Original Research Article

Cost-benefit analyses of nutrient rich small indigenous species in carp polyculture system under barind area in Rajshahi district of Bangladesh

ABSTRACT

This study was conducted in Tanore upazila under Rajshahi district for a period of six months from july 2019 to December 2019. Investigation was carried into the economics of polyculture of Indian major carps with small indigenous fish species (SIS) especially Shing, Magur, Pabda. The species composition were carps with shing (T_1), carps with Magur (T_2), carps with Pabda (T_3) and only carps (T_4). The economic feasibility of four different combinations was analyzed on the basis of the expenditure incurred and total return from sale price of fish in the local market. The net benefits per hectare from 6 months culture period for T_1, T_2, T_3 and T_4 were BDT. 635730.42, 805548.25, 580948.95 and 291489.07, respectively which largely reflected the gross fish production levels of 7680.42±6.68, 8324.94±16.64, 7581.13±24.94 and 6344.55±10.30 kg ha^{-1}. However, carp polyculture with Magar (T_2) provided highest benefit (BDT. 805548.25 ha^{-1}), followed by carps-shing polyculture (BDT. 635730.42/ha^{-1}), carps-Pabda polyculture (BDT. 580948.95 ha^{-1}) and only carps (BDT. 291489.07 ha^{-1}). BCR was obtained highest in Carp-Magur polyculture, followed by carp-shing and carp-Pabda polyculture systems. So, Carp-Magur polyculture may be better as it has ensured better production of protein enriched SIS Magur and also economic point of view and this system is encouraging for rural people because they would get Magur regularly for consumption and carps as cash crop.

Key words: Polyculture, Pond, Carp, BCR, SIS, Barind area

Abbreviations: BCR- Benefit Cost Ratio

1. INTRODUCTION

Bangladesh has the water resources, diverse aquatic wealth and climate suitable for high yields and considerable increase in fish production. Fisheries and aquaculture play a major role in nutrition, employment and foreign exchange earnings with about 18 million people are associated with the fisheries sector, of which 1.4 million people rely exclusively on fisheries related activities (DoF, 2021). In Bangladesh, polyculture may produce an expected production of fish with different feeding habits if stocked in proper ratios, densities and combinations (Halver, 1984). Rural farmers of Bangladesh are becoming interested to culture small indigenous fish species (SIS) like shing, magur, pabda etc. with their existing carp polyculture systems.

Aquaculture, especially carp culture, has become an important sector in Bangladesh in terms of nutrition supply, income and employment generations. Although aquaculture has grown significantly over the years, its full potential is yet to be realized (Jahan *et al.* 2010). The carp polyculture is growing as a small industry and it assisting Bangladeshi people to get additional income. In this aspect, to make profit from this culture it is a very important task to analyze cost, return and benefit of carp culture (Roy *et al*. 2003).

Economic feasibility is an important and correlation with sustainable carp-SIS polyculture system. Shang (1981) emphasized the importance of economic analysis, as it provides a basis not only for the decision making of the individual farmers but also for the formulation of aquaculture policies. Now a days carps and SIS polyculture is not a new thought in Bangladesh but there is lack of information on culture of carps and SIS especially Shing, Magur, Pabda in carp fattening pond in a polyculture system. Sufficient amount of minerals, iron and zinc are present among the indigenous small fishes (Roos *et al.,* 2007). Hence, the present research works has been designated and proposed to polyculture technique of Carps i.e, Rohu, Catla, Mrigel, Silver carp with small indigenous species i.e, Shing, Magur, Pabda in fattening pond to assess the growth, survival rate and analyze the benefit cost ratio of culture technologies.

2. MATERIALS AND METHODS

The present study was conducted in Tanore upazilla of Barind area under Rajshahi District, Bangladesh for a period of six month from July 2019 to December 2019. 12 (Twelve) experimental ponds with an average area of 0.78 ha and average depth of 3m were selected for this study. Ponds were well prepared by using lime (CaO) @ 250kg ha^{-1}. After seven days of liming, the ponds were fertilized with urea and TSP at the rate of 125g $deci^{-1}$ per 15 days each. The experiment consisted of four treatments with three replications. Four treatments were assigned for this study as T_1 (silver carp-742 ha^{-1}, catla-990 ha^{-1}, rui-1485 ha^{-1}, mrigel-990 $ha^{-1}$and shing 5,000 ha^{-1}), T_2 (silver carp-742 ha^{-1}, catla-990 ha^{-1}, rui-1485 ha^{-1}, mrigel-990 $ha^{-1}$and magur 5,000 ha^{-1}), T_3-(silver carp-742 ha^{-1}, catla-990 ha^{-1}, rui-1485 ha^{-1} , mrigel-990 $ha^{-1}$and pabda 5,000 ha^{-1}) and T_4-(silver carp-742 ha^{-1},catla-1235 ha^{-1},rui-1729 ha^{-1} and mrigel-1235 ha^{-1}) each with three replications. The initial average weight of fishes were silver carp-252.53g, catla-270g, rui-245g, mrigel-235g, shing-2.03g, magur-3.28g, pabda- 1.51g, respectively.

2.4 Experimental design

The experiment was conducted with four different treatments each with three replications.

Treatment-1: carps (silver carp+catla+rui+mrigel) + shing
Treatment-2: carps (silver carp+catla+rui+mrigel) + magur
Treatment-3: carps (silver carp+catla+rui+mrigel) + pabda
Treatment-4: Only carps (silver carp+catla+rui+mrigel)

Table 1. Layout of the experimental system

Treatment	Replication	Average pond area (ha)	Species combination	Stocking density (ind./dec)
T_1	R1 R2 R3	0.80	Silver carp	3
			Catla	4
			Rui	6
			Mrigel	4
			Shing	20
T_2	R1 R2 R3	0.73	Silver carp	3
			Catla	4
			Rui	6
			Mrigel	4
T_3	R1 R2 R3	0.53	Silver carp	3
			Catla	4
			Rui	6
			Mrigel	4
			Pabda	20
T_4	R1 R2 R3	1.06	Silver carp	3
			Catla	5
			Rui	7
			Mrigel	5

The following parameters were used to evaluate the growth of fishes:
Weight gain (g) = Mean final weight (g) – Mean initial weight (g)

Survival rate % $= \frac{\text{No. of survived hatchling}}{\text{Total no. of eggs}}$

The net benefit and benefit-cost ratio (BCR) were calculated by using following formula:

Net profit= Total Revenue (BDT) – Total cost (BDT)

BCR (B/C) = Total Revenue ÷ Total cost

2.5 Data analysis

The data were coded, compiled, tabulated and analyzed by one-way analysis of variance (ANOVA) (using SPSS 16.0 programme). For each comparison, statistically significant differences were determined by setting the aggregate type I error at 5% ($p<0.05$).

3. RESULTS AND DISCUSSION

The mean value of survival rate of Silver carp, Catla, Rui, Mrigel, Shing, Magur and Pabda varied from 87.48±1.23 (T_2) to 90.90±1.33(T_1), 88.38± 0.25(T_1) to 91.28±4.56 (T_4), 90.53±1.46

(T_3) to 93.01±0.70 (T_1), 88.12±1.25 (T_2) to 91.09±2.17 (T_3), 78.20±1.75 (T_1), 71.60±4.53(T_2) and 74.00±1.49 (T_3), respectively (Table 2). These findings were more or less similar with the findings of different research works Alam *et al.* (1995). Total fish production after six months of culture period, were 7680.42, 8324.94, 7581.13 and 6344.55 kg/ha in T_1, T_2, T_3 and T_4 treatments, respectively (Table 4). The maximum total fish production was obtained in T_2, where carps were stocked with Magur and lower production in T_4, where only carps were stocked. The medium fish production was obtained in T_1 and T_3 where carps with Shing and Pabda were stocked, respectively. It is clear that the stocking of small fish in large carp polyculture has affected the growth of carps. DoF (2021) also conducted an experiment where found similar results.

Table.2: Growth performance and production of Carps and SIS species under Four different treatments over a culture period.

Parameters	Species	T_1	T_2	T_3	T_4
Initial mean Wt.(g)	*H. molitrix*	257.58±12.84a	249.34±12.64a	262.62±9.67a	240.61±8.56a
	C.catla	276.82±24.99a	259.91±17.03a	276.54±29.24a	268.89±24.86a
	L.rohita	249.33±4.40a	242.24±10.44a	250.53±18.79a	243.67±6.22a
	C.mrigala	237.93±2.90a	235.13±6.52a	235.72±3.76a	235.35±5.62a
	H.fossilis	2.03±.07a	-	-	-
	C.batrachus	-	3.28±.20a	-	-
	O. pabda	-	-	1.51±.06a	
Final mean wt.(g)	*H. molitrix*	1769.68±10.24a	1674.05±13.43b	1667.99±18.98b	1685.83±53.47b
	C.catla	1869.31±41.97a	1836.88±13.59a	1825.98±17.50a	1908.85±90.81b
	L.rohita	1682.78±28.38a	1626.64±16.92a	1635.48±51.11a	1690.74±42.50a
	C.mrigala	1525.39±80.74a	1495.67±6.13b	1452.30±6.91b	1586.48±41.16a
	H.fossilis	209.96±12.89a	-	-	-
	C.batrachus	-	327.83±14.66a	-	-
	O. pabda	-	-	166.04±12.64a	-
Weight gain (g)	*H. molitrix*	1512.10±10.24a	1424.71±13.43b	1412.37±18.98b	1445.22±53.47b
	C.catla	1592.86±41.97a	1576.97±13.59a	1549.44±17.50a	1639.96±90.81b
	L.rohita	1433.45±28.38a	1384.40±16.92a	1348.95±51.11a	1447.07±42.50a
	C.mrigala	1433.45±80.74a	1260.54±6.13b	1216.58±6.91b	1351.13±41.16a
	H.fossilis	207.93±12.89a	-	-	-
	C.batrachus	-	324.55±14.66a	-	-
	O. pabda	-	-	164.53±12.64a	-
Survival Rate (%)	*H. molitrix*	90.90±1.33a	87.48±1.23b	88.63±0.55a	90.65±2.79a
	C.catla	88.38±0.25a	89.50±2.95a	89.96±1.08a	91.28±4.56a
	L.rohita	93.01±0.70a	92.26±1.41a	90.53±1.46a	91.99±1.54b
	C.mrigala	88.76±1.21a	88.12±1.25b	91.09±2.17a	90.90±1.05a
	H.fossilis	78.20±1.75a			
	C.batrachus		71.60±0.83a		

	O. pabda			74.00±1.49a	
Yield (kg/ha/6 months)	*H. molitrix*	796.35±5.64a	726.95±11.75b	736.43±9.91b	805.32±6.56a
	C.catla	1635.64±13.25b	1630.54±11.14a	1636.49±6.03a	1735.97±4.49b
	L.rohita	1937.30±6.64a	1860.60±6.94ab	1842.29±7.43a	2032.07±5.15b
	C.mrigala	1340.43±2.19a	1307.17±5.68b	1318.03±11.55a	1436.81±6.76ab
	H.fossilis	1026.17±3.51a			
	C.batrachus		1607.71±5.97a		
	O. pabda			1159.14±4.44a	

Values with the same superscript are not significantly different at p>0.05

3.1 Cost benefit Analysis

3.1.1 Total production Cost

The total operational cost was observed Tk. 864820.53, 853012.32, 846321.54, 897361.26 for treatments 1, 2, 3 and 4 respectively per ha pond per 6 months duration (Table 3). Fingerling were the main investment and the profit was calculated by subtracting the expenditures on pond management from the value of the harvested fish (Table 3). The production cost was comparative higher in treatments 4 where only carps were stocked separately, because the Feed price of carps were comparatively higher. In order to expand this production technology, it is necessary to ensure availability of local brood stock. Other input costs were more or less similar among three treatments.

Table 3: Cost analysis of carp-SIS poly culture (BDT/ha)

	T_1	T_2	T_3	T_4	F value	P value
Variable Cost (BDT/ha)						
Seed cost	141532.61±162.13a	139254.24±135.65a	132688.62±231.61b	147256.55±221.05a	9.57	0.01
Feed cost	380788.44±1761.61b	371258.41±1217.35a	371133.94±1970.05b	407605.22±1252.70b	3.37	0.03
Fixed Cost (BDT/ha)					00	00
Lease value	115000	115000	115000	115000	00	00
Liming	3000	3000	3000	3000	00	00
Fertilization	13500	13500	13500	13500	00	00
Excavation	12000	12000	12000	12000	00	00
Equipment	123000	123000	123000	123000	00	00
Labor	36000	36000	36000	36000	00	00
Harvesting Cost	25000	25000	25000	25000	00	00
Others	15000	15000	15000	15000	00	00

Total cost (BDT/ha)	864820.53±1322.74a	853012.32±1122.06a	846321.54±1322.60b	897361.26±1056.27a	3.31	0.04

Values with the same superscript are not significantly different at $p>0.05$

3.1.2 Total revenue earned:

It was found that the gross fish production of treatment T_1, T_2, T_3 and T_4 were 7680.42±6.68, 8324.94±16.64, 7581.13±24.94 and 6344.55±10.30 kg ha^{-1}, respectively. The total revenue was calculated Tk. 1500550.95, 1658560.57, 1427270.49 and 1188850.33 in treatments 1,2,3 and 4, respectively per ha pond per 6 months duration (Table 4). Among Four treatments, carp polyculture system with Magur (T_2) was made highest net benefit Tk. 805548.25, then carp-shing culture system (T_1) was earned Tk. 635730.42, carp - Pabda culture system (T_3) earned Tk. 580948.95 and only carps culture system (T4) was earned Tk. 291489.07 per hectare per 6 months.

Table 4: Benefit analysis of carp-SIS poly culture (BDT/ha)

Species	**T_1**			**T_2**			**T_3**			**T_4**		
	Production (kg)	**Price/kg**	**Total price (Tk)**	**Production(kg)**	**Price/kg**	**Total price (Tk)**	**Production(kg)**	**Price/kg**	**Total price (Tk)**	**Production(kg)**	**Price/kg**	**Total price (Tk)**
Silver carp	1193.05±12.13	170	202810.19±11.94	1089.16±9.67	170	185130.47±19.64	1103.30±9.58	170	187510.99±16.35	1141.44±5.85	170	193970.14±12.52
Catla	1635.57±21.51	190	310650.11±6.75	1630.34±17.67	190	309700.22±45.97	1636.77±10.01	190	310840.65±13.31	1452.05±7.97	190	275880.01±9.97
Rui	2323.61±19.09	200	464600.24±5.65	2232.49±13.64	200	446400.01±12.21	2211.75±8.75	200	442200.10±11.39	2711.88±14.64	200	542200.19±3.21
Mrigel	1372.71±15.51	170	233240.21±4.31	1317.49±4.97	170	223890.77±9.97	1316.44±4.47	170	223720.21±6.85	1040.95±5.95	170	176800.97±4.94

Shing	1157.61±9.76	250	289250.95±8.21	-								
Magur				2056.71±8.87	240	493440.44±15.95						
Pabda							1315.01±3.21	200	263000			
Total	7680.42±6.68		1500550.95±29.64	8324.94±16.64		1658560.57±65.94	7581.13±24.94		1427270.49±31.61	6344.55±10.30		1188850.33±13.39

The mean value of total average yield is presented in Figure 1.

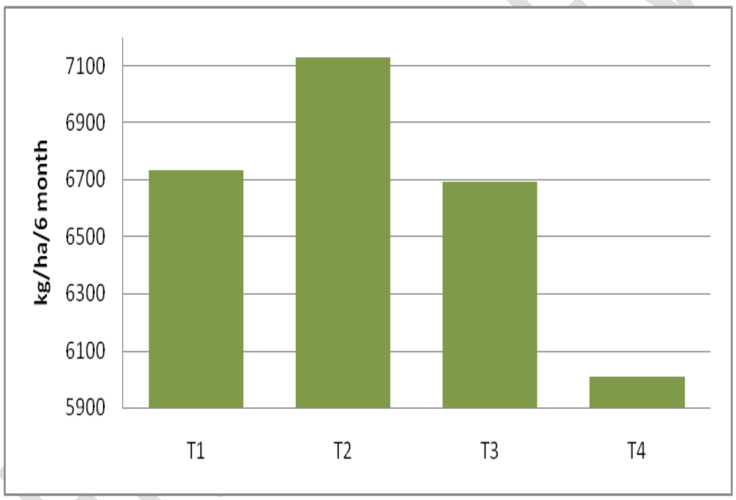

Fig 1. Variation in the total average yield of different treatments during the study period.

3.1.3 Benefit-Cost Ratio

Benefit-cost ratio (BCR) obtained from this study was 1.74, 1.94, 1.69 and 1.32 in T_1, T_2, T_3 and T_4, respectively. Here, benefit-cost ratio (BCR) >1, which means total present value of benefits exceed total present value of costs, investment is economically feasible (Table 5). The highest BCR is found in T_2 and then T_1, T_3 and T_4 respectively. BCR was higher in carp polyculture with Magur because initial weight of the magur was comparatively higher and the operational cost was comparatively lower. The second and third highest BCR was observed in carp-shing and carp-pabda polyculture, respectively. From the analysis of the costs and revenues of four different polyculture systems, it was estimated that the highest benefit was obtained from carp with SIS (magur) polyculture treatment, followed by carp-shing treatment. The lowest benefit was obtained from only carp polyculture treatment. This may be due to comparatively high feed cost and interspecies competition between large carp.

Table 5. Economic feasibility study of the project through (B/C) analysis

Treatment	Total revenue (Tk)	Total cost (Tk)	Net benefit (Tk)	Benefit cost ratio (BCR)
T_1	1500550.95	864820.53	635730.42	1.74
T_2	1658560.57	853012.32	805548.25	1.94
T_3	1427270.49	846321.54	580948.95	1.69
T_4	1188850.33	897361.26	291489.07	1.32

Variation of cost benefit ratio of different treatments is presented in Figure 2.

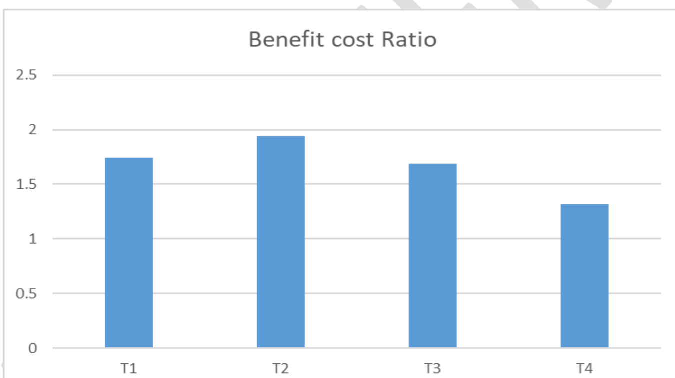

Fig 2. Variation in the mean value of cost benefit ratio of different treatments during the study period.

Similar finding of BCR was observed by DoF (2021) in their experiment. However, while there was no significant difference in net benefit between T_1, T_2 and T_3, but net benefit in T_4 was significantly ($P<0.05$) lower than T_2. These small indigenous fish species (SIS) provide food and nutrition, subsistence and supplemental income to the great majority people in this country, particularly the poor and disadvantaged. Roy *et al*. (2003) reported that Benefit-cost ratio (BCR) was obtained 3.94, 3.21 and 2.61 in only Carp (T_1), Carp with Mola (T_2) and Carp with Chela (T_3), respectively. BCR was higher in only carp polyculture system because the operational cost was comparatively lower due to the absence of small fish. But in the present study, BCR was lowest in T_4 where only carps were cultivated and higher BCR was found in carps with SIS catfishes. It was observed that SIS selection was more suitable in this study.

4. CONCLUSION

Overall findings indicated that Carp fattening only be highly profitable when there would include high valued small indigenous fish species. It also indicated that among small indigenous species, Magur (treatment T_2) would have the most suitable species for carp based small indigenous species fish farming in fattening pond. Findings of this research will let people know the existing culture status and would be helpful for conducting further research efforts in the study areas.

6. REFERENCES

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