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FISH-PADDY CROP ROTATION PRACTICE IN SOUTH- WEST COASTAL REGION OF BANGLADESH: A PROFITABLE TECHNOLOGY FOR THE POOR FARMERS

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Abstract

The study was conducted at the farmer's pond at Sadar Upazilla of Bagerhat District, South-west coastal region of Bangladesh during the period from May 2006 to April 2007 to understand the present status of crop rotation practice and assess the production and cost benefit ratio of the existing culture practices. Two treatments viz., the crop rotation with paddy (T_1) and the shrimp-prawn-fish culture (T_2) were used in the studies. Shrimp (*Penaeus monodon*), prawn (*Macrobrachium rosenbergii*), and catla (*Catla catla*) were stocked at 20000, 10000, and 250 individuals/ha, respectively, in both treatments. In T_1, aquaculture phase was from May to December 2006, and the episode of paddy (BRRI dhan 28) cultivation was initiated after full harvest of aqua products and continued till April. Similar farm inputs were given for the common components in both the treatments. Shrimps were harvested four months following stocking in both T_1 and T_2 treatments. In T_1, production of shrimp, prawn, and catla were 347.20, 355.35, and 140.4 kg/ha, respectively and in T_2, productions were 354.38, 432.37, and 204.7 kg/ha, respectively. In T_1, total paddy production was 6200 kg/ha. Net benefit in T_1 and T_2 was Tk. 300,477 and Tk. 262,561/ha, respectively.

Keywords: Crop rotation, shrimp, prawn, fish production, economics.

Introduction

Bangladesh is an agro-fisheries oriented country. Fishes play an important role in the economy of many developing countries like Bangladesh and it contributes 63% of the nation's animal protein intake, about 5.6% to the GDP and more than 12.5% of the export earnings (Mazid, 2002). Rice is cultivated in about 10 million ha, which is about 75% of the country's total cropped area. There are 3 types of rice cultured in our country Aus, Aman, and Boro. Total production of these rice are 18.8 million mt. (Banglapedia, 2003). The natural environment and climate of southwest coastal region in Bangladesh is favourable for fish paddy crop rotation. This region is a charming place for the combination of all types of water, such as fresh, brackish, and marine water.

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Riverine giant prawn (*Macrobrachium rosenbergii*) and giant tiger shrimp (*Penaeus monodon*) can tolerate a certain range of salinity. The level of salinity decreases up to zero during the rainy season (July-September) and increases the during dry season (November-May) in this region. Catla (*Catla catla)* was cultured with shrimp to keep environment friendly reducing phytoplankton bloom. The paddy cultivated BRRI 28 can tolerate a narrow range of salinity (about 5 ppt). Crop rotation means cultivating different crops by turns which are developed for unproductive soils as well as better utilization of land. In the view of fish culture, it means culturing several types of species one after another as considering their life cycle (Gupta and Mazid, 1993) which allows mutual and beneficial biological effects on culture of different types.

Bagerhat District is the most productive zone for crop rotation. About 25,000-31,000 ha land of Bagerhat District is used alternatively for fish and paddy culture. The cultivable land is shrinking day by day for new settlements and physical infrastructures. Therefore, it is important to search more water areas for producing more fish. There is a less chance of disease outbreak in crop rotation rather than the year round fish culture system (Paul, 2000). Single crop production over the year in the same field may reduce the fertility of the soil and accumulate harmful nutrients in the pond bottom. Cultivable land reduction, seasonal inundation, and disease problems can be minimized by adopting fish paddy crop rotation. In this system, the fish excreta, unutilized feed and the residual fertilizers increased the fertility of the soil and improved paddy production. On the other hand, stumps of harvested paddy and the ploughing of the soil help increase the productivity of water and can enhance fish production. Fish-paddy rotational system allows paddy plants to absorb harmful nutrients as its manure. Thus the aim of the study was to understand the present status of crop rotation practice in Bagerhat District and assess the production and cost benefit ratio of the existing culture practices.

Materials and Method

The study was conducted in the farmer's ponds at Sadar Upazila of Bagerhat District, south-west coastal region of Bangladesh about 160 km north upward from the Bay of Bengal for a period of 12 months from May 2006 to April 2007. The water of this region is slightly saline because of daily tidal fluctuation of reverine water which allows different types of culture practices, such as monoculture, polyculture, integrated culture, and crop rotation. The size of the ponds varied from 0.75 to 1.5 hectares. Two types of fish culture that is polyculture and crop rotation (fish-paddy) were practiced in this region. In crop rotation system, the residue of one crop are used as fertilizer and feed for another crop, which reduces the input cost of the venture at a significant extent.

The experiment was designed with two treatments, the crop rotation with paddy (T_1) and the shrimp-prawn-fish culture (T_2). During pond preparation, both treatments were fully dried and ploughed followed by liming and fertilization. In T_1, limestone, TSP, and cowdung were used as 120, 50, and 200 kg/ha, respectively, and in T_2, it was 240, 120, and 420 kg/ha, respectively. Before stocking of fry, urea 10 kg, TSP 5 kg, and cowdung 20 kg/ha were used in non-crop rotation ponds after watering but not used in crop rotation ponds. In T_1, fish was cultured from May-November and paddy was cultured from December to April. In T_2, shrimp-prawn-fish culture was carried out from May to April. In both, treatments, shrimp (*Penaeus monodon*), prawn (*Macrobrachium rosenbergii*), and catla (*Catla catla*) were cultured and the stocking density of every species was same in both T_1 and T_2 treatments. Species-wise stocking density in T_1 and T_2 treatments are shown in Table 1.

Table 1. Species -wise stocking density and culture period in T_1 and T_2.

Items	Stocking density (no. of individuals/ha)		Culture period	
	T_1	T_2	T_1	T_2
Penaeus monodon	20000	20000	May-September	May-September
Macrobrachium rosenbergii	10000	10000	May-December	May-March
Catla catla	250	250	May-December	May- March
Paddy (BRRI dhan 28)			December-April	

In T_1 culture period for shrimp was five months from May to September; prawn and catla were cultured for seven months from May to December; and paddy was cultured from December to April. In T_2, shrimp was cultured from May-September; prawn and catla were cultured from May to March. During the month of May, after seven days of watering shrimp, prawn, and catla fry were stocked in the ponds at the density of 20000, 1000, and 250 individuals/ha, respectively. For both treatments, shrimp and catla fry were collected from hatchery and prawn was collected from natural source. In both treatments urea, TSP and cowdung were used 4, 2, and 50 kg/ha/day, respectively, up to first 30 days of stocking. After stocking, pellet feeds (Sunny, starter-1 and 2) were used for the first two weeks at the rate of 10% of their body weight. Fish meal (30%), mustard oil cake (20%), wheat bran (25%), rice bran (25%) were used at the rate of 500 g/ha/day for the third week after stocking at the rate of 9% of body weight. With hand made feed, artificial pellet was used and the amount was 5% of body weight after one month up to third month. After three months, the amount was decreased to 3% of body weight up to last. Feeding was stopped in case of

excessive rainfall and at the time of sampling. The important hydrographical parameters, such as temperature, dissolved oxygen, pH, salinity, and transparency were monitored monthly using standard method. The water level was maintained by pump machine from the river. The weight of shrimp, prawn, and catla were monitored and recorded monthly through random sampling method. The number of samples were 50. In T_1, harvesting was completed for shrimp within September and for prawn and catla within December. The survival rate was determined by harvesting all fishes. Within one week, subsequent to harvesting of fishes from T_1, the ponds' area were prepared for paddy plantation by ploughing and 50 kg TSP/ha was used before transplantation of Boro paddy (BRRI dhan 28). Seeds of paddy were sown in November for raising seedlings. The seedlings were transplanted in 23 × 23 cm distance in rows and columns. After 15 days of transplantation, 25 kg urea/ha was used and again after 45 days, 90 kg/ha was used. In paddy production, no pesticide was used. Pest was controlled by Integrated Pest Management (IPM) method. The paddy culture period was about four and a half months. In non-crop rotation ponds (T_2), shrimp was harvested within September and prawn and catla were harvested within March.

Results and Discussion

Hydrological parameters

During the study period, monthly water temperature at the experimental ponds varied from 19.13 to 33.40 °C. The lowest and the highest average water temperature were recorded during the period of January and June, respectively. Ali *et al*. (1982) stated that 20.5 to 36.5°C temperature is favourable for fish culture. Ali (1990) reported that the suitable water temperature in the rice fields ranged from 27 to 40° C.

Table 2. Hydrological parameters of the studied ponds.

Parameters	T_1		T_2	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Temperature (°C)	19.3	33.40	19.13	32.90
DO (mg/L)	5.65	6.89	5.56	6.70
pH	7.0	8.5	6.9	8.6
Salinity (ppt)	0.5	13	0.5	8
Transparency (cm)	28	38	26	37

The monthly average dissolved oxygen level (DO) at the experimental ponds varied from 5.56 to 6.89 mg/L (Table 2). The highest and the lowest average DO

was recorded during the period of November and September, respectively. Banergee (1967) reported 7.0 mg/L of dissolved oxygen of water body is good for productivity whereas the range from 3.0 to 5.0 mg/L is unproductive for fish culture. The monthly average pH at the experimental ponds varied from 6.9 to 8.6 (Table 2). The highest and the lowest average pH was recorded during the period of December and July, respectively. The monthly average pH at the experimental ponds ranged from 6.9 to 8.6 (Table 2). The best range of water pH for coastal aquaculture is 7-9 (Boyd and Fast, 1992). Ghosh (1992) opined that pH of water in the rice field ranging from 7.1 to 8.0 is within productive level.

The monthly average salinity at the experimental ponds varied from 0.5 to 13 ppt (Table 2). The highest and the lowest average salinity was recorded during the period of May and July, respectively. Fluctuations in salinity below 8 ppt. or above 18 ppt. has been reported to retard the growth of penaeid shrimp (Boyd and Fast, 1992).

The monthly average transparency at the experimental ponds varied from 26 to 38 cm (Table 2). The highest and the lowest average transparency was recorded during the period of October and January, respectively. Saha and Sinha (1969) recorded the highest value of transparency during August and September due to increased rainfall.

Growth

After 120 days of culture period, the average final body weights of shrimp in T_1 and T_2 were 26.4 and 27.2 g, respectively (Fig. 1). Hossain *et al.* (1992) found the final body weight of 21.65g for 120 days culture of shrimp where hand made feeds were used and stocking density was 30,000/ha and the culture system was improved extensively. So, results of the present study are satisfactory compared to reports of the study quoted above. Hoq *et al.* (1994) reported a weight gain of 27.99 g in 105 days with a stocking density of 4 PL /m^2. They used both hand made and pellet feeds and the culture system was improved extensively. After six months of culture period in the ponds of T_1 and 8 months culture period in the ponds of T_2, the average final body weights of prawn were 52 and 64 g, respectively (Fig. 2). Shafi and Quddus (1973) found the final body weight 50.25 g for 180 days culture period of prawn. They used hand made feeds and stocking density was 15,000/ha and the culture system was improved extensively. At the same time, average final body weights of catla in T_1 and T_2 were 780 and 1150 g respectively (Fig. 3). Lakshmanan *et al.* (1967) found the final body weight 1100.20 g, for 240 days culture of catla. He used hand made feeds and the culture system was improved extensively which coincides the present study

findings. Fish growth was better in T_2 than T_1 due to more supplementary feed and fertilizer utilization.

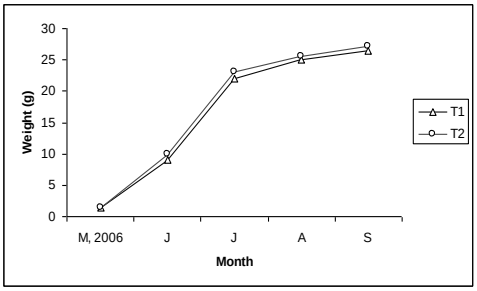

Fig.1. Monthly growth of *Penaeus monodon* by wt (g) in T_1 and T_2

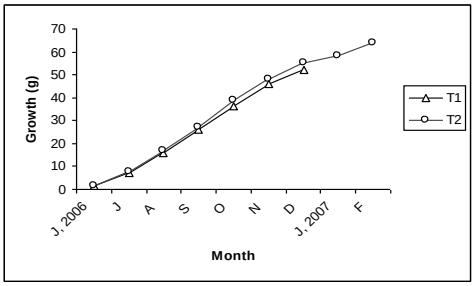

Fig.2. Monthly growth of *Macrobrachium rosenbergii* by wt (g) in T_1 and T_2

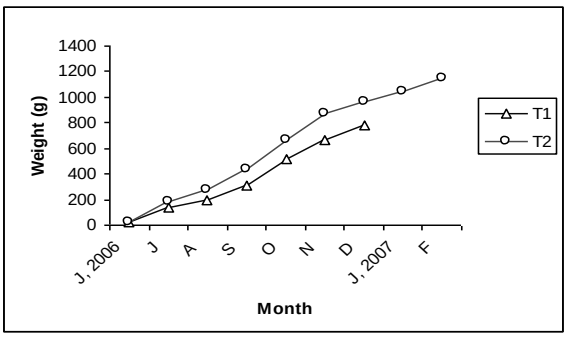

Fig. 3. Monthly growth of *Catla catla* in T_1 and T_2

Survival rate

Average survival rate of *P. monodon* in all the ponds under T_1 and T_2 was 56.30% and 55.20%, *Macrobrachium rosenbergii* was 71.35% and 69.95%, and *Catla catla* was 75.5% and 75.20% , respectively (Table 3 and 4). The survival rate of fish of crop rotation ponds is better than the fish of non- crop rotation ponds due to better environmental condition. The survival rate recorded for catla was higher than the survival rates 65-68% which was recorded by Rahman *et al.* (1995) at the stocking density of 5000/ha of 190 days culture period in the improved extensive culture system. Motoh (1981) found 64% survival rate of *P. monodon* at the stocking density of 32,000/ha of 105 days culture and the culture system was improved extensive. Results of the present study for *P. monodon* survivality is slightly distorted by the Motoh (1981) survivality. Humayun (1988) found 58-71% survivality of *Macrobrachium rosenbergii,* at the stocking density of 12,000/ha for 185 days culture, whose range is approximately similar to the results of the present study.

Cost benefit analysis

Total production cost in T_1 including paddy production cost was 88,539 Tk./ha (Table 3 and 4). Total production cost in T_1 and T_2 was 74,644 and 99,884 Tk./ha.

Table 3. Total expenditure/ha for fish production in T_1 and T_2.

Items		Rate	Amount		Total (Tk.)	
			T_1	T_2	T_1	T_2
Pond preparation		-	-	-	12,000	13,300
Lime		18 Tk/kg	118 Kg	247 Kg	2,124	4,446
Fertilizer	Urea	7 Tk/kg	10 kg	35 kg	70	245
	TSP	22 Tk/kg	57 kg	140 kg	1,254	3,080
	Cowdung	4 Tk/kg	215 kg	500 kg	860	2000
Fry	Shrimp PL	1175 tk/ thousand	20000	20000	23,750	23750
	Prawn PL	1900 tk/ thousand	10000	10000	19,000	19,000
	Catla fry	250 Pieces	4 Tk/ piece	4 Tk/ piece	1000	1000
Feed	Fry feed (Sunny)	23 Tk/ kg	28 kg	57 kg	644	1311
	Grower fish (Hand made)	18 Tk/ kg	305 kg	600 kg	5,490	10,800
Labour cost		100 Tk/man	50 men	170 men	5,000	17000
Harvesting		100 Tk/man	35 men	40 men	3,500	4000
Total					**74,644**	**99,884**

Table 4. Total expenditure/ha for paddy production in T_1 treatment.

Items		Rate	Amount	Total (Tk.)
Land preparation		-	-	2,500
Fertilizer	Urea	7Tk./kg	115 kg	805
	TSP	22Tk./kg	40 kg	880
Seed cost		20Tk. /kg	72 kg	1,440
Plantation cost		90Tk./man	20 men	1,800
Weeding cost		90Tk./man	15 men	1,350
Watering cost		-	-	1,520
Harvesting		90Tk./man	40 men	3,600
Total				**13,895**

Fish production

The average gross fish productions in T_1 and T_2 were recorded 842.95 kg/ha and 991.45 kg/ha, respectively. The total fish production varied between the two treatments because in T_1, fish was cultured for six months and in T_2 fish was cultured for eight months. The first one is crop rotation pond. In T_1, the production of shrimp, prawn, and catla were 347.20, 355.35, and 140.4 kg/ha, respectively (Table 5, Fig. 4). Molla *et al.* (1986) recorded 440-480 kg/ha production of catla in six months culture period. In T_2, the production of shrimp, prawn, and catla were 354.38, 432.37, and 204.7 kg/ha, respectively (Table 6). Quddus *et al.* (1990) recorded 585 kg/ha shrimp through improved extensive method in 120 days culture period at the stocking density of 28,000/ha which was higher than the production of shrimp in the present study.

Table 5. Production and price of shrimp, prawn, and catla in T_1 /ha.

Species	No. of Fries	No. of catch	Survivality (%)	Grade	No. of individuals	Average individual wt (g)	Grade-wise production (kg/ha)	Rate (Tk./ kg)	Total Taka
				66	1558	17.40	27.11	250	6,777.5
Shrimp	20000	13371	66.8	44	9352	24.02	224.64	350	78,624
				30	1886	35.00	66.01	450	29,704.5
				20	575	51.20	29.44	550	16,192
					Total		**347.20**		**1,31,298**
				5	100	202	20.2	650	13,130
Prawn	10000	6778	67.78	10	579	103	59.64	600	35,784
				20	3453	52.20	180.25	400	72,100
				30	2646	36	95.26	300	28,578
					Total		**355.35**		**1,49,592**
Catla	250	180	72	-	-	780	**140.4**	65	**9,126**

Paddy production

Paddy production from the crop rotation ponds of T_1 was 6200 kg/ha, which yielded the income from paddy cultivation of Tk. 93000/ha. Income from selling straw was Tk. 6000/ha. So the gross income from paddy during the culture period was Tk. 99000/ha. The production of grain was 3400-3800 kg/ha by Rahman *et al.* (1995), which was lower to the production of grain recorded in the present study.

Table 6. Production (kg/ha) and price of shrimp, prawn, and catla in T_2.

Species	No. of Fries	No. of catches	Survivality (%)	Grade	No. of individuals	Average individual wt (g)	Grade- wise production (kg/ha)	Rate (Tk/ kg)	Total Taka
				66	1458	17.55	25.59	250	6397.50
Shrimp	20000	13110	65.55	44	8702	24.10	209.72	350	73402
				30	2147	36.00	77.29	450	34780.50
				20	803	52.03	41.78	550	22979
					Total		354.38		137559
				5	372	202.40	75.29	650	48938.50
Prawn	10000	6645	66.45	10	1109	103.25	114.50	600	68700
				20	3467	52.20	180.98	400	72392
				30	1697	36.30	61.60	300	18480
					Total		432.37		208510.5
Catla	250	178	71.2	-	-	1150	204.70	80	16376

Net profit from two treatments, fish-paddy crop-rotation (T_1) and only fish culture (T_2) were Tk. 3,00,477 and Tk. 2,62,561/ha, respectively (Table 7). In general, fish farming is more than 200% profitable through improved extensive system (Hoq *et al*., 1994). So the above statement supports the results of the present study.

Table 7. Income, production cost, and net profit in T_1 and T_2 treatments.

Items	Production and income (Tk./ha)	
	T_1	T_2
Production cost	88,539	99,884
Gross income	3,89,016	3,62,445.5
Net profit	3,00,477	2,62,561.5

Conclusion

The fish paddy crop rotation system enhances the fertility of the ponds. It takes low investment but gives the reasonable production. The remaining part of paddy can be used as fertilizer or feed for the cultivable species, thus it can minimize the cost of fertilizer and supplementary feed. Therefore, crop rotation practice can be introduced for the poor and marginal fish farmer to reduce the investment cost. But it is not suitable for all areas. The land area with lower altitude where water exists round the year, it is difficult to culture paddy but the land that contains water for a particular time is suitable for crop rotation practice. During the period of February to June, the salinity is high so *Penaeid* shrimp can be cultured. During the rainy season, fresh water is increased so paddy and other fishes can be cultured easily.

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