectively whereas the gross return per hectare per year from the treatments 1, 2, and 3 were Tk. 296,000, Tk. 490,000, and Tk. 630,000 respectively. The gross return or income was calculated by selling the total amount of fish harvested from the ponds under treatments 1, 2, and 3 at the rate of Tk. 100/kg. The net benefit per hectare per year was Tk. 58,320; 152,320 and 192,320 for treatments 1, 2 and 3 respectively. Cost-benefit ratios showed that percent benefit on investment under treatments 1, 2 and 3 were 25%, 45% and 44% respectively. Throughout the experiment the costs for three treatments were not equal but the return is higher in treatment 2 than those of treatments 1and 2.

CONCLUSION

Considering the findings of the present study, it might be concluded that treatment-3 (fish population density, 160 per decimal = *H. molitrix* 64+ *O. niloticus* 64 + *C. mrigala* 32) is the best in respect of growth and production. According to the profit-cost analysis, treatment-2 (ratio 1:0.45) is the best but it is almost same to that of treatment-3 (ratio 1:0.44). So, it might be suggested that the population density of 120 fish per decimal is best for polyculture of silver carp, tilapia and mrigal (ratio 4:4:2).

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