# Study on Integrated Rice-Fish Farming in Babugonj Upazilla of Barisal District



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**Session: 1998-99**



**This thesis is submitted to the Fisheries and Marine Resource Technology Discipline in partial fulfillment of the requirements for the degree of Masters of Science in Fisheries and Marine Resource Technology**

**May 2003**

**Study on Integrated Rice-Fish Farming in Babugonj Upazilla of Barisal District**

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# DECLARATION

***These results submitted in this thesis are entirely of the candidate's own investigations and no part of the results has been accepted for any degree, nor it is being concurrently submitted for any degree***

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**Candidate**

**Dilip Banik**

**Dedicated to**

**My Parents**

**&**

**Beloved Devjanee**

# Contents

# Acknowledgement

All praises are due to the Almighty God Who created, and afterwards enabled me to complete the research work successfully.

I would like to express his deep appreciation to my respective and honorable teacher Professor Dr. Khairul Azam, Head, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna, whose kind and continuous inspiration, scholastic guidance, constructive criticism and constant encouragement me to complete this thesis paper successfully.

I express my deepest sense of gratitude and sincere appreciation to my Supervisor Dr. Khandaker Anisul Huq, Associate Professor, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna for his constant vigilance, scholastic, constructive guidance, advice, patience and encouragement to complete this paper.

I wish to complement all of my teachers for their enthusiastic suggestions, continuous encouragement and help with necessary materials.

I accord my hearty reverence to Mr. Anisur Rahman Talukder, Upazilla Fisheries Officer and Mr. Shaymol Kumer Das, Additional Agriculture Officer, Babugonj, Barisal for their guidance, constant encouragement and helpful suggestions.

I also wish to express my deep sense of appreciation to Mr. Ashoke Kr. Sarker A.E.S Fourth Fisheries Project, DoF. for his guidance,helpful suggestion.

I like to extend thanks to the farmers of Ghatokerchar village in Babuganj Upazilla, Barisal District.

I also take heartful thanks to Mr. and Mrs. Harinarayan Roy for their extreme support and help and also give especial thanks to Mr. And Mrs. Dipak Banik, Bidhan my younger brother and Archana, Mita and Panna my younger sisters for their great cooperative and encouragement.

I am also conveying thanks to my friends Mahashin, Nazmul, Mini bhabi and juniors Forhad, Biswajit, and Sagor whose inspirations were all along with me during the hard and tedious times.

I wish to offer sincere gratitude and indebtedness to my parents for their kin interest, generous support and encouragement to carry out the work successfully.

**May 2003** **Dilip Banik**

# Abstract

The study was undertaken at Ghotokerchar village in Babugonj upazilla under Barisal district to assess the feasibility and economic viability of integrated rice fish farming during June to December (Amon season) 2001. Two treatments were designed as treatment T1 (indicates rice cum fish culture) and treatment T2 (indicates rice monoculture). In treatment T1 rice with five species of fish fingerlings viz. thai sarpunti (*Puntius gonionotus*), Common carp (*C. carpio*), rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) were stocked at the rate of 5434 individuals/ha according to Department of Agriculture Extension's recommendation. In treatment T2 the lands were used only for rice production. Fertilizer as urea, TSP, MP and gypsum were used at the rate of 247 kg/ha, 154 kg/ha, 77 kg/ha and 128 kg/ha in T1. On the other hand, T2 was fertilized in the traditional method. The values of water temperature, dissolved oxygen, pH and water depths were found within suitable range for rice-fish farming. Among the species the higher growth (209.99g) and survival rate (73%) was recorded in common carp. The net fish production was recorded to be 397.69 kg/ha in treatment T1. The rice production was higher 3920.24 kg/ha in treatment T1 followed by 3428.01 kg/ha in treatment T2. The benefit cost ratio was higher in treatment T1 (1.96) than in treatment T2 (1.63).

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# Chapter-One

# INTRODUCTION

# 1.0 Introduction

Bangladesh is a developing country. The population of our country is increasing day by day, but the cultivable lands are not increasing. Now it is proper time to produce multiple crops in same lands and same time. There is the possibility to adopt integrated rice-fish culture in different region of Bangladesh. Barisal has a great advantage to habituate such culture system. From the history, it was observed that this zone is very much potential for rice culture. It has a great diverse of low-lying land where rice-fish culture system may be adopted successfully. The study was undertaken at Ghotokerchar village in Babugonj upazilla under Barisal district. Rice fish culture has gained attention because of observations that certain pesticides can control rice pests without affecting fish (Arec, 1985). Moreover, fish culture in rice fields not only increases fish production but may also increase rice production. Integrated rice-fish farming has a long and varied history in Asia. The practice existed in China about two thousands years ago (Li, 1992). Almost one million ha in China and 94000 ha in Indonesia was reported to be under rice-fish farming (Lightfoot *et al.,* 1990). While similar estimates are not available for Thailand and have been expanding rapidly in both countries. Culturing fish and azolla in rice fields is also an important component of organic faming in China (Zaide *et al.,* 1998).

Integrated rice-fish farming practices are highly variable. Fish are usually cultured within rice areas protected from excess flooding by dikes. The rice plot normally includes a small trench, ditch, sump or refuge pond where fish can be held when water levels are low or prior, to harvest. Fish are cultured concurrently with rice or in rotation. A wide variety of fish species have been cultured, including Common carp (*Cyprinus carpio*); Indian major carp such as Rohu (*Labeo rohita*); Mirgal (*Cirrhinus mirgala*) and Catla (*Catla catla*); Chinse carps such as Silver carp (*Hypophthalmicthys molitrix*), and occasionally Grass carp (*Ctenopharyngodon idella*); Nile tilapia (*Orechromis niloticus*); Silver barb (*Barbodes gonionotus*) and Snakeskin gourami (*Trichogaster pectoralis*). Reported fish production figures also vary widely ranging from 100 kg/ha to over 2000 kg/ha, depending on the intensity of the system (Lightfoot *et al.,* 1992). In China, average fish production in 1998 from 800000 ha of rice fields was estimated at 133 kg/ha (MacKay, 1995). In

Indonesia, rice fields are also used as nurseries for raising fingerlings of common carp (Nalim, 1994).

Rice and fish are the staple food of the 134 million people of Bangladesh. Rice production was increased with the introduction of high yielding varieties of rice and increased area under irrigation and flood control during the 1980s and 1990s, but fish production did not increase to the same extent due to the overexploitation of natural aquatic resources and environmental degradation. In the past, poor rural households caught fish from the common property, inland open water resources, to meet their needs. With the decline in catches from open waters as a result of overexploitation and a decrease in floodplain area due to flood control, the availability of fish to the rural poor has declined. Before the intensification of agriculture, farmers captured wild fish that entered the rice fields through flooding by excavation of a sump in the low-lying area of their farms. That source also has dried up with intensification of agriculture and flood control.

The decline in wild stocks, coupled with increasing demand for fish, has led researchers in Bangladesh in the 1970s and 1980s to study the feasibility of integrating fish culture with rice farming. CARE (Bangladesh) has been active in advocating the benefits of adopting integrated rice-fish farming to farmers as a part of its integrated pest management program (CARE, 1992, Kamp and Gregory, 1993).

With a population of 134 million and growing at 1.47% per year, Bangladesh has been facing considerable challenges in meeting the food needs of its population (BBS 2001). The traditional staples of the Bangladeshi diet have been rice and fish. Rice production has increased with the growing population, but production of fish from traditional inland water sources, particularly rivers, has not increased to the same extent. Wild fish stocks are decreasing under increased exploitation, as well as environmental threats, and may not be able meet the growing demand. Fish availability in rural areas is declining and prices are increasing, which will result in fish becoming unaffordable to a majority of Bangladeshi. Per captia protein consumption at 50.5 g/day in 1992-1993 (BBS 1995) is on the decline. Of this, animal protein makes up 7.7 g, with fish contributing the major share with 59.1 %. Even this modest level will decline, if fish production is not increased on a national scale.

Under these circumstances, it is not surprising that aquaculture is growing rapidly. Aquaculture production increased by 9.9% during 1989-1990 to 1995-1996, accounting for 31.0% of total fish production. Pond culture systems have considerable potential for addressing the gap between supply and demand, but they may not in themselves be sufficient since rural households do not have access to ponds.

Integrated fish farming refers to the production integrated management and comprehensive use of aquaculture, agriculture and livestock with an emphasis on aquaculture (IIRR, Silang, Cavite, Philipines, 1992). The knowledge that it is technically possible to cultivate fish as an extra crop in rice-flood waters has been known for thousands of years. However this practice has not been widely adopted despite of its apparent advantages for food production and farm household income. Integrated aquaculture complements and improves the overall yield in terms of labor input and efficiency in terms of resource use (Little and Muir, 1987). The most common forms of integration are those were there is a direct and simple link between activities, such as the use of animal and crop wastes as fish fed and fertilizer. New rice-fish culture is a common practice of integrated farming system. In many systems under intensive rice cultivation, yields are declining, high chemical fertilizer use is causing serious pollution or health problems, pests are becoming resistant and expensive to control and the soils are being depleted of micro-nutrients. Research has shown that introducing fish into a rice farm can help ameliorate all these negative factors. The accumulating fish pond mud provides nutrients for the soil, reducing the use of chemical fertilizers. Fish can be very effective in weed and pest control (as they are predators of many pests), reducing the use and cost of chemicals. The fish provide a highly nutritious protein food for the farmer and the local community. Thus, adding fish to rice fields not only provides an additional product and reduces the cost of fertilization and pest control also improves the productivity and ecological sustainability of rice farming. In fact, aquaculture is now accepted as a strategy for integrated pest management on rice farms.

Integrated rice-fish farming probably the best example of integration, where each other directly benefit the elements, rice and fish. Fish activities in the rice fields enhance the fertility and environment of rice fields and as a result rice yield is increase by 10-15% with very few exceptions (Hora and Pillay, 1962; Khoo and Tan, 1980; Nie *et al.*, 1985; Zhang, 1986; Li, 1988; Dela Cruz *et al.*, 1992 and Kamp and Gragory, 1993). Rice fish culture requires very little extra labor in addition rice cultivation and fish can be reared at the same time. Furthermore, saving labor for weeding can compensate for this extra labor, as fish tends to reduce the incidence of weeds. Fish on the other hand, can play an important role reduce pesticide use by eating rice pest.

Although rice-fish culture as mentioned earlier is still in experimental stage. Some agencies have come forward to promote its technology at farmer's level. As a result, rice-fish farming technology has been slowly extended and adopted by the farmers in Bangladesh. Farming system and environmental studies of Bangladesh Agricultural University, Bangladesh Fisheries Research Institute (BFRI), North-west Fisheries Extension Project (NEEP) in northwest part of Bangladesh CARE, Rangpur and some other local NGOs have been promoting rice-fish farming technology through extension and conducting on station and field based trials for the last 10 years.

Concurrent culture of fish within the rice field has been reported to increase nutrient concentration and uptake by rice (Panda *et al.*, 1987) and rice yields (Lightfoot *et al.*, 1990). Various pathways have been traced for fish to contribute to soil fertility (Pierce, 1968; Khoo and Tan, 1989; Lipton. 1993 and Middendorp, 1985).

Considering the enormous importance of integrated rice-fish farming present study was undertaken with the following objectives:

1. To evaluate the economic performances of integrated rice fish farming.

2. To determine the suitable species of rice fish culture.

Chapter-Two

# REVIEW OF LITERATURES

## 2.0 Review of Literatures

Research work like culture of rice and fish with a similar complex is very rare in Bangladesh. However an attempt has been made to present short discussion of the available literature related to present study.

According to Dewan (1993) NRDP conducted experiments on rice-fish culture by stocking *H. molitrix, L. rohita, C. Mrigala* and *C. carpio* at the stocking densities ranging from 2075-6246/ha. The yield of fish obtained from these experiments varied from 223-700 kg/ha.

Ahmed *et al.* (1995) stated that *C. carpio, P. gonionotus* and *O. niloticus* are suitable fish species for simultaneous method of fish culture in rice field. The stocking densities recommended by them by them were 2500-3000/ha in monoculture 5000/ha in mixed culture and the suggested species ratios were 1:1 for two species combination and 2:2:1 for 3 species combination. The fertilizers such as urea, TSP, MP and gypsum were suggested to apply at rate of 200 kg/ha, 153 kg/ha, 77 kg/ha and 128 kg/ha respectively. The suggested sticking density for monoculture was found to be low especially for *P. gonionotus* and *O. niloticus.*

Aktheruzzaman *et al.* (1993) found that the production of fish ranged from 15 to 127 kg/ha with an average of 76 kg/ha in fields stocked with *P. gonionotus*, 76.75 to 261.75 kg/ha with an average of 56.6 kg/ha from field stocked with *C. carpio* and 14.75 to 222.5 kg/ha with an average of 99.75 kg/ha form fields stocked with mixture of *P. gonionotus* and *C. carpio.* Recovery of fish was found to be 68% in case of *P. gonionotus* and 53% in case of *C. carpio.* Average size reached at harvest were 38 g for *P. gonionotus* and 63 g for C. *Carpio.*

Alam (1996) conducted a research on rice -fish culture in the rice field at Dhaka district. He observed that farmers got 3-5 tones of rice and 234 kg of fish from one hectare of rice field. The net benefits obtained from fish and rice were TK. 1350 and 5000 respectively. The author showed that rice-fish integration is quite attractive.

Ali *et al.* (1998) cultured fish in deep-water rice (DWR) environment using net pen and polder system. In net pen rohu and Thai silver barb were cultured, where as a 5 species combinations (rohu, mrigal, common carp, grass carp and Thai silver barb) were cultured with BR-3-rice variety and DWR. In polder system 2.8 t/ha of fish and 7.33 t/ha of rice were produced with 5 species combinations.

CARE (1992) Bangladesh, initiated for studies for evaluating the use of rice fields as nurseries. The stocking rates used for hatchlings and fry were 315,000-600,000 and 5000-100000/ha respectively. Fingerlings were harvested two months after stocking. The rate for hatchlings was 3-5% and in the case of fry it was 31-45% under both stocking regimes, more that 75% of the farmers were able to make a profit. Net benefit averaged TK. 11,689/ha at high stocking densities of sperm and fry respectively.

Dela Cruz (1986a) stated that in rice culture, additional efforts have to taken to strengthen the dykes and install a metal screen at both the inlet and outlet to avoid fish escape. Trenches, 40-50 cm in width and 20-30 cm in depth, must also be built. This occupies 2-4% of the rice field area. Dela Cruz (1986a) also stated that trenches in the rice-fish systems are constructed to provide more space a refuge for fish, and for ease of feeding and harvesting.

Dewan (1992) conducted experiments on both simultaneous and alternate method of rice-fish culture by stocking fishes in different species combinations and stocking densities. Simultaneous method of rice-fish culture experiments were conducted form 1985 to 1990 by stocking *C. mrigal, L. rohita, C. reba, C. carpio, O. niloticus, P. gonionotus* and *C. batrachus* at the stocking densities ranging from 1521-7000/ha. These studies were carried out both in station (Agronomy field laboratory) and in farmers' fields during aman season by giving 2-3 replications. All the experimental plots were fertilized with urea. TSP and MP at the rate of 178 kg, 125 kg and 67 kg/ha respectively. Rice bean as supplementary feed was applied at the rate 2-3% body weight of fish in the experiment conducted on station. The yield of fish recorded in different experiments ranged form 43-508 kg/ha. The highest yield was 508 kg/ha in monoculture of *P. gonionotus* higher yield (278 kg/ha) was recorded in *C. carpio.*

BFRI undertook studies on rice-fish culture in 68 farmers plots during boro season in collaboration with DAE and ICLARM in 1992 (Gupta and Mazid, 1993). The experimental plots were selected from 12 Thana of Mymenisngh and Jamalpur Districts. The rice plots were stocked with *P. gonionotus* and *C. carpio* at a stocking density of 3000/ha. These two species of fishes were stocked in the plots either singly or in combination in the ratio of 1:1. Some farmers used rice-bran and oil cake while some other used duck weeds as supplementary feeds for fish. Average fish production obtained was 229.4 kg/ha and that of rice yields recorded were 4.4 t/ha with fish and 4.2 t/ha without fish.

Ghosh (1992) conducted experiment by stocking *O. mossambicus* and *C. carpio* at a density of 2500 kg/ha in the rice plots at the Central Rice Institute, Cuttack, India. The average size of common carp recorded at harvesting was 200 g and the yield obtained was 77 kg/ha/90 days. In another experiment *C. carpio* yielded 76.2 kg/ha when they were stocked at 7250/ha. The survival of *C. carpio* was 34%.

Grover (1976) conducted an experiment at the fresh water aquaculture center in the Philipines *Tilapia mossambica* and *Cyprinus carpio* were stocked in that rice-field. The yield was 69-208 kg/ha.

Hickling (1962) stated that the depth of water in rice field for fish culture is mainly 12-15 cm in spring add summer as deep as 18cm in the autumn up to harvest. He stated that generally the production of carp 100-200 kg/ha and the production of *Tilapia nilotic* in Tanzania were 110 kg/ha and paddy field in Taiwan was stocked with fry of Tilapia at the rate of 7000-8000/ha.

Hora and Pillay (1962) reported that rice-fish culture increases rice yield by about 15%. Ibrahim (1975) cultured tilapia in paddy field in Tanaznia and total production of tilapia obtained by him was 112 kg/ha.

Hossain *et al.* (1988) conducted experiment on paddy-cum-fish culture in field laboratory and farmers' fields by stocking with Thai sarputi, mirror carp, mrigal, catla and rohu. The experiment was conducted of a period of 90 days and the yield obtains by them 96.33

kg/ha and 146 kg/ha in farmers' field and field laboratory of Bangladesh Agricultural University, Mymensingh. The growth rate of different species of fishes obtained by them were 95.2-135 g, 113-189.4g, 62g, and 115g in *P. gonionotus, C. carpio, L. rohita, C. catla and C. mrigala* respectively.

Islam *et al.* (1998) conducted an experiment in farmers' fields under Paikgacha Thana, Khulna to study the suitable integrated rice-cum fish culture. Mix and monoculture of *Puntius gonionotus* and *Cyprinus carpio* were stoked at a density of 3750/ha in all the experimental plots. It was found that two cultured species *Cyprinus carpio* attained the highest average individual weight (160g) and survival (81.06%). With respect to biomass and income, highest average fish production and net profit per ha (306.74 kg and TK. 8177.91) were obtained in mixed culture of *Puntius gonionotus* and *Cyprinus carpio.*

Kohinoor *et al.* (1993) of BFRI conducted two rice-fish culture experiments, one in 1988 and another in 1989 during Aman season. Six plots with the size of 1360-2880 $m^2$ were selected from Mymensingh district for the purpose. Each plot was provided with ditch covering 3% of the plot area *P. gonionotus* was stocked at a density of 2000/ha in 3plots each year. The experimental plots were fertilized with urea, TSP, MP and gypsum at the rate of 150, 225, 75 and 75 kg/ha respectively. Rice seedlings of BR-11 were transplanted in the plots. The fish culture period continued for 85-90 days in 1998 and 70-75 days in 1989. The yield of fish recorded was 98.4 kg/ha and 73.6 kg/ha in 1988 and 1989 respectively and rice yield varied between 4.8-5 t/ha.

Li (1992) stated that fish ditches and sumps are dug in rice fields to overcome the constrains posed by sun drying and the application of chemicals and fertilizers. The shallow ditch in usually 33 cm in width, with the small sump usually 1-2 $m^2$ wide and 80 cm deep. Ditches and sumps cover 5-8% of the rice fields area the area the wide ditches are 45-cm width and depth; while the large sump is2.5-4m wide and 1.5-1.8 m deep. Ditches and sumps might be dug on the side of a plot.

Lightfoot *et al.* (1992) summarized published data on rice field from China, India, India, Indonesia, Philippines and Thailand to find that average percent increases in rice yields ranged from 4.6 to 28.6.

Mazid *el al.* (1992) conducted rice-fish culture experiments in 50 farmers plots selected from four Thana of Mymensingh District during Aman season. The experimental plots were stocked with *P goniontus* and *C. carpio* singly and in combination at a stocking rate of 3000/ha. In case of mixed culture, the stocking ratio was 1:1 the average yield of fish recorded were 76 kg/ha for *P. gonionotus.* 157 kg/ha for *C. carpio* and 100kg/ha in combination of two species.

MCC (1994) conducted rice-fish culture experiments both by simultaneous and alternate systems in 1994 to test the technologies by FSRDP of BAU in Noakhali area, with the objective to find suitable species, species ratio and stocking density. Studies on simultaneous method were undertaken by giving 3 treatments with control. In treatment T1 and treatment T2 *P. gonionotus* and *C. carpio* were stocked at the densities of 5500/ha (10:1) and 387/ha (2.5:1) respectively, and in treatment T3 *O. niloticus* and *C. carpio* were stocked at a density of 5500 ha (10:1) Rice seedlings of BR-23 were transplanted in the by giving two row spacing viz., 20cm and 35cm. The fish yields recorded were 162-240 kg/ha. The highest yield of rice (3.5t/ha) was recorded from the field stocked with *P. gonionotus* and *C. carpio* compared to other treatments and even rice alone (MCC, 1994).

Miah *et al.* (1994) studied rice-fish culture for the integrated farming system research at Shuvullah, Mirzapur, Bangladesh. Gross income from thai Sharputi obtained by the farmers was TK. 3570.94 per hectare.

Chapter-Three

# MATERIALS AND METHODS

# 3.0. Materials and Methods

## 3.1. Study Area and Duration:

The study was carried out at Ghatokerchar village of Babugonj upazilla under Barisal District: The study was conducted from June to December (Aman Season), 2001.

## 3.2 Experimental Design:

To study the economic variability of rice-fish farming, two treatments were set up in the experiment namely Treatment T1 and Treatment T2. In each treatment, There were three replication namely R1, R2 and R3 of which the cultivable land ranges from 40-50 decimal. In the experiment, the hectare is used as a unit for calculation. The farmers in each treatment were selected by the following criteria:

Treatment T1: Trained farmers were used for rich fish farming and the training was provided by the Fisheries Training and Extension project under Department of Fisheries.

Treatment T2: Traditional farmers were selected whose lands were used only for rice production.

## 3.3 Plot Preparation:

The farmers excavated ditches and trenches during summer and soil was placing on the dike to maintenance over-flow. The plots were ploughed in two times. Firstly power tiller was used before12-13 days of transplantation and secondly harrow was used for leveling the plots before 2-3 days of transplantation. Height and strengthen dike is important for plot preparation to avoid high tide and the excavation of ditch and trench is used as fish shelter when water level was low. Net screens were used in the dike to drain out excess water during heavy rainfall and to prevent the fish from escaping. On the other hand, the traditional farmers were not maintaining of above criteria. They just prepared their land for rice cultivation.

### 3.4 Construction of Ditch and Trench for Fish:

For the convenience of fish movements and also to provide refuge for high water temperature and low water level, a small ditch was constructed in each plot. Trenches and ditches provide shelter for the fish during the periods of sun drying and applying fertilizers and insecticides. The trenches were 45 cm wide and 45 cm deep. The ditches were located at the nearby the inlet or outlet (Figure-01). About 6% of the total paddy field were covered by the trenches and ditches. The outer trenches were away from the dike by 2 rows of rice plants. Each ditch of the plot was connected with the rest of the field by a small trenches for facilitate the movement of the fish in the rice field. The depth of the ditches was 65 cm.

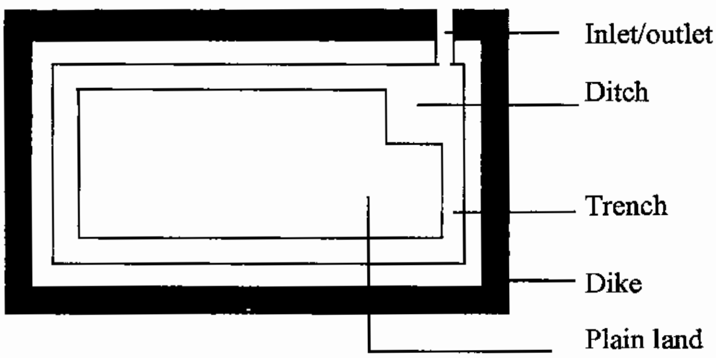


Figure-1: ditch and trench for fish in the rice field.

### 3.5 Fertilizer application:

T1 was fertilized with urea, TSP, MP and gypsum at the rate of 247 kg/ha. 154 kg/ha, 77 kg/ha and 128 kg/ha respectively as recommended by Department of Agriculture Extension. On the other hand, T2 was fertilized in the traditional method. TSP, MP and gypsum were applied just one time before 2-3 days of transplantation. Urea was applied after 30, 45, 55 days of transplanting rice with one third of the total dose in each application.

### 3.6 Rice Variety and Transplantation:

High yielding varieties (HYV) like BR-23 rice was selected for the experiment. Sprouted seeds were shown on a well-prepared wet seedbed on 20 June 2001. The 25-30 days old rice seedlings are normally recommended to use for transplantation (Vergara, 1985). The rice seedlings were transplanted on 15 to 20 July 2001 in alternate row spacing of 30cm and 15cm which is recommended by Hossain *et al.* (1990). The alternate row spacing would provide enough space for easy movement for fishes.

### 3.7 Collection and Stocking of Fish Fingerlings:

Due to its shallowness and rapid changes of water parameters highly resistant powered species like Common carp (*C. carpio*) and thai sarputi (*Puntius gonionotus)* were stocked. The farmers also stocked rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) in the rice field. The fingerlings were collected from local Fish nursery. Farmers stocked fish fingerlings in rice plots 15 days after rice transplantation and when water in the rice field raises up to a depth of at least 8-10 cm. The stocking density (T1) in each plot was given 5434 fingerlings per hectare (Table-01).

### 3.8 Input Used:

The inputs most commonly applied were rich bran and cattle manure. Total quantities were rough estimates. About 649 kg/ha of mean rates of rich bran and cattle manure of 1146 kg/ha were used during the cultivable period. Other inputs like duckweed (*Lemna sp.*) was also used every now and then during the experiment.

### 3.9 Rice Management:

To ensure the rice management according to conventional farmer's practice, one farmer from that locality was involved for growing rice. However, all the activities done with rice were cross-checked against the recommendation of the Department of Agriculture Extension (DAE) for that region and no major difference was observed between the farmers' practice and the recommendation of DAE.

Water level was raised to 10-15 cm 25 days after transplanting to grow natural food in the rice fields. During the period of fish culture water level was maintained manually between

8-38cm. Water level was raised gradually with the growth of rice and fish. Water level was monitored every 4-5 days but measured and recorded fortnightly.

No pesticide was applied to the crop in treatment T1 because fish mortality is commonly seen directly or shortly after pesticide application. But in treatment T2 traditional farmers commonly used pesticide (Sumithion, Malathion, Diazionon) to control pest and diseases. Bird perches were placed in the plots aiming to reduce pest of rice.

### 3.10 Fish Management:

No proper management technique was applied during fish culture other than water supply. During fish culture period, water level was maintained manually between 8-38 cm. There is no major problem.

Supplementary feed was not adequately supplied because the field was enriched with abundance of natural feeds.



### 3.11 Monitoring:

Farms were visited at fortnightly intervals and information collected on the basis of inputs used for rice-fish, pest control, water depth in rice fields, irrigation and production of fish and rice. Major water quality parameters (temperature, dissolved oxygen, pH, water depths) of the farms were measured at fortnightly intervals. At the close of the season, harvests and sales were also recorded (data collection format used is in appendix 01). To determine and assess the constraint of rice-fish farming a questionnaire survey was conducted by providing question sheet among the farmers of the study area (appendix-2).

### 3.12 Measurement of water quality parameters:

Aquatic habitats are influenced by the interaction of physico-chemical forces. Therefore attempts had been taken to measure and record the status of different physico-chemical parameters of water of the plots during the experiment. The water parameter such as water temperature, dissolved oxygen, hydrogen ion concentration (pH), water depths in the plots were recorded fortnightly. The water temperature and water depths were measured by using a Celsius thermometer and measuring scale respectively. Dissolved oxygen and pH was measured with the help of a battery operated DO meter (YSI/Model 58) and an electronic pH meter (Jenway model 3020) respectively.

### 3.13 Harvesting of Rice and Fish:

Rice was harvested 130-135 days after transplanting rice seedlings from each plot. Threshing was done immediately after harvest. Water was drained out slowly from the rice field but water retained in the ditch and trenches from where fishes were collected by netting in treatment T1. The fishes collected form each plot and recorded species wise. The total weight of individual species was measured plot wise.

### 3.14 Growth Estimation of Fish:

To estimate the growth, 10% of each fish species were sampled fortnightly with the help of cast net from each plot. The weight of individuals was recorded separately from each plot in treatment T1. Before measuring the weight of fish excess water of the body was socked by using tissue paper. Growth performance of the fishes was determined by the following ways (Rahman, 2001):

$$\text{Weight gained (g)} = \text{Mean final weight (g)} - \text{Mean initial weight (g)}$$

$$\text{Percentage of weight gained} = \frac{\text{Weight gained (g)}}{\text{Initial weight (g)}} \times 100$$

$$\text{Net increase} = \text{Final weight (g)} - \text{Initial weight (g)}$$

### 3.15 Estimation of Survival Rate and Fish Production:

The survival rates of fishes and production were estimated on the basis of number of fish harvested at the end of the experiment. The gross and net production of fish for each treatment were determined by the following formula (Ghosh, R. 2002):

$$\text{Survival rate (\%)} = \frac{\text{No. of harvested fish}}{\text{Initial No. of fishes}} \times 100$$

$$\text{Gross production (kg/ha)} = \frac{\text{Survival rate} \times \text{Stocking density} \times \text{Final weight (g)}}{1000}$$

$$\text{Net production (kg/ha)} = \frac{\text{Survival rate} \times \text{Stocking density} \times \text{Net increase (g)}}{1000}$$

### 3.16 Data Collection:

Data were collected both from the primary and secondary sources.

**3.16.1 Primary Sources:** The primary data were assembled through field survey by using a prescribed (see in appendix-1) questionnaire. The questionnaire form was filled up through fortnightly field visit.

**3.16.2 Secondary Sources:** Further relevant information on rice fish farming system was collected from research journals, reports and WebPages available on the Internet.

### 3.17 Data Analysis:

The obtained data were analyzed by using Microsoft Excel (version 5).

## 3.18 Economic Analysis:

The benefit cost analysis was calculated by the following formula given by Loudon and Loudon, 2000.

Total cost (Tk.) = Fertilizer (Tk) + Lime (Tk.) + Fry (Tk.) &/ Seed (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.

# Chapter-Four

# RESULTS AND DISCUSSION

# 4.0 Results and Discussion

## 4.1 Water Quality Parameters:

A suitable range of water quality parameters is the prerequisite for good environmental condition. Culture of fish and other aquatic organisms are completely depending on the water quality parameters. Water quality parameters, which were observed during the experiment, found within the acceptable ranges. The values of water quality parameters of rice fields in the treatments (water temperature, dissolved oxygen, pH and water depths) are gradually represent below:

### 4.1.1 Temperature ($^0$C):

Water temperature is one of the most important water quality parameters of a water body. The water temperature was more or less similar between the treatments in the study period. However, the average temperature was highest (29.49±5.06$^0$C) in treatment T1 (Table-2 and Figure-3). The average water temperature was found to fluctuate between 21.4±0.28 to 35.3±0.28$^0$C and 21.3±0.28 to 35.2±0.14$^0$C in treatment T1 and treatment T2 respectively (Table-2 and Figure-2). Ghosh (1992) mentioned that the water temperature in the rice fields ranging from 27$^0$C to 29$^0$C is suitable for fish culture. Ali (1990) reported that the suitable water temperature in the rice fields ranging from 27$^0$C to 40$^0$C.

The recorded maximum temperature were 35.3±0.28$^0$C and 35.2±0.14$^0$C on 1st August whereas the minimum were 21.4±0.28 $^0$C and 21.3±0.28$^0$C on 1st December in treatment T1 and T2 respectively (Figure-2). Durve and Bal (1961) and Lakshmanal *et al.*(1967) also recorded same temperature. The water temperature of the experimental plots decreased gradually towards the end in December. In treatment T1, the temperature varies from 21.4±0.28 to 35.3±0.28$^0$C which was optimum level for fish growth. Temperature fluctuations directly influence the growth rate of fish. Rahman (1992) stated that for 1$^0$C rise of water temperature metabolic rate of fish increase 10% and for 10$^0$C rise of water temperature metabolic rate becomes double. From Table-03, it is conspicuous that the growth rate is directly related to temperature was approximately the same, which also was found by Islam (1998). He reported that the optimum temperature for the growth of carp fish is 25-35$^0$C

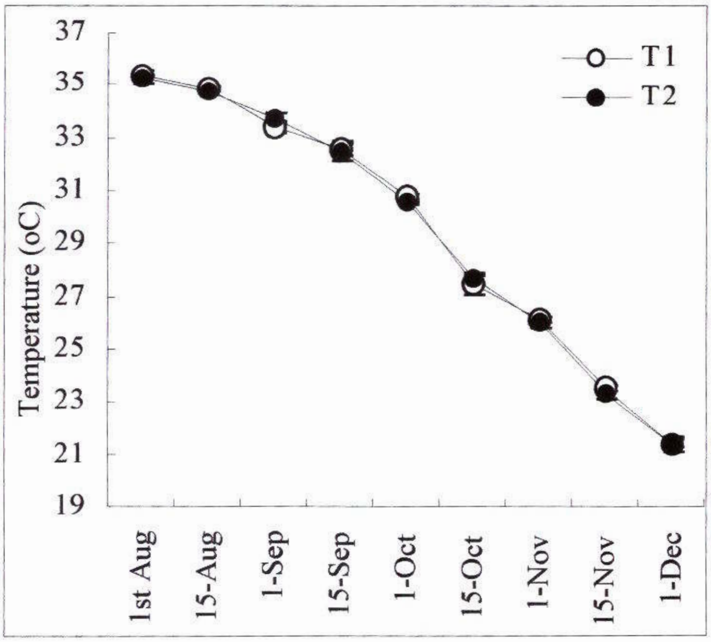


Figure-2: Fortnightly variation of water temperature between the treatments.

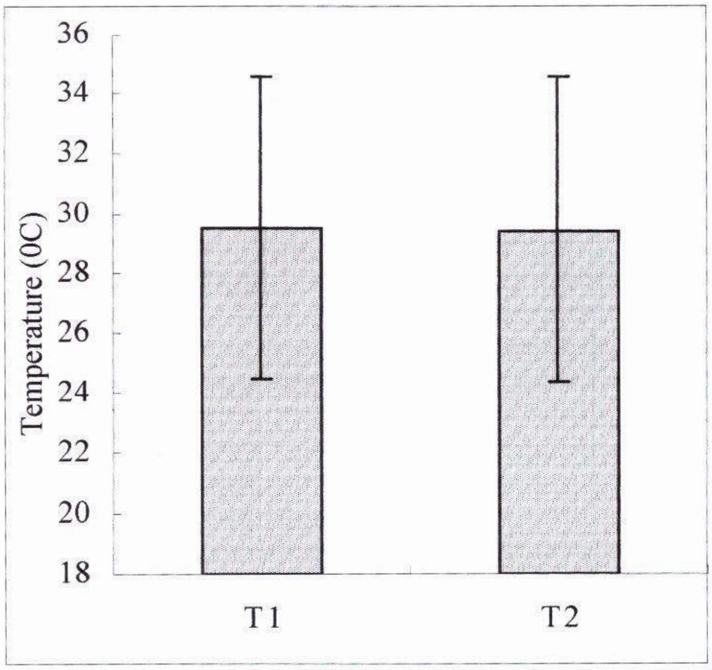




Figure-3: Variation of average water temperature between the treatments.

### 4.1.2 Dissolved Oxygen (mg/L):

During the study period, the ranges of dissolved oxygen 3.95±0.21to5.85±0.07 mg/L in treatment T1 and 3.55±0.07 to 5.58±0.04 in treatment T2 (Table-2 and Figure-4). The finding of the present study is quite similar by Ghosh and his coworkers in 1984. They recorded range of dissolved oxygen of rice fields was 3.5 to 6.17 mg/L. The range of dissolved oxygen content (3.7 to 6.0 mg/L) recorded by Uddin (1998) in his experiment conducted on rice-fish culture is almost close to the present study. Ghosh (1992) stated that dissolved oxygen content of the water in rice fields were 3.2 to 4.5 mg/L in monsoon, 3.0 to 4.4 mg/L in winter and 2.2 to 2.9 mg/L in summer. Alikunhi *et al.*(1957) stated that good productive pond water for fish culture should have fair amount of dissolved oxygen that would be 5 to 7 mg/L.

The average values of dissolved oxygen were recorded 4.98±0.71 mg/L and 4.67±0.67 mg/L in treatment T1 and treatment T2 respectively (Figure-5). Maximum dissolved oxygen content was recorded 5.85±0.07 mg/L on 1st November and the minimum 3.55±0.07 mg/L on 1st August. The dissolved oxygen content of the water in all the treatments were found to increase gradually towards the end of the season. This might be associated with the gradual increase of shade on the water surface caused by the luxuriant growth of leaves of rice plants, which ultimately reduced the photosynthetic activities of phytoplankton associated with decreased water temperature and rate of decomposition by bacteria at the end of the season. Bacterial decomposition is an oxidation process in which large amount of dissolved oxygen needed (Rahman 1992).

### 4.1.3 pH:

The pH values were almost neutral (6.25±0.07 to 7.75±0.07) during the study period. Ghosh (1992) opined that pH of water in the rice field ranging from 7.1 to 8.0 is within productive level. Whitton *et al.*(1987) also recorded the range of pH values between 6.53 and 7.08 in deep water rice field in Bangladesh.

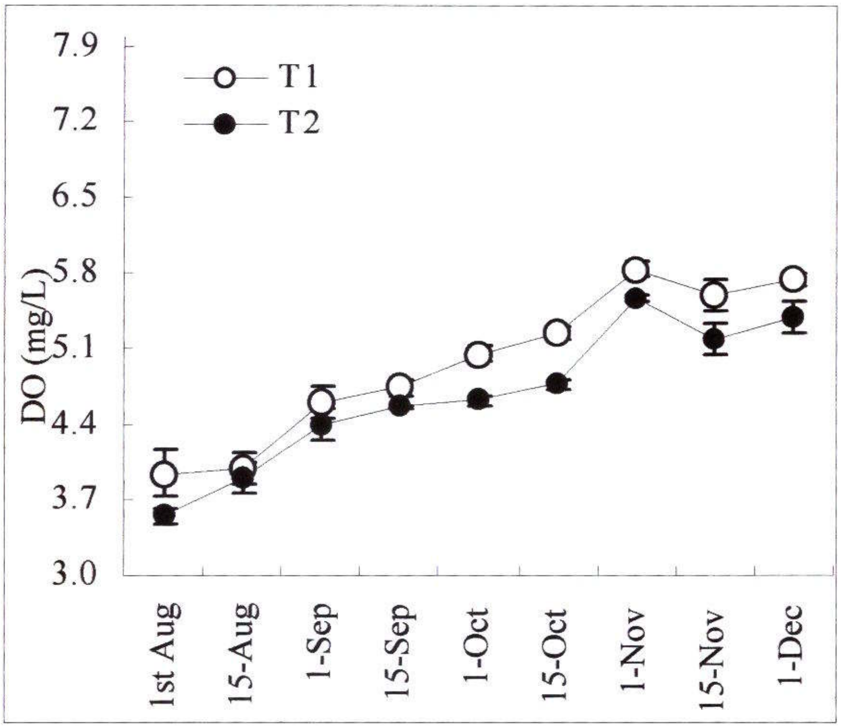


Figure-4: Fortnightly variation of dissolved oxygen between the treatments.



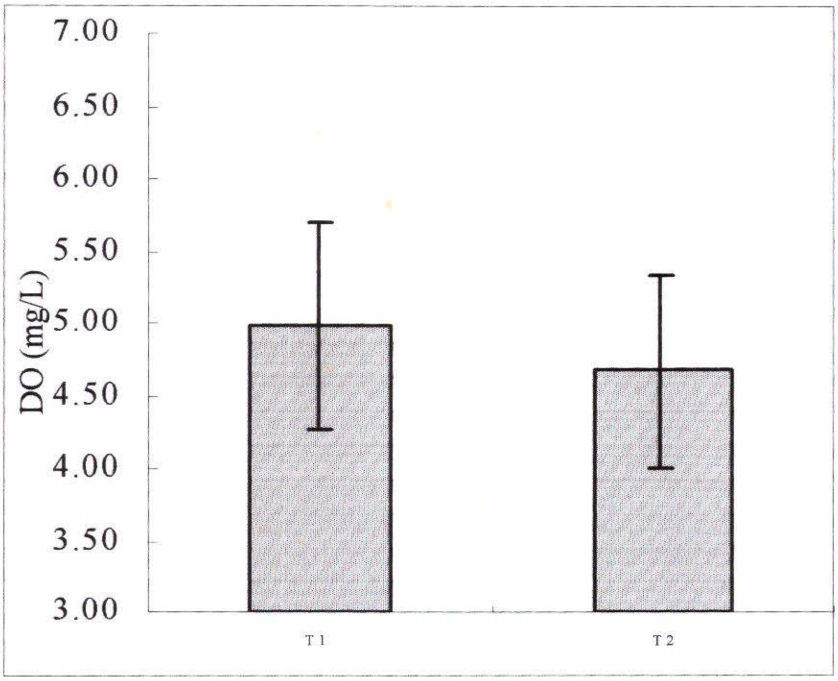


Figure-5: Variation of average dissolved oxygen between the treatments.

The average pH values were recorded 7.23±0.47 and 7.28±0.45 in treatment T1 and T2 respectively (Table-2 and Figure-7). This was almost close to the value of 7.6 and 7.4 obtain by Rahman (1990) and Neazuddin (1992) respectively in their paddy cum fish culture experiments.

The highest value 7.75±0.7 was recorded on 1st October and 1st November in treatment T1 and treatment T2 respectively. The lowest pH value was recorded 6.25±0.07 on 1st August in treatment T1 (Figure-6). The low values can be attributed to the high rate of decomposition of organic matter in presence of extreme temperature and also to the less penetration of sunlight due to luxuriant growth of vegetative parts of the rice plants which greatly hampered the photosynthesis of aquatic plants (Rahman 2001).

### 4.1.4 Water Depth (cm):

The area of T1 was more or less plain land and water depth was somewhat similar in different rice-field during study period. The water depth in rice fields during study period varied from 8.5±0.71 to 37.5±0.71 cm and 5.5±0.71 to 32.5±0.71 cm in treatment T1 and treatment T2 respectively (Table-2 and Figure-8).

The average values of water depth was recorded 22.97±10.64cm and 18.33±10.39cm in treatment T1 and treatment T2 respectively (Figure-9). During some sampling periods, there was a little water in the rice field where the depth reading was taken and the fish were forced to move to low-lying areas or to ditches. This would have an effect on the growth and survival of fish. The land of treatment T1 is somewhat higher than that of treatment T2. Ghosh (1992) stated that the suitable range of water depth is 1-33 cm in rice cum fish culture.

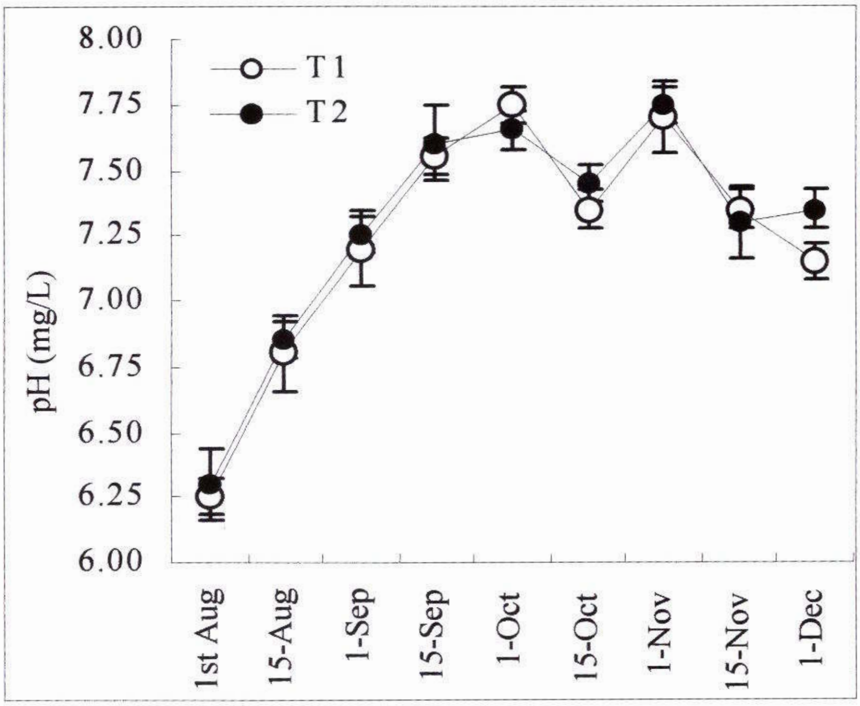


Figure-6: Fortnightly variation of pH between the treatments.

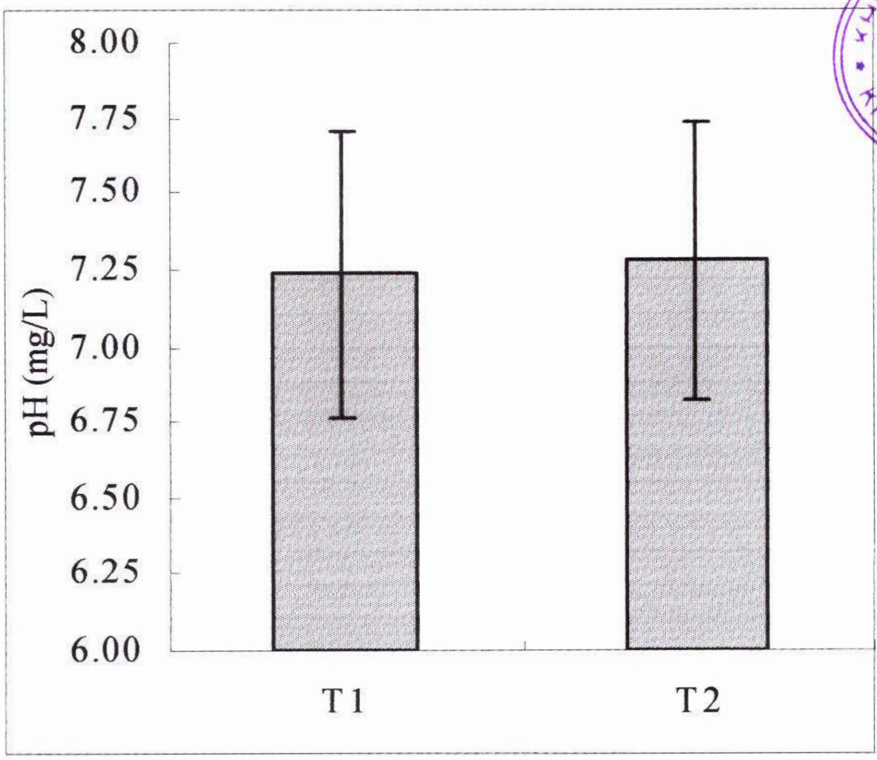


Figure-7: Variation of average pH between the treatments.

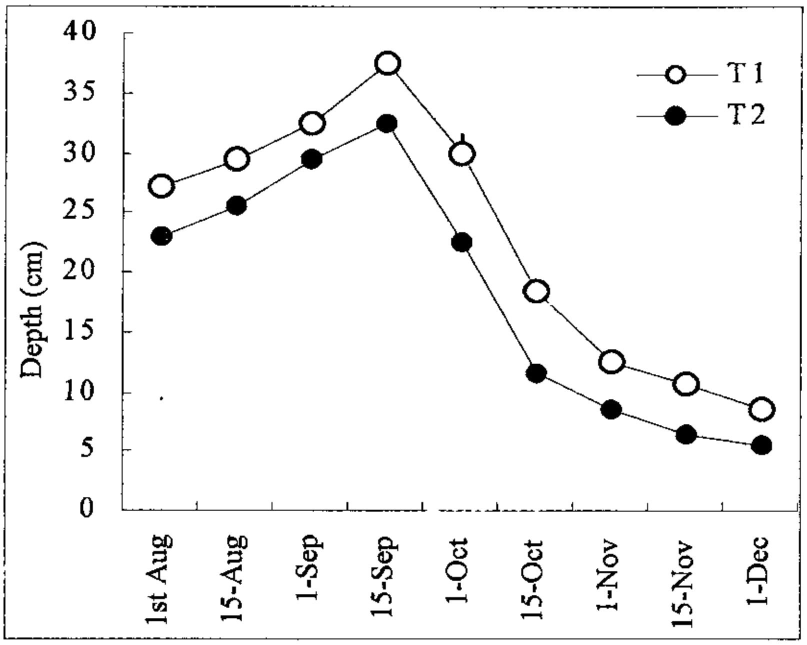


Figure-8: Fortnightly variation of water depth between the treatments.

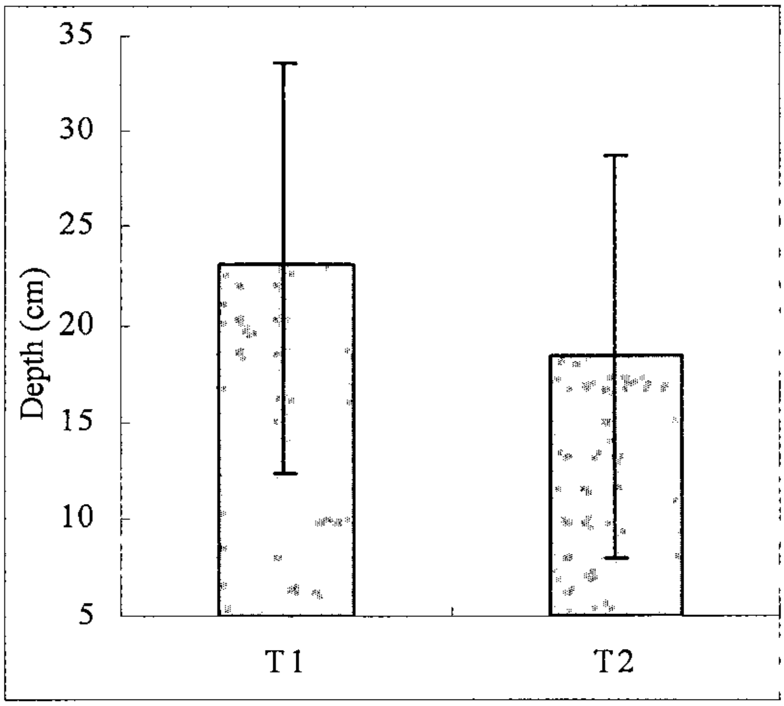


Figure-9: Variation of average water depth between the treatments.

## 4.2 Growth Performance of Fishes:

Due to observe the growth performance in rice cum fish culture, thai sarpunti, common carp, rohu, catla and mrigal were stocked in treatment T1. The mean initial weight of thai sarpunti, common carp, rohu, catla and mrigal were recorded 11.1g, 14.0g, 16.5g, 17.2g and 15.5g respectively. The mean final weight of these species was recorded 94.82g, 194.1g, 101.2g, 75.4g and 80.4g respectively. The net weight increase was recorded as highest 180.1g in common carp and the lowest 58.2g in catle (Table-4a and Figure-10). This report was similar to Ghosh (1992) findings, in which the average size of common carp recorded at harvesting was 200g. Fortnightly average increase of fish species showed more or less rapid growth rate at the beginning and then slows down gradually towards the end of the experiment (Table-4b and Figure-11). The relatively slow growth rate of fish towards the end of the experiment might be associated with the gradual decrease of temperature towards winter season (Rahman 1992).

It is observed that the growth performance of thai sarpunti and commmon carp is remarkable but the growth performance of rohu, catle, mrigal is comparatively lower. The gain weight of thai sarpunti and common carp have market demand. It may consider as a surplus production with rice culture in a same land. No raring cost is needed for fish culture. But rice production comparatively higher than that of monoculture. So culture of thai sarpunti and common carp may be generated extra income if the water source is available. For the reason, it can be suggested that thai sarpunti and common carp is ideal for rice fish culture system.

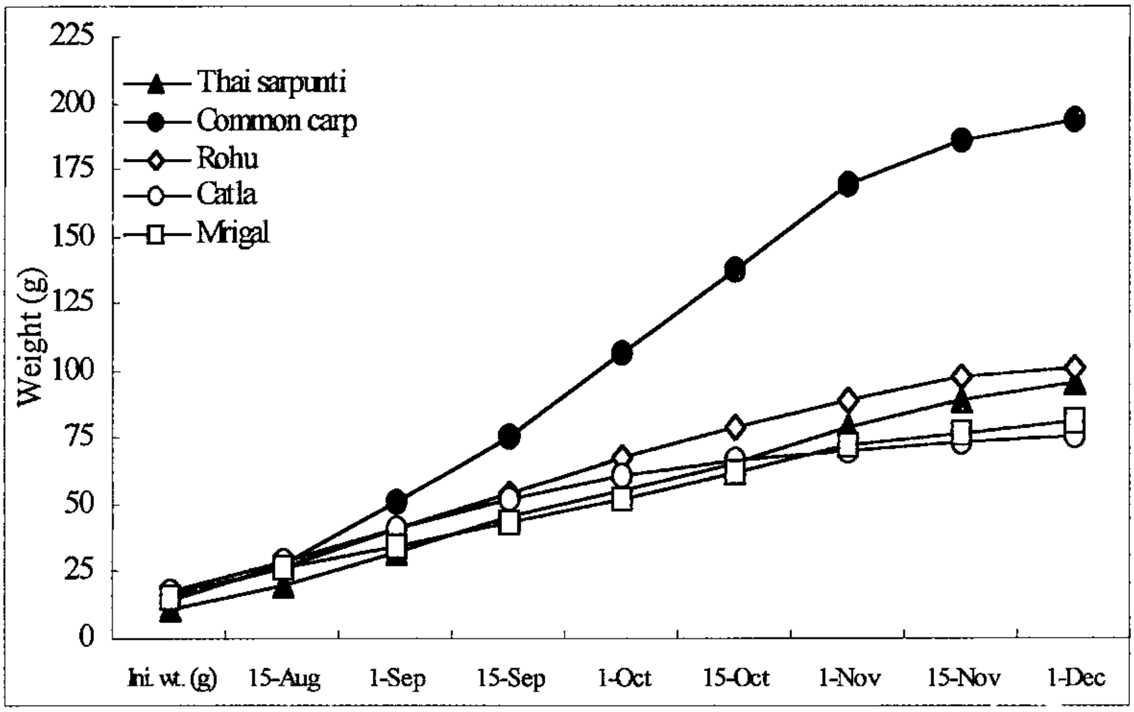


Figure –10: Fortnightly variation of growth in treatment T1

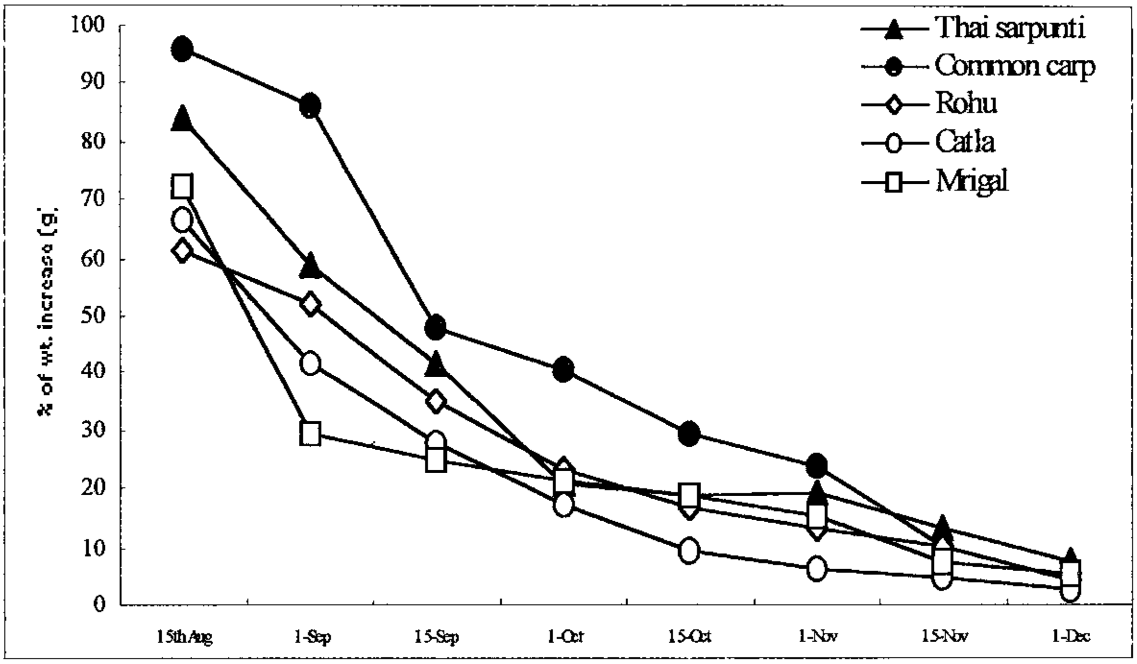


Figure-11: Growth performance of different species in treatment

### 4.3 Survival Rate of Fishes:

The average survival rate of thai sarpunti, common carp, rohu, catla and mrigal was 70%, 73%, 68%, 71% and 57% respectively (Table-5 and Figure-12). Among the species the lowest survival rate was recorded in mrigal (57%) compared to other species. Probably it might be associated with their schooling behavior that makes them easily available to snakes and other predators. The survival rate recorded for thai sarpunti was higher than the survival rates (65% and 68%) recorded by Rahman *et al.* (1995) respectively in their experiment.

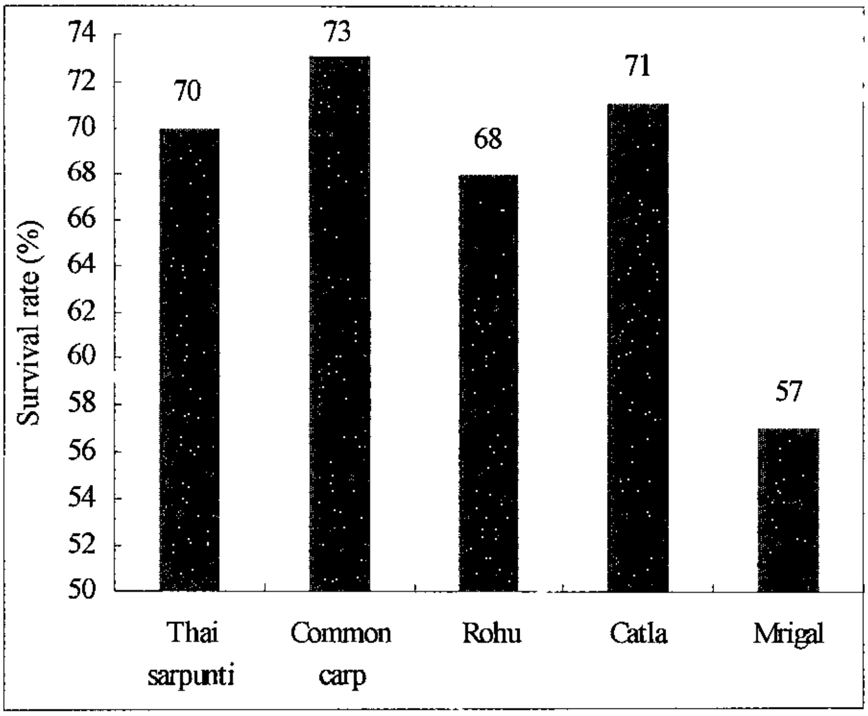


Figure-12: Survival rate of different species in treatment T1.

## 4.4 Fish Production:

In treatment T1, average gross and net production was recorded 451.88 kg/ha and 397.69 kg/ha respectively (Table-6). Dewan (1993) also found 223-700 kg/ha in gross production.

Average gross production of thai sarpunti, common carp, rohu, catla and mrigal was recorded 98.37 kg/ha, 209.99 kg/ha, 67.99 kg/ha, 52.89 kg/ha and 22.64 kg/ha respectively (Figure-13 and Table-5). Average net production increase of thai sarpunti, common carp, rohu, catla and mrigal was recorded 86.85 kg/ha, 194.84 kg/ha, 56.90 kg/ha, 40.83 kg/ha and 18.27 kg/ha respectively (Figure-13 and Table-5).

Among the five species of fish the yield of common carp was the highest and mrigal was the lowest. The gross and net production of common carp was recorded 209.99 kg/ha and 194.84 kg/ha respectively. Khan and co-workers (1997) obtained a production of 233.49 kg/ha of common carp in rice fish culture that is almost close to the present study. Hickling (1962) also recorded 100 to 200 kg/ha of common carp production in the rice fields in Japan. So, production of common carp in rice-fish culture is more or less similar to other studies.

In the present study the contribution of rohu was mentionable, 99.90 kg/ha. At the end of the experiment when all the fishes were harvested catla and mrigal were found smaller in size. The production of thai sarpunti recorded by Khan and co-workers (1997) was 229.22-kg/ha that is higher to the production recorded in the present study. The production of thai sarpunti obtained by MCC (1994) was almost similar to the production recorded of the present experiment.

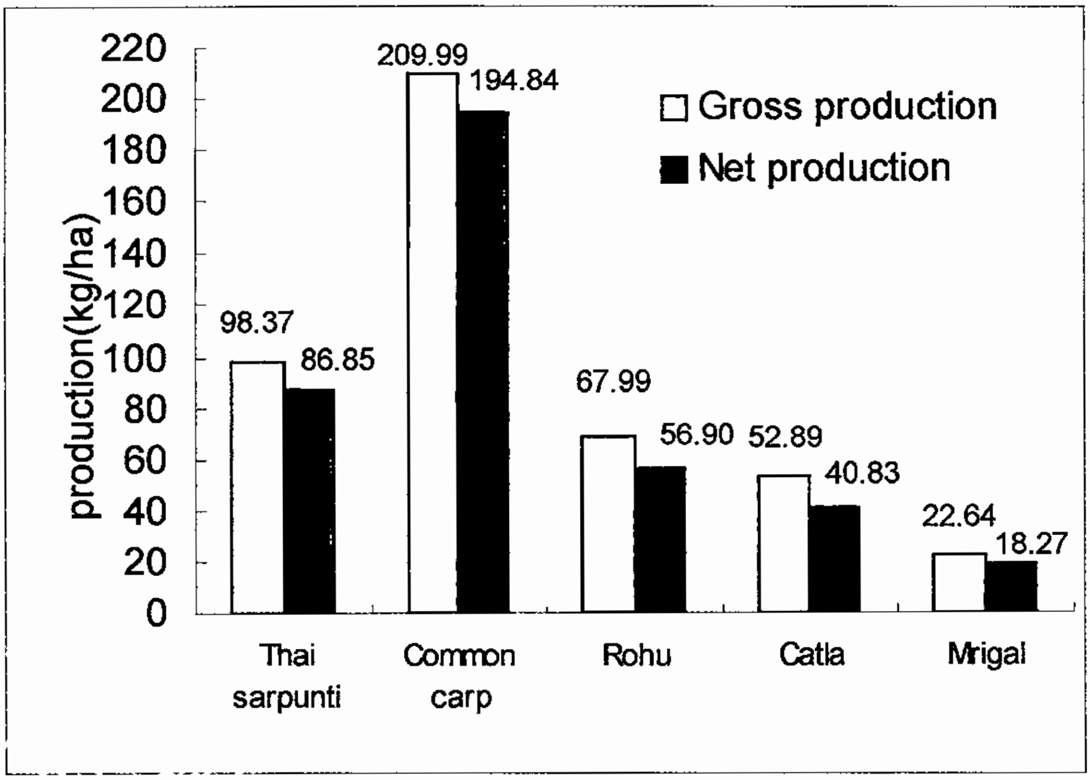


Figure-13: Gross and net production (kg/ha) of different species in treatment T1.

### 4.5 Rice production:

Between the two treatments, the average production of rice were recorded 3920.24 kg/ha in T1 that was closely followed by the production (3428.01kg/ha) of treatment T2 (Figure-14 and Table-7). The production of three replications (R1, R2 and R3) were recorded 3895.64kg/ha, 3926.50 kg/ha, 3938.50 kg/ha in T1 and 3460.60 kg/ha, 3402.88 kg/ha, 3420.55 kg/ha in T2 respectively (Table-7).

The production of grain and straw obtained in T1 were found to differ significantly from the production of T2. The production of grain obtained by Haroon *et al.* (1992), Gupta and Mazid (1993), Kohinoor *et al.* (1993) and MCC (1994) were almost similar to the production of grain recorded in the present study. Akhteruzzaman *et al.* (1993), Mazid *et al.* (1992) 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. Kamp and Gregory (1993) indicated 10-15% increases in rice yields from integrated farming compared to yields from monoculture rice.

Fish might have also increased the availability of nutrients in soil by their faces 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 faces to nitrogen accumulation at the soil surface. Gaunt *et al.* (1993) also stated that within irrigated rice-fish systems, the application of nitrogen to the crop during the growth cycle is often a key factor in rice growth and yield.

### 4.6 Economic analysis:

The gross and net income were calculated as 39340.13 Tk./ha and 19222.13 Tk/ha in treatment T1 and 20568.04 Tk./ha and 7943.04 Tk./ha in treatment T2 respectively (Figure-15 and Table-08). The net benefit was higher than the findings of CARE (1992) and Miah *et al.* (1994). The benefit cost ratio was calculated 1.96 in Treatment T1 and 1.63 in treatment T2 (Figure-16).

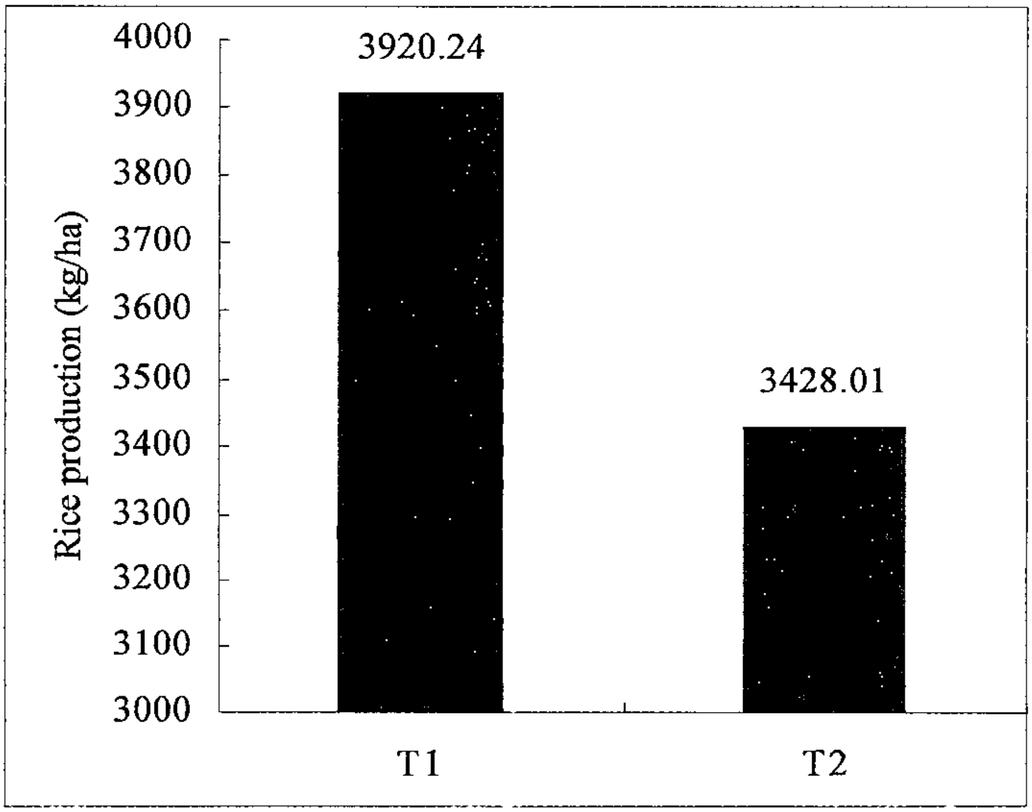


Figure-14: comparison of rice production (kg/ha) between the treatments in the study period.

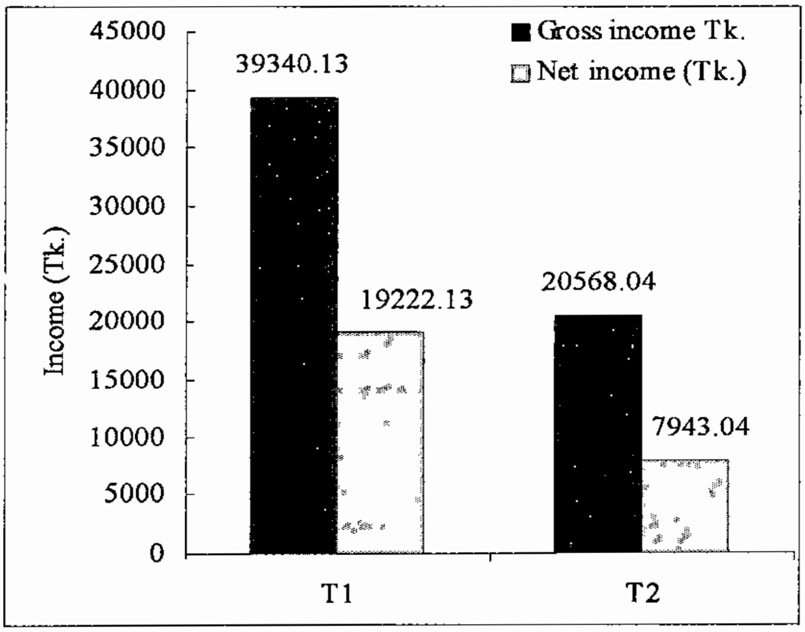


Figure-15: Gross and net income (Tk.) in different treatments in the study period.

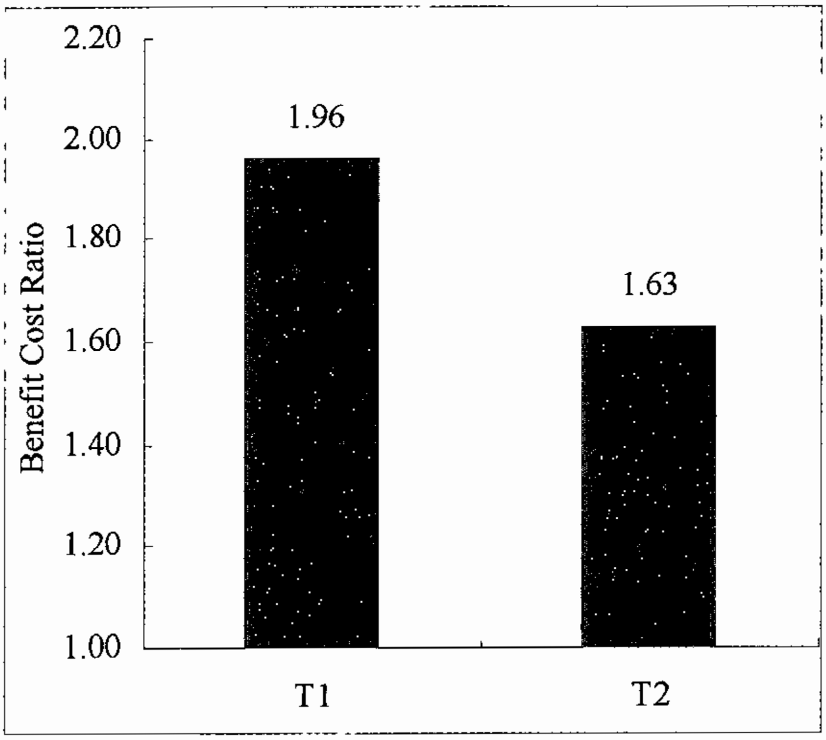


Figure-16: Comparison of benefit cost ratio between the treatments.

## 4.7 Constraints to Development:

Major biological, technical and socio-economic constraints to raising fish in rice fields are listed below.

- In order to harvest market-size within three to four months, farmers have to stock large fingerlings that are not available in sufficient quantities at the right time.
- Indiscriminate use of insecticides in rice causes heavy moralities in the fish population, though utilization of insecticides was very limited in the study area.
- Pests, especially crabs and rats, make small holes in the dike, which make it difficult to retain water at the desire depth.
- "Rice-fish farming is risky because of excessive rainfall causing flooding or prolonged drought", said by the farmers of Babugonj upazilla. Though the present study not hampered by such incident.
- It is very difficult to prevent fish escape in fragmented holdings demarcated by low dikes that permit water from one field to follow into another. Moreover, farmers are reluctant to raise buns or make trenches in small rice-fields.
- Poaching of fish in various ways is also a problem.
- Over density is a major problem. The farmers do not try to follow the recommendations of Department Agriculture Extension. They released fingerlings 35-45 nos. (average) per decimal, which caused under growth of fish.
- Farmers do not want to culture fish in their fields because of their lack of knowledge about improved methods of rice and fish farming and its benefits.
- Expert extension workers needed for proper motivation for the farmers.
- Insufficient revenant research on how to improve farming systems.

These problems are not permanent. These problems can easily overcome by awareness and proper management.

Chapter-Five

# CONCLUSION

## 5.0 Conclusion

Millions of people of Bangladesh live in villages. Most of them are farmers and day labors. Without making any progress of them the development of Bangladesh is quite meaningless. We all should try to ameliorate their condition for the rapid development of our country. Because rice production is becoming less profitable to farmers due to low prices in context of high input and stagnant yields. So it is needed to encourage and diversify farmers from rice monoculture. This study has clearly indicated that integrated rice fish farming is viable, low-cost economic activity with multiple benefits including increased incomes and greater availability of fish to rural farming households, especially those who do not have ownership or have access to a pond. Moreover, integrated rice fish farming decreased labor requirements in view of lower weed infestation and optimum utilization of land and water resources. Farmers cannot consume fish for shortage of money. So culture of fish in rice fields the farmers can earn money by filling up their demands. Moreover nitrogenous fish faces are added in the rice field, which ultimately act as manure for the cultivation.

Integration of aquaculture with rice farming during the rained and irrigated seasons in Bangladesh is a viable environment friendly activity with multiple benefits and an entry point to integrated pest management. The sustainability of the operation is indicated by the fact that, in spite of the small size of fish at harvest (due to the short rearing period low water depth), many farmers adopt integrated farming. The study also indicates that the benefits of new technology will accrue to relatively prosperous farmers unless institutional support is provided for marginal farmers to take advantage of new technologies and research output. However, as observed in the case of the green revolution. Small farmers will take to new technologies once the economic viability is established and extension services, easy availability of seed of required species and credit are ensured.

Rice as mono crop farming by itself is becoming a low profit enterprise, as nearly one third of the value of the crop is paid for fertilizers, pesticides, labor and sometimes for irrigation. Integration of fish with rice in suitable areas can increase farmer's income. In view of the different agencies working for reducing pesticide use and the tendency of integration (rice and fish) farmers not to use or minimize use of pesticides, activities aimed at promoting integrated pest management (IPM) and rice-fish culture should be coordinated. In view of the potential of rice and fish to generate moderate, but important benefits to a large section of rural poor at affordable risk. Developed agencies should take necessary steps for resolving the constraints stated and given more attention for the spread of the technology, in areas where topography of the land permits.

It is concluded from this study that integrated rice-fish farming is more profitable than that of rice monoculture. The trained farmers of the experiment are more profitable than that of traditional farmers. The water quality parameters viz. temperature, dissolved oxygen pH etc are favorable for fish growth and economic analysis reveals that rice-fish culture system is very much beneficial for poverty alleviation, extra income generation, creation of employment opportunity and all over the development of the country. Which clearly indicated the economic viability of this technology in Babugonj upazilla of Barisal district.

Chapter-Six

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Chapter-Seven

# APPENDICES

# Appendix-I

## Monitoring Sheet for Integrated Rice- Fish Farming

### A. Identification

- Name of the farmer ........................................
- Village...........................................................
- Upazilla............................................................
- Land holdings of the farmer............................
- Occupation.....................................................
- Has farmer cultured fish before? ....................
- If yes, for how many years............................

### B. Particular of rice fish plot

- Land type (high/medium/low).........................
- Soil type (clay, loam, silt, sand etc.)................
- Area of rice plot including ditch ($m^2$)..............
- Area of ditch ($m^2$).............................................
- Depth of ditch (cm)..........................................
- Age of ditch (years)..........................................
- Purpose of which ditch was dug ?....................
- Area of dike ($m^2$)..............................................
- Rice variety.....................................................
- Date of transportation......................................

### C. (1) Rice farming activities or inputs (land preparation, transplantation, weeding, pesticide application, irrigation, harvesting etc.)

| Date | Activities or inputs | No/ kg | Labor | Time spent (hr) | Cost (Tk.) | Source of cost | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**C. (2) Pesticide used**

| Date | Type of brand | Amount (kg/ml) | Cost (Tk.) | Method of application | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**C. (3). Application of integrated pest management (IPM)**

| Date | Method of application | Time spent (hr) | Cost (Tk.) | Result |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**D. (1). Stocking particulars**

| Date | Species | No. | Average length (cm) | Average wt. (g) | Cost (Tk.) | Remarks |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**D. (2). Activities or inputs for fish culture (ditch excavation, fingerlings, feed (given type), cattle manure, liming, harvesting etc.)**

| Activities or inputs | | | | Labor | | |
|---|---|---|---|---|---|---|
| Date | Inputs | Quantity (kg) | Cost (Tk.) | Hired | Own | Cost (Tk.) |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**D. (3). Water depth monitoring**

| Date | Depth of water in field (cm) | Depth of water in ditch (cm) | % of field under water | Remarks |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**E. (1). Fish production**

| Date of harvesting | Species | No. | Average wt. (g) | Total wt. (g) | How to use | | | | Income (TK) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sold | Consumed | Given away | Restock | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**F. Rice Production**

From stocked field (kg)..........................................

Price (TK./ kg)......................................................

Amount of this variety sold (kg)...............................

Income from this sale (TK.)....................................

## Appendix –02

## Questionnaire Survey to assess the adoption and impact of integrated rice-fish farming.

01. Name of farmer's:

02. Farmer's occupation:

03. Do you cultivate rice? ☐ Yes ☐ No

04. Approximate gross income of rice cultivation:

05. Level of water during aman cultivation:

06. Is it possible to culture fish with rice: ☐ Yes ☐ No

    If yes, why do you not practice it?

    ______________________________

    ______________________________

07. Why do you begin to culture fish in rice field?

    ______________________________

    ______________________________

08. Have you rice farming methods changed because of rice fish farming?

    ☐ Yes ☐ No

    If yes , describe how: ______________________________

    ______________________________

Table-01: Department of Agriculture Extension recommends stocking density of different species in treatment T1.

| Local name | Scientific name | Stocking density (No./ha) |
|---|---|---|
| Thai sarpunti | *Puntius goniontus* | 1482 |
| Common carp | *Cyprinus carpio* | 1482 |
| Rohu | *Labeo rohita* | 988 |
| Catla | *Catla catla* | 988 |
| Mrigal | *Cirrhinus mrigala* | 494 |
| Total | | 5434 |

Table02: Fortnightly variations (± SE) of water quality parameters in rice field during study period.

| Parameters | Treatments | 1 Aug | 15 Aug | 1 Sept | 15 Sept | 1 Oct | 15 Oct | 1 Nov | 15 Nov | 1 Dec | Average (SE ±) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°c) | $T_1$ | 35.3±0.28 | 34.85±0.07 | 33.3±0.21 | 32.6±0.28 | 30.8±0.14 | 27.45±0.35 | 26.15±0.07 | 23.55±0.07 | 21.4±0.28 | 29.94±5.06 |
| | $T_2$ | 35.2±0.14 | 34.75±0.07 | 33.65±0.21 | 32.46±0.35 | 30.55±0.07 | 27.65±0.21 | 26.05±0.21 | 23.3±0.14 | 21.3±0.14 | 29.43±5.10 |
| Dissolved oxygen (mg/l) | $T_1$ | 3.95±0.21 | 4±0.14 | 4.6±0.14 | 4.75±0.07 | 5.05±0.07 | 5.25±0.07 | 5.85±0.07 | 5.6±0.14 | 5.75±0.07 | 4.48±0.71 |
| | $T_2$ | 3.55±0.07 | 3.9±0.14 | 4.45±0.14 | 4.57± 0.02 | 4.63± 0.05 | 4.78± 0.04 | 5.58± 0.04 | 5.2± 0.14 | 5.4± 0.14 | 4.67± 0.67 |
| pH | $T_1$ | 6.25± 0.07 | 6.8± 0.14 | 7.2± 0.14 | 7.55± 0.07 | 7.75± 0.07 | 7.35± 0.07 | 7.7± 0.14 | 7.35± 0.07 | 7.15± 0.07 | 7.23± 0.47 |
| | $T_2$ | 6.3± 0.14 | 6.85± 0.07 | 7.25± 0.07 | 7.6± 0.14 | 7.65± 0.07 | 7.45± 0.07 | 7.75± 0.07 | 7.3± 0.14 | 7.35± 0.07 | 7.28± 0.45 |
| Depth(cm) | $T_1$ | 27.2± 0.42 | 29.5± 0.71 | 32.5± 0.71 | 37.5± 0.71 | 30± 0.71 | 18.5± 0.71 | 12.5± 0.71 | 10.5± 0.71 | 08.5± 0.71 | 22.97± 10.64 |
| | $T_2$ | 23± 0.28 | 25.5± 0.71 | 29.5± 0.71 | 32.5± 0.71 | 22.5± 0.71 | 11.5± 0.71 | 08.5± 0.71 | 06.5± 0.71 | 5.5± 0.71 | 18.33± 10.39 |

*The values are the average of three plots in each treatment.

Table-03: Relationship between temperature changes and percent of body weight gain of cultured species.

| | 15th Aug | 1-Sep | 15-Sep | 1-Oct | 15-Oct | 1-Nov | 15-Nov | 1-Dec |
|---|---|---|---|---|---|---|---|---|
| Temperature | 34.85±0.07 | 33.3±0.21 | 32.6±0.28 | 30.4±0.14 | 27.45±0.35 | 26.15±0.07 | 23.55±0.07 | 21.4±0.28 |
| Thai sarpunti | 83.78 | 58.82 | 41.67 | 20.70 | 18.77 | 18.84 | 13.04 | 7.26 |
| Common carp | 95.71 | 86.13 | 47.84 | 40.72 | 29.22 | 23.78 | 9.90 | 4.08 |
| Rohu | 61.21 | 52.26 | 35.06 | 23.40 | 16.44 | 12.72 | 9.69 | 4.22 |
| Catla | 66.28 | 41.96 | 26.60 | 17.90 | 9.24 | 6.19 | 4.55 | 2.59 |
| Mrigal | 72.26 | 29.21 | 24.93 | 21.35 | 18.74 | 15.14 | 7.13 | 4.96 |

Table-4a: Fortnightly variation of weight (g) gain in treatment T1 in the study period.

| | Ini. wt. (g) | 15-Aug | 1-Sep | 15-Sep | 1-Oct | 15-Oct | 1-Nov | 15-Nov | 1-Dec |
|---|---|---|---|---|---|---|---|---|---|
| Thai sarpunti | 11.1 | 20.4 | 32.4 | 45.9 | 55.4 | 65.8 | 78.2 | 88.4 | 94.82 |
| Common carp | 14 | 27.4 | 51 | 75.4 | 106.1 | 137.1 | 169.7 | 186.5 | 194.1 |
| Rohu | 16.5 | 26.6 | 40.5 | 54.7 | 67.5 | 78.6 | 88.6 | 97.1 | 101.2 |
| Catla | 17.2 | 28.6 | 40.6 | 51.4 | 60.6 | 66.2 | 70.3 | 73.5 | 75.4 |
| Mrigal | 15.5 | 26.7 | 34.5 | 43.1 | 52.3 | 62.1 | 71.5 | 76.6 | 80.4 |

Table-4b: Fortnightly variation of weight increase in percentage in treatment T1 in the study period.

| | 15th Aug | 1-Sep | 15-Sep | 1-Oct | 15-Oct | 1-Nov | 15-Nov | 1-Dec |
|---|---|---|---|---|---|---|---|---|
| Thai sarpunti | 83.78 | 58.82 | 41.67 | 20.70 | 18.77 | 18.84 | 13.04 | 7.26 |
| Common carp | 95.71 | 86.13 | 47.84 | 40.72 | 29.22 | 23.78 | 9.90 | 4.08 |
| Rohu | 61.21 | 52.26 | 35.06 | 23.40 | 16.44 | 12.72 | 9.69 | 4.22 |
| Catla | 66.28 | 41.96 | 26.60 | 17.90 | 9.24 | 6.19 | 4.55 | 2.59 |
| Mrigal | 72.26 | 29.21 | 24.93 | 21.35 | 18.74 | 15.14 | 7.13 | 4.96 |

Table-05: Survival rate (%) and production (kg/ha) of fishes in the study period in treatment T1.

| Species | Stocking density | Survival rate (%) | Initial wt. (g) | Final wt. (g) | Net wt. (g) | Gross production (kg/ha) | Net production (kg/ha) |
|---|---|---|---|---|---|---|---|
| Thai sarpunti | 1482 | 70 | 11.1 | 94.82 | 83.72 | 98.37 | 86.85 |
| Common carp | 1482 | 73 | 14 | 194.1 | 180.1 | 209.99 | 194.84 |
| Rohu | 988 | 68 | 16.5 | 101.2 | 84.7 | 67.99 | 56.90 |
| Catla | 988 | 71 | 17.2 | 75.4 | 52.89 | 52.89 | 40.83 |
| Mrigal | 494 | 57 | 15.5 | 80.4 | 64.9 | 22.64 | 18.27 |
| **Total** | 5434 | | | | | 451.88 | 397.69 |

Table-06: Production of fishes in three replications in treatment T1.

| Replication | Gross production(Kg/ha) | Net production gain(Kg/ha) |
|---|---|---|
| R1 | 442.54 | 390.60 |
| R2 | 454.60 | 398.80 |
| R3 | 458.50 | 403.67 |
| Average | 451.88 | 397.69 |

Table-07: Rice production in three replications in treatment T1and T2.

| Replication | Production (Kg/ha) | |
|---|---|---|
| | Treatment T1 | Treatment T2 |
| R1 | 3895.64 | 3460.60 |
| R2 | 3926.50 | 3402.88 |
| R3 | 3938.50 | 3420.55 |
| Average | 3920.24 | 3428.01 |