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Study on the Cultural Suitability of *Amblypharyngodon mola* with *Barbodes gonionotus* and *Cyprinus carpio* in a Farmer's Rice Fields

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Abstract: The experiment was carried out simultaneously to compare the growth performance of *Amblypharyngodon mola* in rice fish culture system with *Barbodes gonionotus* and *cyprinus carpio* in farmer's rice fields near to Bangladesh Agricultural University campus, Mymensingh for a period of 113 days from 12th August to 3rd December, 2002. Three treatments viz., T_1 with *A. mola* and *B. gonionotus*, T_2 with *A. mola* and *C. carpio* and T_3 as control (without fish) were used in this study. Each treatment was provided with three replications. All the treatments were fertilized with urea (200 kg ha^{-1}), TSP (150 kg ha^{-1}) and MP (75 kg ha^{-1}). With respect to cultural suitability, *A. mola* showed comparatively high growth rate and survival rate when it was stocked with *C. carpio* than with *B. gonionotus*. Among the three species *A. mola* showed the lowest growth rate and *C. carpio* showed the highest growth rate by average, net and percentage of increase. The production of fish were also recorded higher (576.27 kg ha^{-1}) in the treatments stocked with *A. mola* and *C. carpio* than (298.91 kg ha^{-1}) the treatment stocked with *A. mola* and *B. gonionotus*. However, the growth rate and survival rate of *A. mola* were always higher in treatment T_1. Significantly ($P<0.01$) higher yield of grain and straw were obtained in the treatments with fish than without fish and they were found to increase over the control by 15.88-19.34% for grain and 12.78-15.34% for straw. The initial values (before rice transplantation) of soil pH, organic matter, total nitrogen, phosphorus and potassium contents did not show any significant difference among the treatments in most cases, but the final values (after harvest of rice and fish) of the same were recorded significantly higher in the treatments with fish than that of control (without fish) in most of the cases except pH.

Key words: SIS, *A. mola*, *B. gonionotus*, *C. carpio*, rice fields

INTRODUCTION

Introduction of fish into the rice fields in a managed way have a number of advantages, such as it helps in increasing the yield of rice by take up harmful insects, pests and weeds[1,2] and increase the farm fertility by adding organic excreta. In Bangladesh, total efforts of fish culture have been mainly directed to the culture of Indian major carps and some exotic carps. But there are more than 50 small indigenous species of fishes (SIS) which play an important role in the national diet of Bangladesh. There is a great potential of culture of these small indigenous fish species[3]. Among these mola (*Amblypharyngodon mola*) has drawn special interest because of its high nutritional value. It is most demandable and delicious small indigenous fish to the people of Bangladesh. The potential biological advantages which *A. mola* offer is their rapid growth, several spawning in the same season and possibility to culture in the shallow stagnant water like rice fields[4]. Mola is particularly important for its high content of vitamin A than any other edible fish[5].

Bangladesh, an agro-based country, is endowed with vast potential of integrating fish culture with rice farming. The total area of rice fields in Bangladesh is about 10.14 million ha which can play an important role in increasing fish production[6]. Rice fish culture is considered as an ecosystem that fully utilizes natural resources, save energy and recycled waste. It improves sustainability, productivity and profitability of the farms[7] and provides additional income from the production of fish and also increases the yield of rice[8]. In this integrated culture system, both rice and fish are benefited and help each

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other. In view of the above facts, the present study has been designed to determine the cultural suitability of *Amblypharyngodon mola* with *Barbodes gonionotus* and *Cyprinus carpio* in a farmer's rice fields.

MATERIALS AND METHODS

The experiment was conducted in 9 different size farmer's rice plots near to Bangladesh Agricultural University campus from 12th August to 3rd December, 2002. The area of the plots ranges from 35 to 45 decimals. All the plots were facilitate by having small ponds, the size of which varies from 3 to 7 decimals. Rainwater and irrigated water from the deep tube-well were the sources of water supply to the experimental plots. Small water channels (0.70 m width and 0.30 m depth) were made between the plots of the experiment to supply water. Embankments (0.70 m height and 0.50 m width) were made surrounding the experimental areas, which have made the plots free from flood. The plots were well ploughed, leveled and made weed free. All the experimental plots were fertilized with urea, triple super phosphate (TSP) and muriate of potash (MP) at the rate of 200, 150 and 75 kg ha^{-1}, respectively. The 45 days old seedlings of rice variety BR-10 were transplanted on 12 to 15 August, 2002 in alternative row spacing of 35±15 cm. The plant to plant distance given was 20 cm. The alternate raw spacing would provide enough space for easy movement of fishes and sunlight to fall on water between the raw and improve the yield of plankton, fish and rice. Three treatments were tried in this experiment and each treatment was provided with three replications. In T_1 *A. mola* was stocked with *B. gonionotus* and in T_2 *A. mola* was stocked with *C. carpio*. In T_3 was kept as control i.e. without fish. The stocking densities given were 20,000 ha^{-1} for *A. mola* and 5,000 ha^{-1} for both *B. gonionotus* and *C. carpio*. Stocking of fingerlings was done after 12 to 15 days of transplanting rice seedlings. During the period of fish culture, water level between 15-30 cm. No pesticide was applied to the crop and no supplementary feed was used for fish.

Water quality parameters: Water temperature and dissolved oxygen were measured directly in the field with the help of a Celsius thermometer and a digital electronic DO meter (YSI, MODEL 58), respectively. pH was measured with the help of an electrical pH meter (JENWAY, MODEL 3020) in the Water Quality and Pond Dynamics Laboratory of Fisheries Faculty from the water which was collected from the rice fields.

The concentration of nitrate-nitrogen (mg L^{-1}) and phosphate-phosphorus (mg L^{-1}) of water samples were determined in the laboratory after filtering the water samples taken from each rice field plot by using spectrophotometer (HACK DR 2000) and reagent pillow nitrover-3 and phosver-3. Chlorophyll-a (µg L^{-1}) was measured by using methods described by Stirling[9].

Harvesting of rice and fish: On maturity, the rice was harvested plot wise at 3rd December, 2002, i.e., 113 days after transplanting of seedlings. To determine the yield of rice grain and straw, representative samples of rice were taken from each plot comprising an area of 10 m^2 randomly. The grain and straw were then cleaned, sun dried to 14% moisture content and weighted plot wise and then converted to ton/ha. The fishes were harvested immediately after harvesting of rice i.e., after 95 days of stocking fingerlings.

Estimation of growth, survival and yield of fish: The length (cm) and weight (g) of fish were recorded separately with the help of measuring scale and a portable sensitive electronic balance (Model OHAUS CT 1200-S). The collected fishes from the plots were counted and the number was recorded separately species wise and plot wise. The total length (cm) and weight (g) of 30 fish of each species were taken randomly without any bias from each plot to determine the survival rate, growth and yield of fish.

Chemical analysis of soil: To determine the nutrient concentration of soil, the soil samples were collected at a depth of 0-15 cm from the surface of each treatment. The samples were collected in two installments: first, before rice transplantation and finally, after the harvest of rice and fish then the samples were air dried and ground to pass through 2 mm sieve. Then the parameters of soil viz., pH, organic matter, total nitrogen, available phosphorus and potassium were analyzed by following standard methods outlined by Pipers[10], Jackson[11], Black[12] and Page[13].

Data analysis: All the data were obtained in the experiment were analyzed statistically using Analysis of Variance (ANOVA). The mean values were compared using Duncan's Multiple Range Test[14].

RESULTS AND DISCUSSION

Water quality parameters: The range of water temperature recorded in the present study was found to range from 25.84-30.21°C in all the treatments (Table 1). The water temperature recorded by Gosh[15] and Chowdhury *et al.*[16] ranged from 27.0-29.0°C and

Table 1: Mean values (±S.E.) of different water quality parameters with range under three different treatments of the experiment

Treatments	Parameters					
	Temp. (°C)	DO (mg L^{-1})	pH	NO_4-N (mg L^{-1})	PO_4-P (mg L^{-1})	Chlorophyll-a (µg L^{-1})
T_1	28.43±0.12	4.05±0.06	7.11±0.06	1.83±0.10	0.56±0.06	17.44±0.67
	26.20-30.21	3.92-4.16	6.88-7.33	1.60-2.10	0.38-0.66	14.26-21.31
T_2	8.09±0.09	3.84±0.07	7.35±0.07	1.76±0.08	0.59±0.05	17.99±0.78
	25.84-29.80	3.70-4.00	7.04-7.55	1.59-1.93	0.42-0.71	15.07-22.05
T_3	28.19±0.10	4.09±0.06	7.36±0.09	1.81±0.09	0.68±0.06	20.33±0.82
	26.12-30.08	3.85-4.25	7.08-7.62	1.57-2.12	0.57-0.82	15.23-26.17

Table 2: Growth rate, survival rate and production of fish under two different treatments

		Number ha^{-1}	Average weight (g)		Weight gained			
Treatments	Species stocked	Stocked	Initial	Final	Net increase	(%) increase	Survival (%)	Production (kg ha^{-1})
T_1	*A. mola*	20000	0.98±0.03	2.45±0.05	1.47±0.04	150.00	38	18.62
	B. gonionotus	5000	6.41±0.09	83.67±0.79	77.26±0.77	1205.30	67	280.29
Total		25000						298.91
T_2	*A. mola*	20000	0.95±0.03	2.48±0.02	1.53±0.05	161.05	47	23.31
	C. carpio	5000	8.52±0.22	184.32±1.85	175.80±1.91	2063.38	60	552.96
Total		25000						576.27

Table 3: Average yield of rice grain and straw and their percentage of increase over the control in three different treatments.

	Average yield (mt ha^{-1})		% of increase over the control	
Treatments	Grain	Straw	Grain	Straw
T_1	6.35±0.07^{a}	7.50±0.02^{a}	15.88	12.78
T_2	6.54±0.06^{a}	7.67±0.08^{a}	19.34	15.34
T_3	5.48±0.04^{b}	6.65±0.08^{b}	-	-

Table 4: Concentration of different nutrients in soil before rice transplantation (Initial) and at harvest (Final) under three different treatments.

Treat-ments	pH		Organic matter (%)		Total nitrogen (%)		Phosphorus (ppm)		Potassium (ppm)	
	Initial	Final	Initial	Final	Initial	Initial	Final	Initial	Final	Initial
T_1	6.35^{a}±0.01	6.42^{a}±0.02	1.106^{a}±0.002	1.937^{a}±0.008	0.055^{a}±0.006	0.153^{a}±0.006	10.269^{a}±0.083	12.793^{a}±0.102	53.175^{a}±1.079	69.775^{a}±0.722
T_2	6.46^{a}±0.04	6.25^{a}±0.01	1.113^{a}±0.004	1.985^{a}±0.006	0.056^{a}±0.009	0.158^{a}±0.007	10.085^{a}±0.040	13.106^{a}±0.078	54.548^{a}±0.679	73.108^{a}±1.687
T_3	6.57^{a}±0.03	6.54^{a}±0.02	1.108^{a}±0.005	1.516^{b}±0.010	0.053^{a}±0.004	0.107^{b}±0.004	10.164^{a}±0.031	11.032^{b}±0.128	54.673^{a}±1.014	60.857^{b}±0.681

Dissimilar alphabets exhibit significant differences ($P<0.05$)   Similar alphabets exhibit no significant difference

27.30-31.20°C in the rice fields which were more or less close to the findings of the present study. The range of dissolved oxygen content of the present study (3.70-4.25 mg L^{-1}) were found to lie within the values 3.90-4.50 mg L^{-1} and 3.5-6.17 mg L^{-1} recorded by Chowdhury *et al.*[16] and Gosh *et al.*[17] , respectively in their study on rice fish culture. Dissolved oxygen content was relatively low in T_2 than T_1 and T_3. This might be due to the activity of *C. carpio* in the bottom of rice fields which makes the water turbid and lowers the DO content. Gosh[15] also reported that dissolved oxygen content of the water in rice fields ranged from 3.2 to 4.5 mg L^{-1} in monsoon and 2.2 to 2.9 mg L^{-1} in summer, respectively. In the present study, the pH values of water found to be ranged between 6.88-7.62 which was almost close to the neutral value indicating suitable condition for fish culture. The ranges of pH values obtained by Whitton *et al.*[18], Ali[19], Ghosh[15] and Chowdhury *et al.*[16] were 6.53-7.08, 7.1-8.0, 6.7-7.8 and 5.63-8.20, respectively which considered by them within productive level for rice-fish culture. The range of nitrate-nitrogen values recorded by Ali[20] and Whitton *et al.*[18] were 0.22-0.23 and 0.0006-0.05 mg L^{-1}, respectively. The values of nitrate-nitrogen recorded in the present study (1.57-2.12 mg L^{-1}) were higher than those of the above statements. One of the possible causes of higher values of nitrate-nitrogen was fertilization with urea in three installments (15, 55 and 70 days after transplanting of rice seedlings). However, nitrate values recorded by Ghosh[15] and Chowdhury *et al.*[16] ranged from 0.02-2.60 and 1.30-3.40 mg L^{-1}, respectively and these results more or less agree with the findings of the present study. The values of phosphate-phosphorus concentrations obtained in the present study (0.38-0.82 mg L^{-1}) lie within the range (0.03-0.99 mg L^{-1}), reported by Ghosh[15]. Whereas, Chowdhury *et al.*[16] obtained wide range of phosphate-phosphorus concentrations ranged from 0.05-2.62 mg L^{-1} in his study on rice-fish culture. Alikunhi[21] suggested that good productive pond water for fish cultivation should have a concentration of phosphate within the range of 0.02-0.4 ppm. Chlorophyll-a concentration per unit volume of water is a good index of planktonic biomass represented by chlorophyll pigment. The concentrations of chlorophyll-a among different treatments were found to range from 14.26-26.17 μg L^{-1} . The range of Chlorophyll-a values (20.5-24.8 μg L^{-1}) reported by Nath[22] in her experiment on rice-fish culture was almost close to the values recorded in the present study. Ali[20] recorded the chlorophyll-a concentration of 45.2 μg L^{-1} in rice fields in Malaysia. Again the values of chlorophyll-a the present study lie within the ranges (14.7-55.1 and 10.1-41.0 μg L^{-1}) recorded by Uddin[23] and Chowdhury *et al.*[16], respectively. However, among all the treatments comparatively high concentration of Chlorophyll-a was recorded in T_3 (control) than T_1 and T_2 (with fish) which might be attributed to grazing pressure of fish on phytoplankton. Again the values of Chlorophyll-a concentration showed remarkable fluctuations during the study period which might be associated with fertilization, variation of water depth and grazing by fish.

Growth of fish: During the experimental period the growth rate of *A. mola* by average, net and percentage of increase was higher in combination with *C. carpio* in T_2 which was more or less closely followed by combination with *B. gonionotus* in T_1. The lower growth of *A. mola* in combination with *B. gonionotus* in T_1 might be associated with more food competition between them as both of them are plankton feeder in the same water zone (Table 2). However, the growth rate of *A. mola* by average, net and percentage of increase in weight was much higher than the growth rate reported by Chowdhury *et al.*[16] and Das[24], respectively. Mondol[25] reported that the average growth rate of *A. mola* were 6.7 cm and 2.7 g which is more or less close to the present study. The growth rate of *B. gonionotus* recorded by Chowdhury[26] was almost similar to the findings of the present study. Whereas the growth rate of this fish (38.0, 54.42 and 66.3 g) reported by Akhteruzzaman *et al.*[27] Uddin *et al.*[28] and Chowdhury *et al.*[4] were found less growth rate obtained in the present study. But the growth rate (95-115 g) recorded by Hossain *et al.*[29] was higher than the growth rate recorded in the present study. The growth rate of *C. carpio* recorded in the present study was almost similar to the growth rate (113-189.4 g) reported by Hossain *et al.*[29]. But the growth rates (63 and 114 g) reported by Akhteruzzaman *et al.*[27] and Chowdhury *et al.*[4] were far less than the growth rate recorded in the present study.

Survival of fish: The survival rate of fish was determined from the recovery data at the end of the experiments. The survival rate of *A. mola* recorded in T_2 were 47% (stocked with *C. carpio*) was higher than the same obtained in T_1 (38%) when it was stocked with *B. gonionotus* (Table 2). The survival rate of *A. mola* recorded by Chowdhury[26] 37 to 42%, Mondol[25] 35 to 42% and Das[24] 37 to 44% were more or less similar to the survival rate obtained in the present study. The survival rate of *B. gonionotus* (67%) which was almost close to the survival rates 62, 65, 68 and 69% reported by Rahman *et al.*[30], Akhteruzzaman *et al.*[27], Chowdhury *et al.*[4] and Das[24], respectively in their study. On the other hand, the survival rate of *C. carpio* obtained in the present study (60%) was almost similar to the survival rate (58 to 63%) recorded by Mondol[25] and (61%) by Das[24].

Yield of fish: The yield of *A. mola* recorded in the present study was 18.62 kg ha^{-1} in T_1 and 23.31 kg ha^{-1} in T_2, respectively (Table 2). In case of *A. mola*, the yield of newly produced fries were not counted here as they were too small to be harvested. However, the yield of *A. mola* (12.5, 7.92 and 8.96 kg ha^{-1}) recorded by Chowdhury *et al.*[4] was lower than the yield obtained in the present study. But the yield of the same 1,750 kg ha^{-1} per year and 58.57 kg ha^{-1} 4^{-1} months recorded by Ameen *et al.*[31] and Islam [32]; respectively were much higher than the yield obtained in the present study. The yield of *B. gonionotus* recorded by Khan *et al.*[33], Uddin *et al.*[28] and Chowdhury *et al.*[4] were 229.22, 244.9 and 169.29 kg ha^{-1}, respectively which were much lower than the yield of *B. gonionotus* (280.29 kg ha^{-1}) obtained in the present study. On the other hand, the production of *C. carpio* (552.96 kg ha^{-1}) recorded in the present study was found to lie within the range (300-747 kg ha^{-1}) recorded by Yuchang and Yixian[34] from the stocking of *C. carpio* in rice fields. Whereas the production of *C. carpio* recorded by Khan *et al.*[33] and Chowdhury *et al.*[4] were 233.49 and 252.92 kg ha^{-1}, respectively which were far less than the production obtained in the present study. Between the two treatments, the yield of fish was higher in T_2 (576.78 kg ha^{-1}) stocked with *A. mola* and *C. carpio* than T_1 (298.91 kg ha^{-1}) stocked with *A. mola* and *B. gonionotus*. However, these yield of fish are much higher than the yield obtained by Chowdhury *et al.*[4] by stocking *A. mola, B. gonionotus* and *C. carpio*.

Yield of rice grain and straw: The average production of rice grain obtained in T_1, T_2 and T_3 were 6.35, 6.54 and 5.48 mt ha^{-1}, respectively which was found to increase by about 15.88% in T_1 and 19.34% in T_2 than in T_3 (control i.e., without fish) of the experiment. The average production of straw recorded in T_1, T_2 and T_3 were 7.50, 7.67 and 6.65 mt ha^{-1}, respectively which was found to increase by about 12.78% in T_1 and 15.34% in T_2 than that of T_3 (i.e. control) (Table 3). The yield of grain and straw were found to differ significantly ($P< 0.05$) between the treatments with fish and without fish. Among the three treatments, the highest yield of grain and straw were obtained in T_2 stocked with *A. mola* and *C. carpio* which was closely followed by the yield obtained in T_1 stocked with *A. mola* and *B. gonionotus* and the lowest of the same was obtained in T_3 (without fish).

The increased productions of both grain and straw in the treatments with fish than without fish (control) indicate that the introduction of fish in rice fields improves the production of grain and straw. These findings agree with the findings of Purba[35], Uddin *et al.*[36] and Chowdhury *et al.*[36] who also obtained significant difference in the production of grain and straw between the treatments with and without fish in rice-fish culture. The production of rice grain and straw reported by Chowdhury *et al.*[4] and Uddin *et al.*[28] were less than the production of the same obtained in the present study. However, the production of grain recorded by Haroon and Alam[37], Gupta and Mazid[38] and Kohinoor *et al.*[39] in their experiments on rice-fish culture were more or less close to the same obtained in the present study.

In the present study, the production of grain and straw were found to increase in the treatments with fish from that of control (without fish) by about 15.88% and 19.34% in grain and 12.78% and 15.34% in straw in T_1 and T_2, respectively. These findings were in conformity with the findings of Lightfoot *et al.*[7], Uddin *et al.*[36] and Chowdhury *et al.*[4]. These increments of grain and straw production might be associated with the presence of fish in rice fields, which reduces the incidence of weeds and harmful pests by eating upon them. Coche[1] and Kumah *et al.*[40] also stated that introduction of fish in the rice fields reduces the infestation of insects and weeds by feeding upon them and thereby improves the production of rice. Fish also increased the availability of nutrients in soil by their faeces as well as by their movement.

Availability of nutrients in soil: The availability of nutrients in soil of different treatments were determined before rice transplantation and after the harvest of rice and fish (Table 4). The initial and final values of soil pH did not show any significant difference among the treatments. No significant difference was also observed in the initial values of organic matter, total nitrogen, phosphorus and potassium among three treatments, but the final values of them showed significant ($P<0.05$) differences between the treatments with fish and without fish. The significantly higher concentrations of nutrients in the soil with fish than without fish in all the treatments of the experiment clearly indicate that the introduction of fish in the rice fields improved the nutritional status of soil. These might be associated with the accumulation of fish faeces, stirring and turbulence action of fish in rice fields. The results of the present study are in conformity with the findings of Middendrop[41], Xu and Guo[42], Gaunt *et al.*[43], Uddin *et al.*[36] and Chowdhury *et al.*[4]. They stated that the introduction of fish in the rice fields stimulates the activities of microrganisms, increases the availability of organic matter by faeces and increases the release of nutrients for better growth of rice. However, the values of soil nutrients obtained in the present study are more or less close to range of the same recorded by Uddin *et al.*[36] and Chowdhury *et al.*[4].

From the above results of the present study, it may be concluded that the introduction of fish in rice fields has profound impacts on the availability of nutrients in the water and soil which ultimately increase the yield of rice grain and straw and at the same time provides an additional yield of fish from the same land. Thus the rural resources poor farmers will be benefited economically and nutritionally to a considerable extent by adopting rice-fish culture through increased yield of rice grain and straw and additional yield of fish. The species composition of *A. mola* with *C. carpio* was found to be most suitable for rice-fish culture considering the growth, survival and yield as well as their impacts on nutrient concentrations both in water and soil. Since *A. mola* breed in natural condition requires no additional cost to buy for future stocking, if there is a provision of pond in the rice fields for shelter of fish in adverse condition so that they can grow and breed well there.

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