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Mixed Culture of High Valued Small Indigenous Fish Species (SIS) Pabda (*Ompok pabda*) and Gulsha (*Mystus cavasius*) with Monosex Male Tilapia (*Oreochromis niloticus*) in On-Farm Management System

Md. Anwar Hossain Mondal[1*], Md. Mehedi Hasan Sikdar[2], Md. Arifur Rahman[3]

[1]Department of Aquaculture, Faculty of Fisheries, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh
[2]Department of Statistics, Faculty of Agriculture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh
[3]Department of Fisheries Biology and Genetics, Faculty of Fisheries, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

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***Corresponding author:** Dr. Md. Anwar Hossain Mondal
Department of Aquaculture, Faculty of Fisheries, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Abstract **Original Research Article**

The mixed culture study of pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) with monosex tilapia (*Oreochromis niloticus*) was undertaken to assess the growth and production potentials under on-farm condition during March to August 2021 at Patuakhali Science and Technology University. Three stocking densities of pabda and gulsha were tested keeping the monosex male tilapia constant stocking density. Each stocking density of pabda and gulsha was considered as treatment (T) with three replications. Fingerlings of pabda, gulsha and monosex tilapia were stocked at the rate of 150, 200 and 100 per decimal in T1, 200, 250 and 100 per decimal in T_2 and 250,300,100 per decimal in T_3. Formulated protein (30%) enriched floating feed was given twice daily (10.00 am and 5.00 pm) at the rate of 10% body weight throughout the entire culture periods. Water quality analysis showed that the mean values of water temperature, pH and dissolve oxygen were not significantly different among the treatments existing within cultivable ranges. Water transparency was found significantly different (P<0.05) among the treatments. The correlation matrix analysis among stocking density, survival, FCR and production gave a clear picture where stocking density showed negative correlation with survival while survival indicated positive correlation with production. After six months of rearing, the estimated gross productions were 11,441±45.93 kg/ha/6months, 10,972±44.81 kg/ha/6months and 10646±51.72 kg/ha/6months from T1, T2 and T3, respectively. The FCR were found to be 2.12, 2.43 and 2.56 in T_1, T_2 and T_3 .Analysis of variance of total production showed significant difference (p<0.05) among the treatments with higher production in T1 and lower in T3. A simple economic analysis revealed that higher benefit cost ratio (BCR) and net profit was obtained in treatment T_1 (BCR -2.16, net profit: Tk.18,03,525/ha/6 months) followed by treatment T_2 (BCR -1.83, net profit: Tk.14,17,910/ha/6months) and treatment T_3 (BCR-1.69, net profit: Tk. 12,58,281/ha/6 months) consequently. The contribution of averaged adding effect of monosex tilapia was more than 55% in total income in case of all treatments. Therefore, it might be concluded that the polyculture of pabda, gulsha and monosex tilapia followed by T_1 may be a better option considering the production and economic benefits to farmer's ponds in our country.

Keywords: Pabda, Gulsha, GIFT Strain, Polyculture.

INTRODUCTION

Aquaculture is regarded as an important food production weapon in the global fight against poverty and hunger (Tacon *el al.*, 2009). Fisheries is now the second most valuable agricultural activities in Bangladesh, playing a substantial role in nutrition, food security, employment and income generation, trade, source of foreign exchange earnings and over all poverty alleviation in the country. There is no sector in Bangladesh that illustrates the development potentials more clearly than aquaculture and fisheries for sustainable livelihoods of the rural poor (DoF, 2020; FAO, 2020). Fish and fisheries sector contribute 60% of total protein intake, 3.57% to GDP, 26.50% to agricultural production and 1.24% to foreign export earnings in the national economy (DoF, 2020). Aquaculture contributed 62.5 percent of the world's farmed food fish production to the world total fish production (FAO, 2020). Aquaculture is a rapid growing sector in South Asia, particularly in Bangladesh. It contributes 3.5% to the gross domestic products (GDP), 1.23% to the export earnings and supply about 60% of the animal protein to the nation (DoF, 2020). In Bangladesh 260 freshwater species, 475 marine fish species and 12 varieties of exotic fishes under 12 families and 5 orders were recorded (Galib *et al.*, 2010). The inland capture fisheries have been declaiming day by day due to man -made hazards and ecological degradation. Only aquaculture especially pond aquaculture might be a dependable means of achieving increased yields of fish for fed the ever increasing geometric progression population in the country. High valued delicious market demanded fish species either foreign or indigenous are prerequisite for augment aquaculture.In recent years, increasing anthropogenic pressure on the inland water resources has led to drastic degradation of the rich ichthyofauna of Bangladesh. Many important indigenous fish are greatly threatened and a few such as pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) are on the verge of extinction. Pabda and gulsha are commonly found in beels, low lying areas and canals. The young and adult fish of these species gain access to these waters from flooded rivers where it breeds during the monsoon months (May to July). Pabda is omnivorous in nature, eating fishes, crustaceans, protozoans, algae, insect, parts of plant and debris (Taleb *et al.*, 1991), while gulsha is a carnivore, feeding on insect larvae, and small fish (Islam and Azadi 1989). These two fishes are of great favorite to consumers because of its delicious taste and therefore they have a great demand and fetch high price in the market. Mass propagation coupled with judicious culture in controlled environments is often considered as the logical approach for conservation ventures. With this in mind and also to increase its production through aquaculture, the Bangladesh Fisheries Research Institute under its Freshwater Station, Mymensingh (Akhteruzzaman *et al.*, 1991 and 1993) has developed seed production technology through artificial propagation. Though these two species have been reported quite favorable under standard conditions of carp farming (Kohinoor *et al.*, 1997 and Hossain *et al.*, 1998). While, Monosex male tilapia is a promising culture species in Bangladesh. In semi-intensive culture, the production of monosex tilapia production was 25-30tones/ha/year (Hussain, 2020). No effort was made in the past to grow out pabda and gulsha with adding monosex tilapia in pond aquaculture. So, the present research work was designed to evaluate the production performances of pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) with adding monosex tilapia in on-farm management with the following specific Objectives**:**

a) To investigate the growth and production performance of Pabda and gulsha in polyculture system;
b) To assess the suitable stocking density of the two species in polyculture ; and
c) To learn about the adding effects of monosex male tilapia in mixed culture system estimating benefit cost ratio and monitoring physico-chemical parameters.

MATERIALS AND METHODS

Description and preparation of pond

Nine ponds were used for the experiment for a period of six months during March to August 2022 having pond size in 2 decimal. Ponds are primarily rain fed, well exposed to sunlight and without inlet or outlet but had facilities to provide water as and when needed from nearby water sources using a flexible plastic pipe. Prior to the trial, unwanted fish species were removed from the ponds by using rotenone (12.50 kg/ha). After three days, ponds treated with lime at the rate of 247 kg/ha. Before five days of stocking, the ponds were fertilized with cow manure at the rate of 1,000 kg ha-1 and Urea and TSP at the rate of 25 kg ha-1.

Experimental Design

Three stocking densities of pabda (*O. pabda*), gulsha (*M. cavasius*) were tested. Each stocking density of pabda and gulsha was considered as treatment with three replications. The stocking density of mono sex male tilappia (*O. niloticus*) in all the treatments was same. Details of species combination and stocking density are shown in Table 1 details of species combination and stocking density in the three treatments.

Table 1

Treatments	Species combination	Stocking density/ha
T-1	Pabda	150
	Gulsha	200
	Monosex male tilapia	100
T-2	Pabda	200
	Gulsha	250
	Monosex male tilapia	100
T-3	Pabda	250
	Gulsha	300
	Monosex mate tilapia	100

Fingerling collection and stocking in the experimental ponds

Netting was done in the experimental ponds to remove aquatic insects 3 days before stocking. Fingerlings were collected from Maa Fatema Hatchery Jessore through local fish vender. In this experiment, good quality fingerlings and juveniles were selected, and then transported in the oxygenated polythene bags to the field research farm of the Faculty of Fisheries, Patuakhali Science and Technology University (PSTU). Before releasing the fingerlings into the experimental ponds, the initial length and weight of fishes were recorded in 'cm' and 'g' with the help of a measuring scale and a sensitive portable battery-operated balance, respectively. Prior to releasing the fish fingerlings in the ponds, they were acclimatized with the pond water for half an hour. The fishes were stocked as per experimental design through individual counting (Table 1).

Feeding

The fish was fed 30% protein enriched floating feed for twice daily such as morning at 10.00 am and after at 5.0 pm at the rate of 10-15% of the body weight.

Sampling of fish

The fishes were sampled fortnightly by using a cast net and in each sampling, ten fishes were weighted separately to assess the health condition of fish and their growth, using a portable electrical balance.

Growth of fish

Fishes were sampled regularly at monthly interval with a seine net to determine growth rate as well as feed adjustment. About 50 fishes of each species were measured from each pond as sub-sample. These fishes were again released into the ponds after sampling.

Water quality parameter monitoring:

Water quality parameters were measured at 15-days intervals always at around the same hour (10.00-11.00 am). The water quality parameters measured were temperature, transparency, pH, and dissolved oxygen.

Harvesting of Experimental Fishes:

After six months of culture period, fish were harvested by repeated seine netting followed by pond draining. Total bulk weight and number of fish from each pond was recorded. Survival and gross production of fish of each treatment was estimated.

Estimation of growth performance and production of fishes:

The following formulae were applied to calculate the growth performance and production of fish.

1) Length gain (cm) = Average final length – Average initial length
2) Weight gain (g) = Average final weight – Average initial weight
3) Specific growth rate (%/day) = $(LnW_2 - LnW_1) / (T_2 - T_1) \times 100$

Where,
W_2 = Mean final weight (g),
W_2 = Mean initial weight (g),
T_2 = Time at the end of the experiment and
T_1 = Time at the start of the experiment

4) Survival rate (%) = $\frac{\text{No.of actual fish survived}}{\text{No.of actual fish stocked}} \times 100$

5) Food conversion ratio (FCR):

Food conversion ratio (FCR) = $\frac{\text{Amount of feed (KG)}\,\textit{dry basis}}{\text{Live weight gain (KG)}}$

6) Production of fishes: Net Production= No. of fish caught × average final weight

Cost benefit analysis

Cost-benefit ratio was calculated by the following formula:
Total cost (Tk.) = Fertilizer + Lime (Tk.) + Feed (Tk.) + Fry (Tk.) + Miscellaneous (Tk.)
Miscellaneous (Tk.) = Labor + Maintenance cost
Total yield (kg/ha) = Gross production
Total income (Tk.) = Commodity selling price per unit × Total yield
Total net income (Tk.) = Total income (Tk.) – Total cost (Tk.)
Rate of return (%) = (Total income/Total cost) × 100
Benefit cost ratio = Total income/Total cost

Statistical Analysis:

All the analysis will be done using SPSS version 20.0. ANOVA and DMRT were performed to observe whether treatments had any significant variation among them. One-way analysis of variance (ANOVA) was performed for the statistical analysis of growth and production. Finally, the data were processed and analyzed statistically by using Microsoft Excel program and statistical software.

RESULTS

The result that gained from the study on mixed culture of high valued small indigenous fish species (SIS) pabda and gulsha with monosex male tilapia in on farm management system have been presented in this chapter with providing sufficient data and information. The result has been described different headlines like; water quality parameters, survival rate, and growth rate, production of fish and cost-benefit analysis.

Water quality parameters

The mean value of water quality parameters of three treatments are presented in Table 2.

Table 2 All mean values of water quality parameters of experimental ponds under three treatments with (±SD).

Water Quality parameter	T_1	T_2	T_3
Temperature (°C)	27.40 ±1.39 ^{a}	27.58 ± 1.11 ^{a}	27.40 ±1.32 ^{a}
Transparency (cm)	34.19±1.53 ^{a}	33.53±1.21 ^{ab}	37.33±1.49 ^{c}
pH	7.36 ±1.35 ^{a}	7.49 ±1.03	7.42 ±1.20
Dissolved oxygen (mg/L)	5.31±0.74 ^{a}	5.24±0.62 ^{b}	5.15±0.56 ^{c}
Total alkalinity (mg/L)	154±6.30 ^{a}	130±8.44 ^{b}	121±7.60 ^{bc}

*Figures in the same row having the same superscripts are not significantly different (p>0.05)

It is observed from Table 2 that water temperature did not differ much among different ponds. It ranged from 26.01- 28.79°C, 26.47-28.69°C and 26.08-28.32°C in T_1, T_2 and T_3, with the mean values of 27.40 ±1.39 °C, 27.58 ± 1.11 °C and 27.40 ±1.32°C, respectively. Water transparency values of different ponds under three treatments showed variations on different sampling dates. The mean values of water transparency were 34.19±1.53, 33.53±1.21 and 37.33±1.49 cm in T1, T2 and T3, respectively. Significant differences among the treatment means were observed when ANOVA was performed ($p<0.05$). PH varied from 6.01 to 8.71, 6.46 to 8.52 and 6.22 to 8.62 in T1, T2 and T3, respectively. The values of pH recoded in the present experiment were alkaline, indicating the productive nature of the ponds. Dissolved oxygen is the most important chemical factor for all aquatic organisms except for anaerobic bacteria. The dissolved oxygen contents in the experimental ponds ranged from 4.57 to 6.05 mg/L, 4.62 to 5.86 mg/L and 4.59 to 5.71 mg/L in T1, T2 and T3, respectively, with the mean values of 5.31±0.74 mg L-1, 5.24±0.62 mg/L and 5.15±0.56 mg/L. The value of T1 was significantly ($p<0.05$) higher than T2 and T3, while T2 was significantly different from T3. Significantly lower concentration of dissolved oxygen was observed in T2 and T3 where stocking density of fish was higher than T1. The total alkalinity values of the pond water under different treatments were found to be at the productive level. The mean values of total alkalinity in T1, T2 and T3 were found to be 154±6.30 mg/L, 130±8.44 mg/L and 121±7.60 mg/L, respectively. Significant variations ($p<0.05$) were observed among the treatments. Total alkalinity values found within the suitable range in the present study.

Growth and production performances

Survival rate of Pabda, Gulsha and Monosex male Tilapia

The experimental fishes' survival rates are depicted in Table 3. The experiment was carried out for 180 days under three stocking densities and the average survival rate of Pabda found at the end of experiment 72±1.60%, 66±1.83%, and 62±2.90% and also Gulsha found at the end of experiment 67±2.87%, 62±2.0%, and 59±2.0%, and monosex tilapia found at the end of experiment 91±1.56%, 90±1.70%, and 88±1.0% in T_1, T_2, and T_3 respectively (Table 3).

Table 3: Survival rate of Pabda, Gulsha and monosex tilapia under different treatments at the termination of the experiment

Fish species	Survival (%)		
	T_1	T_2	T_3
Pabda	72±1.60	66±1.83	62±2.90
Gulsha	67±2.87	62±2.0	59±2.0
Monosex tilapia	91±1.56	90±1.70	88±1.0

Specific growth rate (SGR) of the experimental fishes

The specific growth rate (SGR %/day) of experimental fishes by weight in all the treatments is presented in Figure. The analysis of variance proved that the variation in the specific growth rate of fishes obtained from different treatments were not significantly different ($p<0.05$). The results on specific growth rate have been shown in (Table 4). The specific growth rate (%/day) of Pabda was found 1.61±0.41, 1.48±0.54, and 1.43±0.23 in T1, T2 and T3 respectively. Similarly Gulsha was found 1.53±0.32, , 1.45±0.45 and 1.36±0.71 and Monosex tilapia was found 1.98±0.58, 1.79±0.43, and 1.71±0.29 in the three treatments T_1, T_2, and T_3 respectively (Table 4).

Table 4: Specific growth rate of Pabda, Gulsha and Monosex tilapia under different treatments

Fish species	Specific growth rate (%/day)		
	Pabda	Gulsha	Monosex tilapia
T1	1.61±0.41	1.53±0.32	1.98±0.58
T2	1.48±0.54	1.45±0.45	1.79±0.43
T3	1.43±0.23	1.36±0.71	1.77±0.29

Production performance

Net gain on weight of Pabda after 180 days of culture periods

The growth performances of Pabda under different stocking densities were recorded at the end of experiment from T_1, T_2 as well as T_3 and has been depicted in Table 5. The initial stocking weight (g) of Pabda at the stocking time was 2.23 g. At the end of the study average net weight (g) gain of Pabda was recorded as 40.36±3.51 gm, 32.73±1.08 and 27.79±4.00 in T_1, T_2 and T_3 respectively. The highest net weight gain was observed under T1 and lowest was in T3. It is evident from the depicted Table 5 that net weight gain increased with decreasing stocking density and vice versa.

Table 5: Net gain on weight (gm) of Pabda after 180 days of culture period

Treatments	Initial stocking weight(g)	Final weight(g)	Net weight gain(g)
T_1	2.23±0.20	42.59±2.51	40.36±3.51
T_2	2.23±0.20	34.33±2.28	32.73±1.08
T_3	2.23±0.20	30.02±1.40	27.79±4.0

Production of Pabda after 180 days culture periods

In the present study the stocking densities in the three treatments T_1, T_2 and T_3 were 150, 200 and 250 Pabda/dec. respectively. At the end of the experiment, the highest yield was recorded in the T_1 (1189± 48.849kg/ha/6months) followed by T_2 and T_1. The lowest production found to be under treatment T_2 comparing with T1 and T3 respectively (Table 6).

Table 6: Production performances of Pabda under different treatment after 180 days of culture periods

Treatments	Pabda			Production (kg)/ha/6months
	Stocking density / decimal	Harvesting no/decimal	Average harvesting weight (gm)	
T_1	150	108	42.59±2.51	1189± 48.84
T_2	200	132	34.33±2.28	1119±29.32
T_3	250	155	30.02±1.40	1149±69.55

Net gain on weight of Gulsha

The growth performances of Gulsha under different stocking densities were recorded at the end of the experiment from T_1, T_2 as well as T_3 and showed in Table 7. The initial averaged stocking weight (gm) of Gulsha was 1.22±0.15 g. At the end of the study averaged net weight (g) gain of Pabda was recorded as 37.27± 2.34 gm, 27.43±2.51 gm and 22.44±3.19 gm in T_1, T_2 and T_3 respectively. The highest weight gain was observed under T1 where stocking was lower and lower weight gain was observed where stocking density were higher (Table 7).

Table 7: Net gain on weight (gm) of Glulsha fish after 180 days of culture period

Treatments	Initial stocking weight(g)	Final weight(g)	Net weight gain(g)
T_1 (200 fish/decimal)	1.22±0.15	38.49±2.33	37.27± 2.34
T_2(250 fish/decimal)	1.22±0.15	27.91±2.32	27.43±2.51
T_3 (300 fish/decimal)	1.22±0.15	23.56±3.21	22.44±3.19

Production of Gulsha

In the present study the stocking densities in the three treatments T_1, T_2 and T_3 were 200, 250 and 300 Gulsha /dec. respectively. At the end of the experiment, the highest yield was recorded in the T_1 (1273±21.63 kg/ha/6 months) followed by T_2 and T_3. The result of the production significantly varied among T_1, T_2 and T_3 (Table 9).

Table 9: Production of Gulsha under different treatment after 180 days of culture periods

Treatments	Gulsha			Production (kg)/ha/6 months
	Stocking decimal/decimal	Harvesting no/decimal	Average harvesting weight (gm)	
T_1	200	134	38.49±2.33	1273±21.63
T_2	250	155	27.91±2.32	1068±53.35
T_3	300	177	23.66±3.21	1034±39.31

Net gain on weight of Monosex male tilapia:

The growth performances of Monosex tilapia under different stocking densities were recorded after 30 days interval from T_1, T_2 as well as T_3. The initial weight (g) of monosex tilapia at the stocking time was 12.80±1.52 gm. At the end of the study averaged net weight (g) gain of monosex male tilapia was recorded as 388.80±7.64 gm, 382.41±8.29 gm and 376.57±6.11

gm in T_1, T_2 and T_3 respectively. The highest weight gain was observed under T1 where relatively stocking densities of other species were low comparing with T2 and T3 (Table 10).

Table 10: Net gain on weight (g) of Monosex male tilapia after 180 days of culture periods

Treatments	Initial stocking weight(g)	Final weight(g)	Net weight gain(g)
T_1 (100 fish/decimal)	12.80±1.52	401.63±7.60	388.80±7.64
T_2(100 fish/decimal)	12.80±1.52	395.21±10.00	382.41±8.29
T_3(100 fish/decimal)	12.80±1.52	389.37±6.11	376.57±6.11

Production of Monosex tilapia

In the present study the stocking densities in the three treatments T_1, T_2 and T_3 were 100, 100 and 100 Monosex /dec. respectively. At the end of the experiment, the highest yield was recorded in the T_1 (9026±76.32 kg/ha/6months) followed by T_2 and T_1. The result of production significantly varied among T_1, T_2 and T_3 (Table 11).

Table 11: Production of Monosex tilapia under different treatment after 180 days of culture periods

Treatments	Monosex tilapia			Production (kg)/ha/6months)
	Stocking density / decimal	Harvesting no/decimal	Average harvesting weight (gm)	
T_1	100	91	401.60±7.64	9026±76.32
T_2	100	90	395.21±10.00	8785±51.83
T_3	100	88	389.37±6.11	8463±46.32

Total production of fish species with FCR under different treatments:

The species wise production record has been furnished in Table 12. The total of fishes were found to be after six months of rearing, the production obtained were 11,441± 45.93 , 10,972± 44.81 and 10646± 51.72 kg/ha/6 months from T1, T2 and T3, respectively (Table 12). The FCR were noticed 2.12, 2.43 and 2.56 under T1, T2 and T3, respectively (Table 14).

Table 12: Showing the total production of Pabda, Gulsha and Monosex tilapia in the three treatments after 180 days of culture periods

Treatments	Fish species	Species wise total production (Kg/ha/6months)	Total production (Kg/ha/6months)	FCR
T1	Pabda	1189± 48.84	11,441± 45.93	2.12
	Gulsha	1273±21.63		
	Monosex tilapia	9026±76.32		
T2	Pabda	1119±29.32	10,972± 44.81	2.43
	Gulsha	1068±53.35		
	Monosex tilapia	8785±51.83		
T3	Pabda	1149±69.55	10,646± 51.72	2.56
	Gulsha	1034±39.31		
	Monosex tilapia	8463±46.32		

Correlation Matrix analysis

Correlation matrix among stocking density, survival, FCR and production of fish is shown in Table 13 and gave a clear picture of the relationships among the parameters. Stocking density showed a negative correlation with survival. It means that if stocking density increased, then survival of fish decreased. While, survival indicated positive correlation with production and FCR. Whereas FCR also attributed positive correlation with production (Table 13).

Table 13: Correlation matrix among stocking density, survival, FCR and production of fish

Parameters	Stocking density	Survival %	FCR	Production Kg.
Stocking density	1.000	-	-	-
Survival	-0.946	1.000	-	-
FCR	0.993*	-0.987*	1.000	-
Production Kg/ha	0.777	-0.629	0.719	1.000

Cost and benefit Analysis from the culture practices

The cost of production and return from culture of pabda, gulsha and monosex tilapia under three treatments are presented in Table 14.

Table14: Cost and return analyses of fish production under different treatments (Tk./ha/6months)

Items/ equipment	T1**(BDT)**		T2**(BDT)**		T3 **(BDT)**	
	Quantity (Kg) /nos.	Cost (Tk.)	Quantity (Kg)	Cost (Tk.)	Quantity (Kg)	Cost (Tk.)
Expenditure (Tk.)						
Pond preparation		10,000		10,000		10,000
Fingerling (3tk./fish)	1,11,150	3,33,450	1,35850	4,07,550	1,60550	4,81,650
Feed (45 Tk/Kg)	24,255	10,91,475	26,662	11,99,790	27,253	12,26,419
Labor cost Tk.500/day	150	75,000		75,000		75,000
Harvesting cost		20,000		20,000		20,000
Total cost (Tk./hectare)		15,29,925		17,12,340		18,13,069
Incomes (Tk.) Sell price of fish						
1.	Pabda Tk.750/Kg	8,91,750	8,39,250		8,61,750	
2.	GulshaTk.500/Kg	6,36,500	5,34,000		5,17,000	
3.	Monosex male tilapia 200/Kg	18,05,200	17,57,000		16,92,600	
Total income (Tk./hectare)		33,33,450	31,30,250		30,71,350	
Net profit (Tk./hectare/6months)		18,03,525	14,17,910		12,58,281	
Benefit Cost Ratio (BCR)		2.18	1.83		1.69	

Total income was calculated by multiplying total production and market price of the fishes. The prices of the pabda were 750 Tk /kg, Gulsha fishes were Tk. 500/kg. and the Monosex tilapia prices was 200 TK/ Kg. The gross incomes from the three treatments ($T_{1,}$ T_2 and T_3) were , 33,33,450, 31,30,250 and, 30,71,350 Tk/ha/6months respectively with Benefit Cost Ration 2.18, 1.83 and 1.69 subsequently under the consecutive treatments (Table 14).

Contribution of Monosex male tilapia adding in Pabda and Gulsha culture**.**

The adding effect of Monosex tilapia in Pabda and Gulsha culture has been depicted in Table 15. It is evident from Table 15 that contribution of monosex tilapia was 54.15%, 56.12% and 55.10% in T1, T2 and T3 respectively with an averaged adding contribution was found to be 55.12% from monosex tilapia addition in all treatment in the form of keeping constant stocking density (100 monosex/decimal in all treatments Table 15). The result of the present research works suggested that any high yielding variety addition in any high valued fish production technology might be contributed more additional income and would make the technology more profitable and sustainable.

Table 15: Adding effect of Monosex male tilapia in Pabda and Gulsha culture system

Treatments	Total income (Tk./ha/6 months)	Income from monosex tilapia (Tk/ha/6months)	% of contribution on total income for addition of monosex tilapia
T1(100 monosex/decimal)	33,33,450	18,05,200	54.15
T2(100 monosex/decimal)	31,30,250	17,57,000	56.12
T3(100 monosex/decimal)	30,71,350	16,92,600	55.10
Averaged contribution =			55.12

DISCUSSION

The validation of results in respect of the other authors finding to related research is a critical task but interesting that make a research confidence in the mind of a researcher. The obtained result from the present study has been discussed below:

The growth and production performance of aquatic organisms depend great extent on the water quality of a water body. Water quality includes all physical and chemical parameters that may affect aquatic production. Kohinoor *et al*., (2011) recorded the temperature is an important water quality parameter which was found to vary from 24.12 °C - 32.8 °C ponds. The variations in temperature among the treatment means were found similar and within the suitable range of growth of fish in tropical ponds (Rahman *et al.*, 1982, Roy *et al*., 2002, Begum *et al*. 2003, Kohinoor *et al*., 2004). Hossain (1998) recorded a water temperature from 21.38 °C to 25.94 °C in their experimental ponds. Kohinoor (1997) temperature varied from 25.80 to 34.70°C with the means of 27.20±2.42, 27.10±2.61 and 27.72±2.33°C in treatments-1, 2 and 3, respectively in semi-intensive culture in mini ponds which are more or less similar to the present study.

Water transparency values of different ponds under three treatments showed variations on different sampling dates. Water transparency values of different ponds under three treatments showed variations on different sampling dates. The mean values of water transparency were 34.22±1.53, 33.53±1.21 and 37.33±1.49 cm in T1, T2 and T3, respectively. Significant differences among the treatment means were observed when ANOVA was performed (p<0.05). The values of transparency sometimes varied within the sampling dates which could be due to difference in abundances of plankton. Boyd (1982) recommended a transparency between 15- 40 cm as appropriate for fish culture. Haque *et al*., (1984) recorded transparency ranged from 12 cm to 37 cm in his experiment which is more or similar to the results of present study. During the study period, a Hydrogen ion concentration (pH) was measured after 15 days interval. The observed mean values of pH were 7.36±81.35, 7.49±1.03 and 7.42 ± 1.20 in the treatments $T_{1,}$ T_2 and T_3 respectively. The pH values of water in all the experimental ponds under different treatment were varied between 6.5 and 8.8. Different authors have reported a wide variations in pH from 7.18 to 9.24 (Kohinoor e*t al.* 1998), 7.03 to 9.03 (Roy *et al*., 2002), 6.8 to 8.20 (Begum *et al*., 2003) and 7.50 to 8.20 (Chakraborty *et al*., 2005) in fertilized fish pond. The values of pH recoded in the present experiment were alkaline, indicating the productive nature of the ponds. Rahman (1992) reported that the range of pH of a suitable water body for fish culture would be 6.5 to 8.5. pH values in the experimental ponds varied from 6.8 to 8.8, which were similar to the findings of Hossain *et al*., (1997). Kohinoor (2018) recorded that the mean values of pH of treatments-1, 2 and 3 were 7.78±0.34, 7.75±0.57 and 7.29±0.49, respectively which were similar to the experiment.

During the study period, dissolved oxygen level was found to be fluctuated among all the three treatments and the observed mean values of DO were 5.31±0.74, 5.24±0.62 and 5.15±0.56 in the treatments $T_{1,}$ T_2 and T_3 respectively. Kohinoor (2018) recorded that the mean values of dissolved oxygen concentration in treatments-1, 2 and 3 were 4.80±0.83, 4.56±0.82 and 4.18±0.65 mg/L, respectively. Kohinoor *et al*., (2016) observed dissolved oxygen ranging from 5.91 to 6.03 mg/L from fish ponds located in Gouripur, Mymensingh, Bangladesh. In another study, Chakraborty and Nur (2012) recorded dissolved oxygen values ranging from 3.80 to 6.12 mg/L. Although fish might survive in 0.50 mg/L dissolved oxygen concentration but most suitable range of DO in a water body for fish culture is suggested from 5.0-8.0 mg/L. However, the fluctuations in DO concentrations in all treatments ponds were within the productive range throughout the experimental period (Boyd 1982).

The total alkalinity values of the pond water under different treatments were found to be at the productive level. The mean values of total alkalinity in T1, T2 and T3 were found to be 154±6.30 mg/L, 130±8.44 mg/L and 121±7.60 mg/L, respectively. Significant variations (p<0.05) were observed among the treatments. Total alkalinity levels for natural waters may range from less than 5 mg/L to more than 500 mg/L (Boyd 1990). Kohinoor (1998) and Roy (2002) were found the average total alkalinity above 100 mg/L in their study. Total alkalinity values found within the suitable range in the present study. Kohinoor *et al*., (2017) recorded that total alkalinity was found 122 to 168, 115 to 155 and 119 to 149 mg/L with mean values of 143±11.12, 138±12.49 and 135±11.64 mg/l in treatments-1, 2 and 3, respectively. When the results of all the ponds collected over the entire experimental periods were compared, there was no significant difference. Higher total alkalinity level in the ponds of three treatments might be due to regular application of lime at fortnightly interval. The variations in total alkalinity in all the treatments were found in productive range for aquaculture ponds (Boyd 1982, Chakraborty and Nur, 2012 and Kohinoor *et al*., 2017). It was observed that pabda reached an average harvesting weight of 42.59±2.51gm, 34.33±2.28 gm and 30.02±1.40 in T1, T2 and T3, respectively. When compared, the harvesting weight of pabda was significantly (p<0.05) higher in T1 than that of T2 and T3. The average weight attained by gulsha was 38.49±2.33, 27.91±2.32 and 23.56±3.21 gm in T1, T2 and T3, respectively. However, it was observed that average weight of gulsha of T1 and T2 were significantly (p<0.05) better than T3. At harvest, the average weight of monosex male tilapia was 401.63±7.60 gm, 395.21±10.00 gm and 389.37±6.24g, in T1, T2 and T3, respectively. The weight of Monosex tilapia was varied significantly (p<0.05) in T1 than other treatments (T2 and T3). The specific growth rate (SGR) of pabda, gulsha, and monosex male tilapia were found to vary from 1.43 to 1.61, 1.36 to 1.53, and 1.47 to 1.98, respectively. Among the treatments, the highest SGR value of fishes was observed in T1. The highest specific growth rates of pabda, gulsha and monosex male tilapia in T1 were 1.61±0.41, 1.53±0.32 and 1.98, ± 0.58 respectively. The probable reason for the maximum weight gain by pabda and gulsha in T1 was lower stocking density. On the other hand, the lowest weight gain was observed in T3 where were stocked in highest density. The low growth rate of pabda and gulsha in T2 and T3 appeared to be related with higher densities and increased competition for food and space and an inverse relationship with the stocking density indicated that space had limiting effects operate on the population (Johnson 1965). The present results well aggrement with the findings of Kohinoor *et al*., (2004) who obtained the best growth in gulsha farming at lower stocking densities. While, in another study Kohinoor *et al*., (2012) reported that the lower density resulted higher size and higher survival rate in *Hropneustes fossilis*. In the present experiment, the highest harvesting weight and highest survival rate have been observed in the lowest stocking density. The lowest stocking densities are expected to provide more space, food and less competition (Ahmed 1984, Hasan *et al*., 1982, Haque *et al*., 1984). The percentage of survival of gulsha and pabda were found to vary with the stocking densities. The highest survival was obtained in T1 where the stocking density of pabda and gulsha were 37,050 and 49,400/ha, respectively. The survival rate showed significant ($p<0.05$) differences among the treatments. Survival was found to be negatively influenced by stocking densities. It might be due to higher competition for food and space among the fishes. The present results agree with the findings of Samad *et al*., (2020) and Kohinoor *et al*., (2004) who achieved the best survival at lower stocking densities in gulsha farming. The high percentage of survival obtained in T1 suggests that such factor as healthy fish, predator free pond, favorable ecological condition etc. were important in influencing survival. Lakshmanan *et al*., (1971) and Choudhury *et al*., (1978) expressed the importance of these factors in governing the survival. After six months of rearing, the total production obtained were 11,441±45.93, 10972± 44.81 and 10646±151.72 kg/ha/6months from T1, T2 and T3, respectively. The highest production was obtained from T1, where pabda and gulsha were stocked at the loest stocking density comparing with others. The production levels showed significant ($p<0.05$) differences among the treatments. The contribution of pabda and gulsha in total production was 45.15% in T1, while in T2 and T3 were 43.88% and 44.90%, while monosex male tilapia contributed 54.15%, 56.12% and 55.10 % in the subsequent treatments respectively. Stocking density showed a negative correlation with survival. It means that if stocking density increased, then survival of fish decreased. While, survival indicated positive correlation with production and FCR. Whereas, FCR also attributed positive correlation with production. Hossain *et al*., 2019 and Samad *et al*., 2020 showed pabda polyculture is proming when practiced polyculture with others valued fish. The production performancs of this study is more in line with Samad *et al*., (2020) and Hossain *et al*., (2019). Sourove (2020) and Karim *et al*., (2017) showed a of production 9.6 ton/ha/6months cultured monosex tilapia which is more or less well agreement with the present study because the study found the production of monosex tilapia near about 8.8 ton/ha/6 months. Mehrim *et al*., (2018) and Neela (2018) investigated near about 55% adding effects of monosex male tilapia in polyculture system which is more close to the finding of the present study as present study calculate averaged 55.12% adding effects of monosex male tilapia in pabda and gulsha mixed culture system.

CONCLUSION

In the present study, the net return was higher than the any other reviewed research findings in Bangladesh. The production as well as economic return was very encouraging and the endangered fish Pabda and gulsha fish culture would add an extra value in such a way that farmer may get an opportunity to consume low value GIFT strain readily than sale them to the market. The aquaculture of endangered small fish like pabda (O. pabda) and gulsha (M. cavasius) with GIFT strain would add social benefit. The fish farmer would get opportunity to sell the high valued pabda and gulsha at a higher price in the market. They would get an opportunity to consume the relatively available low valued fish GIFT rather sell if there is enough opportunities. It was found that polyculture of pabda, gulsha and GIFT is feasible. The production of all three fish species were increasing. The study also revealed that the small and shallow water bodies may generously be used for small indigenous fish species (SIS) culture and indicates the feasibility of attaining a good production of the same along with GIFT strain. Three treatments were assigned in this experiments more or less closely related benefit and performances. It also indicated that feed efficiency was maximum and net return was significantly higher in treatment T_3 compared to other treatments such as T_1 and T_2. The adding effects of GIFT strain was handsome and promising. From this research it was revealed that the culture of high valued small indigenous fish species (SIS) pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) with GIFT strain (*Oreochromis niloticus*) may be a suitable polyculture technology for rural poor. However, to save feed cost, commercial diet should be used in a more efficient way. Moreover, the gross production of polyculture fish culture can be enhanced much with the minimum feed cost through adoption of proper culture practices, administration of good quality feed and maintenance of proper species combinations. Therefore, improvement of culture technology and sufficient consultancy services from DoF and developments partners in time could increase Fish production in the study areas.

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