Bangladesh J. Fish. Res., 5(1), 2001: 29-35

Growth and yield of GIFT (*Oreochromis niloticus*) and Thai silver barb (*Barbodes gonionotus* Bleeker) in rice fields and their effects on the yield of rice

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Abstract
An investigation into the growth and yield of Genetically Improved Farmed Tilapia (GIFT) (*Oreochromis niloticus*) and Silver barb (*Barbodes gonionotus*) in rice fields and their effects on the yield of rice was carried out in nine experimental rice plots. Three treatments viz., treatment-1 with *O. niloticus* (T_1), treatment-2 with *B. gonionotus* (T_2) and treatment - 3 was kept as control (T_3, without fish) were used in this study. Fertilizers such as, Urea (178 kg ha^{-1}), T.S.P (125 kg ha^{-1}) and M.P. (67 kg ha^{-1}) were applied in each treatment. The fishes were stocked @ 6250 ha^{-1} and the experiment was continued for a period of 107 days.

The values of water quality parameters such as, water temperature, dissolved oxygen, pH and chlorophyll-a were found within suitable level. Between the two species, higher specific growth rate was recorded in *O. niloticus* than that of *B. gonionotus*. But *B. gonionotus* showed much higher survival (72%) than that of *O. niloticus* (35%). Similar to survival, higher production (244 kg ha^{-1}) and income (Tk. 6399 ha^{-1}) were recorded in *B. gonionotus* than those of *O. niloticus* (142.8 kg ha^{-1} and Tk. 2137 ha^{-1}). Significant differences ($p<0.01$) in the yield of rice grain and straw were observed between the treatments with fish and without fish.

Key words: GIFT, Thai silver barb, Integrated farming, Rice field

Introduction

Integration of fish with other animals and crops is the most efficient way of increasing production from per unit area of land. The most common forms of integration are those where there is a direct and simple link between activities, such as the use of chemicals and crop waste as fish feed and fertilizer. Rice-fish farming is a common practice of integrated farming system. Integration of aquaculture with rice farming improves sustainability, productivity and profitability of the farm (Lightfoot *et al.* 1990).

Bangladesh is fortunate enough to have its vast water resources. It has 2.83 million ha of seasonal paddy fields where water stands for four to six months (Department of Fisheries 1993) providing great scope for rice-fish culture. Fish harvested from these areas is about 37 kg ha^{-1} (Master Plan Organization 1985). The fish production from these water bodies can be increased to a great extent by introducing rice-fish culture. If 5 % of the rice field in Bangladesh can be brought under rice-fish culture, about 76 thousand tones of fish will be produced per year assuming a conservative fish production of 150 kg $ha^{-1}yr^{-1}$. In the above context, the present experiment was undertaken with the following objectives:

- Compare the water quality parameters *viz.*, water temperature, dissolved oxygen, pH and chlorophyll-a in rice fields with and without fish.
- Compare the growth and yield of *O. niloticus* and *B. gonionotus* in rice fields.
- Determine the suitable species for rice fish culture.
- Determine the impact of fish culture in rice fields and the yield of rice.

Materials and methods

Preparation and management of plot

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University during July-December'97 in aman season. The facility consisted of nine experimental rice plots each comprising an area of 140 m^2. The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three treatments viz., T_1, T_2 and T_3 each with three replications. In T_1 the plots were stocked with fingerlings of *O. niloticus,* in T_2 the plots were stocked with fingerlings of *B. gonionotus* and T_3 was kept as control without fish. Dykes separating the plots were raised about 50 cm from the land. Small water channels (0.5 m width and 0.3 m depth) were made between the plots to supply water to them. A common inlet and outlet was provided on the dykes of each plot to regulate water depth. Metal screens were placed at the outlet and inlet to prevent entrance of wild fish as wells as escapement of stocked fish. A small ditch (1.5 x 1.5 x 0.5 m) was constructed at the low-lying area of each plot to provide refuge for fish during low water level and high water temperature. All the plots were fertilized with Urea, T. S. P. and M. P. @ 178 kg ha^{-1} 125 kg $ha^{-1}$and 67 kg ha^{-1} respectively. Forty five days old BR-10 rice seedlings were transplanted on 19 August'97 in alternate row spacing of 35 cm + 15 cm.

The fingerlings of *O. niloticus* were released in three replications of T_1 at a stocking density of 6250 ha^{-1} 15 days after rice transplantation. The fingerlings of *B. gonionotus* were released in three replications of T_2 at the same stocking density at the same date. T_3 was kept as control without fish to compare the variations of rice grain and straw yield with those stocked with fish. During the period of fish culture water level was maintained between 12-25 cm. Top dressing of Urea fertilizer was done in three occasions at equal amount on 12, 35 and 65 days after transplantation of rice seedlings. Only bird perches (3-4/plot) were placed in the plots aiming to reduce pest infestation.

Harvesting of rice and fish

Rice was harvested after 107 days of transplanting. The representative samples of rice were taken from each plot from an area of 1 m^2 randomly. After threshing and sun drying, the weight of grain and straw of rice were taken plot-wise. Water was drained out slowly from the plots and the fishes were collected by hand picking. The fishes collected from each plot were counted and the number was recorded plot-wise. The total length and weight of individual fish was measured for 30 fishes from each plot.

Estimation of growth of fish

To estimate the growth of fish, 10 fishes were sampled fortnightly with the help of a cast net from each plot. This was done at the time of minimum water level, when most of the fishes took shelter in the trench, then the cast net was spread manually to cover it. Then the length (cm) and weight (g) of individual fish were recorded separately with the help of a measuring scale and a electronic balance. Growth grained by the fishes was expressed in Specific Growth Rate (SGR) by the following ways:

a) Specific Growth Rate (SGR % day) in length $= \dfrac{\log_e L_2 - \log_e L_1}{T_2 - T_1} \times 100$

b) Specific Growth Rate (SGR % day) in weight $= \dfrac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$

Where, L_1 = Initial length of live fish (cm) L_2 = Final length of live fish (cm)
W_1 = Initial weight of live fish (g) W_2 = Final weight of live fish (g)
$T_2 - T_1$ = Duration of the experiment (day)

Estimation of survival and yield of fish

The survival of fishes for each treatment and replication were estimated on the basis of number of fish harvested at the end of the experiment. The gross and net yield of fish for each treatment were determined by multiplying the average gain in weight of fish both in gross and net by the total number of fish survived in each treatment at the end of the experiment. Yield per plot were then converted to yields per ha.

Yield of rice grain and straw

The total weight of dried grain and straw of rice per plot were calculated by multiplying the weight of the grain and straw obtained in per square meter of a particular plot with the total area of each plot. These yields of grain and straw data were then converted to yield per ha.

Measurement of water quality parameters

Water quality parameters in rice fields such as, water temperature, dissolved oxygen, pH and chlorophyll-a were measured once fortnightly. Water temperature (^{0}C) and dissolved oxygen (mg l^{-1}) were measured with the help of a portable DO meter (YSI Model 58) and pH of water was determined with the help of a portable pH meter (Jenway, Model 3020). Chlorophyll-a was determined by using a spectrophotometer (Milton Roy Spectronic, Model 1001 Plus) after filtering water sample through Whatman filter paper (46 cm).

Results

Water quality parameters

Water quality parameters of rice fields such as, temperature, dissolved oxygen, pH and chlorophyll-a were measured and the values so far recorded have been shown in Table 1. The average values of water temperature, dissolved oxygen, pH and chlorophyll-a varied from 29.4±1.78°C-29.5±1.77°C, 4.8±0.42 mg/l – 4.9±0.46 mg/l, 7.3±0.10-7.4±0.14 and 29.04±2.74 µg/l-39.5±4.52 µg/l respectively among the different treatments. A more or less decreasing trend in the values of dissolved oxygen was recorded from the start of the experiment towards the end of it. Chlorophyll-a concentration was recorded higher in treatment T_3 where no fish was stocked than the rest of the treatments.

Growth of fish

During the period of study the SGR by length and weight recorded in *O. niloticus* were 1.07 ± 0.03 % and 2.82 ± 0.49 % and that in *B. gonionotus* were 0.80 ± 0.01 % and 2.30 ± 0.01% respectively (Table 2). However, between the two species *O. niloticus* showed higher SGR than that of *B. gonionotus*.

Survival and yield of fish

Between the two species *B. gnionotus* showed much higher survival (72%) than that of *O. niloticus* (35%).The gross and net yield recorded were 244.9 kg ha^{-1} and 222.8 kg ha^{-1} in *B. gonionotus* and 142.8 kg ha^{-1} and 132.5 kg ha^{-1} in *O. niloticus* respectively (Table 3). Significantly higher ($p<0.01$) gross and net yield were recorded in *B. ginionotus* than those of *O. niloticus*.

Income

At the end of the experiment the gross and net income obtained from fish were Tk. 5712.00 ha^{-1} and Tk. 2137.00 ha^{-1} for *O. niloticus* and Tk. 10286.00 ha^{-1} and Tk. 6399.00 ha^{-1} for *B. gonionotus* respectively (Table 4). The benefit-cost ratio obtained were 0.60 for *O. niloticus* and 1.65 for *B. gonionotus*. The profit obtained from *B. gonionotus* was more than double the profit obtained in *O. niloticus* under rice fish culture.

Table 4. Gross and net income with benefit - cost ratio from fish culture in rice fields

Treatment	Cost (Tk. ha^{-1})			Income(Tk. ha^{-1})		Benefit – cost ratio
	Land preparation	fingerling	Total	Gross	Net	
T_1 (*O. niloticus*)	450	6250x0.50= 3125	3575	142.8x40= 5712	2137	0.60
T_2 (*B. gonionotus*)	450	6250x0.55= 3437	3887	244.9x42= 10286	6399	1.65

Yield of rice and straw

The recorded yield of rice were found to be 4.4-4.7 t ha^{-1} in T_1, 4.5-4.8 t ha^{-1} in T_2 and 3.7-4.2 t ha^{-1} in T_3. The average yield of rice obtained in the treatments T_1, T_2 and T_3 were 4.6 t ha^{-1}, 4.7 t ha^{-1} and 3.9 t ha^{-1} respectively (Table 3). Rice yield increased by about 17% in T_1 and 19% in T_2 than the yield obtained in T_3 (i.e., without fish). Statistically significant differences ($p<0.01$) were recorded in the yield of rice between T_1 and T_3, and T_2 and T_3.

The recorded yield of straw were found to be 4.2-4.5 t ha^{-1} in T_1, 4.4-4.5 t ha^{-1} in T_2 and 3.4-3.7 t ha^{-1} in T_3. The average yield of the same recorded in T_1, T_2 and T_3 were 4.3 t ha^{-1}, 4.4 t ha^{-1} and 3.6 t ha^{-1} respectively after sun drying (Table 3). Straw yield was found to increase by 19% in T_1 and 22% in T_2 as compared to T_3 (i.e., rice monoculture). Statistically significant differences ($p<0.01$) were also recorded in the yield of straw between the treatments with fish and without fish.

Discussion

The water temperature recorded in three treatments during the study period was within suitable range for fish culture. Ghosh (1992) mentioned that the water temperature in the rice field ranging from 27-29^0 C are suitable for fish culture. The range of dissolved oxygen content (3.5-6.8 mg l^{-1}) of water in rice fields of the present study is quite similar to the finding (3.5-6.17 mg l^{-1}) of Ghosh *et al.* (1984). Gosh (1992) also stated that dissolved oxygen content of the water in rice field ranged form 3.0-4.4 mg l^{-1} in winter season. The dissolved oxygen content of the water in all the treatments were found to decrease gradually towards the end of the experiment. This might be associated with the gradual increase of shade on the water surface by rice canopy, which ultimately reduced the photosyntheitc activity of phyotoplankton and the obstraction of rice plants on the free movement of air in the rice fields. The pH values recorded in the present study were within the productive level as reported by Ghosh (1992). Whitton *et al.* (1987) also recorded the pH values between 6.53-7.08 in deepwater rice fields in Bangladesh.

Chlorophyll-a concentration is a good index of planktonic population. During the study period the values of chlorophyll-a concentration were found to range between 17.42 and 60.24 µg l^{-1} among all the treatments. Ali (1990) recorded the chlorophyll-a concentration of 45.2 µg l^{-1} in rice fields in Malaysia which is more or less close to the average values record in T_3 of the present study. Among all the treatments higher average concentration of chlorophyll-a was recorded in T_3 (rice alone) than rest of the two treatments (with fish) which might be attributed to the grazing pressure of fish on plankton. The fortnightly average values of chlorophyll-a content showed noticable fluctuations in all the treatments. This might be associated with fertilization, variation of water depth and grazing by fish.

In the present study it has been observed that between the two species *O. niloticus* showed higher SGR than that of *B. gonionotus* in both length and weight which might be associated with the lower survival of *O. niloticus* resulting in more food and space for the individuals survived. Between the two species *O. niloticus* showed much lower survival (35%) than that of *B. gonionotus* (72%) which might be associated with their schooling behaviour which makes them easily available to snakes and other predators. The survival of *O. niloticus* (68.4%) recorded by Rahman *et al.* (1995) was much higher than the survival recorded in the present study which might be attributed to the relatively smaller size of fingerlings stocked. But the survival recorded for *B. gonionotus* was almost close to the survival 65% and 68% recorded by Rahman *et al.* (1995) and Akhterruzzaman *et al.* (1993) respectively in their experiments.

The yield of fish obtained from the culture of *B. gonionotus* (244.9 kg ha^{-1} by gross, 222.8 kg ha^{-1} by net) was almost double the production recorded for *O. niloticus* (142.8 kg ha^{-1} in gross and 132.5 kg ha^{-1} in net) might be attributed to the much higher survival of *B. gnionotus* than that of *O. niloticus.* The production of *O. niloticus* (416.7 kg ha^{-1}) recorded by Haroon *et al.* (1992) was much higher than the production recorded in the present study might be due to bigger size of fingerlings stocked. But the production of *B. gonionotus* (229.4 kg ha^{-1}) obtained by Gupta and Mazid (1993) was almost similar to the production recorded in the present experiment.

The production of rice grain and straw obtained in T_1 (4.6 t ha^{-1} and 4.3 t ha^{-1}) and T_2 (4.7 t ha^{-1} and 4.4 t ha^{-1}) were found to differ significantly ($p<0.01$) from the production of T_3 (3.9 t ha^{-1} and 3.6 t ha^{-1}). The production of rice grain 4.4 t ha^{-1}, and 4.8 t ha^{-1} obtained by Gupta and Mazid (1993) and Kohinoor *et al.*(1993) respectively were almost similar to the production recorded in the present study. Rice grain and straw yield were found to increase by about 17% and 19% in T_1, and 19% and 22% in T_2 than those of T_3 respectively. Lightfoot *et al.* (1992) summarized published data on rice field from China, India, Indonesia, Philippines and Thiland to show that average percent increases in rice yields ranged from +4.6 to 28.6 due to fish culture. These increament of grain and straw yield might be due to the presence of fish in rice fields which reduces the incidence of weeds and pests by eating upon them. Akhteruzzaman *et al.* (1993) and Mazid *et al.* (1995) 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 yield of rice.

Fish might have also increased the availability of nutrients in soil by their feces as well as by the increased bioperturbation of soil with the movement of fish. Roger (1988) stated that grazing of fish on the aquatic biomass contribute through their feces to nitrogen accumulation at the soil surface.

Conclusions

Culture of fish in the rice fields increase the yield of rice grain and straw. These additional yield of fish, grain and straw of rice will help to improve the economic condition and nutritional status of resource poor farmers. However, between the two species of fish, *B. gonionotus* may be recommended for concurrent rice-fish culture for obtaining better yield and income out of it.

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(Manuscript received 23 November 1999)