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Research Article

POLYCULTURE OF FRESHWATER PRAWN (*MACROBRACHIUM ROSENBERGII*) WITH SOME INDIAN MAJOR CARPS IN COASTAL EARTHEN PONDS OF BAGERHAT

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Abstract

The goal of the study was to assess the productivity and growth of polyculture prawn and carps cultivation at various stocking ratios in Bagerhat district over a four-month period from April to July 2022. Three treatments based on stocking ratios and three repetitions were employed in the randomized block design (RBD) experiment. Fingerlings of major carps (Catla catla, Labeo rohita, and Cirrhinus mrigala) and prawn (*Macrobrachium rosenbergii*) post larvae in T_1, T_2, and T_3 were provided in the following ratios such as 3:1:1:1, 4:1:1:1, and 5:1:1:1, respectively. Both prawns and carps received daily meals consisting of both commercially prepared feeds and formulated feeds made on the farm. Recorded water quality were found to be within acceptable levels for prawn production and to not exhibit significant variations ($p<0.05$) among the treatments. The highest growth of prawn was observed in T_1 (42.00 g), surpassing T_2 (40.00 g) and T_3 (37.00 g). Prawn growth and survival rates were minor in T_3, when there was a greater stocking ratio. While T_2 exhibited higher prawn production (1168.00 kg ha^{-1}) compared to T_3 (1036.00 kg ha^{-1}) and T_1 (945.00 kg ha^{-1}). As opposed to, the highest production was obtained in T_1 (734.40 kg ha^{-1}) and the lowermost in T_3 (486.00 kg ha^{-1}) for catla. In case of rui, the highest production was obtained in T_1 (830.00 kg ha^{-1}) and the lowermost in T_3 (702.00 kg ha^{-1}). The highest production was obtained in T_1 (752.40 kg ha^{-1}) and the lowest in T_3 (702.00 kg ha^{-1}) for mrigal. T_2 produced significantly ($p<0.05$) more prawn and carps collectively (3303.80 kg ha^{-1}) than T_1 (3261.0 kg ha^{-1}) and T_3 (2926.0 kg ha^{-1}), respectively. The net profit was found significantly higher in T_2 (BDT 2,77,305.00 ha^{-1}) where the ratio of prawn and carp species was 4:1:1:1/m^2 followed by T_3 (BDT 2,29,686.00 ha^{-1}) with stocking ratio of 5:1:1:1/m^2 and T_1 (BDT 1,77,393.00 ha^{-1}) with stocking ratio of 3:1:1:1/m^2. As such, it is proposed that prawn farmers employ the stocking ratio that's 4:1:1:1/m² for the concurrent production of prawns and big carps aiming to enhance both prawn and fish production and economic profitability.

Introduction

Over the past few decades, the fisheries sector in Bangladesh has become increasingly integral to the country's economy. Since gaining independence in 1971, Bangladesh has witnessed noteworthy advancements in this sector. The fisheries industry now plays a crucial role in the socioeconomic development of the nation, demonstrating considerable potential for future growth within the agricultural economy. Currently, it makes a significant contribution of 2.43% to the overall national GDP and constitutes approximately one-fourth (22.14%) of the agricultural GDP (DoF, 2023). The freshwater prawn (*M. rosenbergii*), has garnered considerable focus as a species for aquaculture in various tropical and sub-tropical nations globally (Perry and Tarver, 1987). Its omnivorous nourishing behavior, with a preference for benthic food sources, makes it a suitable species for inclusion in polyculture systems. Prawn populations are naturally limited in their overall production due to antagonistic interactions, which underscores the importance of polyculture in optimizing the efficiency of the entire pond (New, 1990).

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In South Asia, the traditional semi-intensive carp polyculture technique includes the combination of carp species that are native and hybrid. (*Uddin et al.*, 1994; *Miah et al.*, 1997). Though, in Bangladesh, the preferred traditional aquaculture approach is the polyculture of three primary Indian carp species, which include *C. catla*, *L. rohita*, and *C. mrigala*. On occasion, other exotic carp species like *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, and *Cyprinus carpio* are also integrated into this system (Azim and Wahab, 2003).

In numerous countries worldwide, the practice of cultivating a mixed culture of prawns with carp species has grown in popularity as a result of its potential, production efficiency and economic benefits. Unfortunately, prawn farmers often face challenges such as various diseases, leading to inadequate prawn harvests and substantial economic losses. To mitigate these losses, some farmers turn to alternative crops, such as carp species, to compensate for the sudden failure of their prawn crops. The success of prawn and carp polyculture relies on different factors, with stocking density/ratio being a crucial determinant. In Bangladesh, where prawn farming is prevalent, sporadic research has been conducted on the mixed farming of prawns and carp species. Given the significance of these variables, the present research was conducted to evaluate the effect of freshwater prawn stock ratios on catla, rui and mrigal in brackishwater ponds.

Materials and Methods

Study area and layout

The trials were carried out in the sadar upazila of Bagerhat district in nine (09) clay ponds with brackish water. The pond's average size was 400 m^2, and its average water depth ranged from 0.8 to 1.6 m. From April to July of 2022, a 180-day research study was conducted. A randomized block design (RBD) was utilized in the trial, and the three treatments were T_1, T_2, and T_3. In each of these treatments, there were three replications labeled as R_1, R_2, and R_3. Prawn (*M. rosenbergii*) post larvae and carp fingerlings were seeded in the appropriate ratios of 3:1:1:1, 4:1:1:1 and 5:1:1:1 for T_1, T_2, and $T_{3,}$ respectively.

Pre stocking management

Every experimental pond was dried off and exposed in the direct sunshine. Preparation of the ponds included reinforcing the embankments and clearing them of all types of weeds. Prior to the commencement of the study, agricultural lime (CaCo3) was administered at an amount of 250 kg ha^{-1} to address the pH of the soil. After then, tidal water gradually filled the ponds from the adjacent tidal canal until they reached a depth of 0.9 meters using a screen net. In order to neutralize the effects of rotenone, which was applied at a dosage of 3 parts per million (ppm) to eradicate undesired species, 125 kg ha^{-1} of lime ($CaCo_3$) was applied. Urea 50 kg and triple superphosphate (TSP) 100 kg were used for fertilization per hectare, respectively, after a 5-day period following the cleaning. Within 4-5 days of conception, water developed a green coloration. In order to keep possible disease vectors like snails and snakes out of the streams surrounding the ponds, fine-mesh polyester net had been put in as a barrier.

Stocking of prawn and major carps

Post larvae of prawn (*M. rosenbergii*) were obtained at Foyla Bazar, Rampal, Bagerhat, while fingerlings of major carps were collected in a Bagerhat private hatchery. Oxygenated polythene bags were used to carry fingerlings from the nursery to the research site. After stocking prawn PL for 25 days, carps were present in every pond. The plastic bags were placed in the experimental ponds for approximately half an hour prior to the release of the fingerlings and PL. To help the fish adjust to the pond's temperature, water was cycled through the plastic bags and the pond during this period. Following that, the PL and fingerlings were released into the experimental ponds. Prawn PL were placed at 3, 4 and 5/m^2 in T_1, T_2, and T_3, respectively, however carp fingerlings were stocked at 1/m^2 in all ponds. Before being placed in the ponds, thirty percent of each specimen had its initial weight and length measured individually using a digital balance (Bangladesh, EK 3052, Camry digital electrical balance) and a measuring scale.

Management after stocking

Ponds were supplied with commercial pelleted prawn feed from the local market, which contained crude lipid 5.0%, crude fiber 7.0%, moisture 10.0% and protein 31.0%. The first month's 10% of the total prawn biomass was supplied as prawn meal, which was served six days a week. This was then reduced to 6% in the following month and finally to 3% for the duration of the trial. The carps were fed a farm-made feed that included wheat flour-20%, maize flour-15%, fish meal-20%, mustard oil cake-5%, and rice bran-40%. They were fed three times a day for the first two months, and by finished of the culture period; feeding rate was accustomed to 5-3% of their body weight. The daily meal was divided into three equal portions, which were delivered at 7:00–8:00 am in the morning, 11:00 am–12:00 pm in the midday, and 6:00-7:00 pm in the afternoon. Carp feed was provided before prawn feed to optimize feed utilization and minimize competition for food among the different species being cultivated. Lime was applied to each of the ponds on every month at rates ranging from 50.0-75.0 kg ha^{-1}, adjusted according to the water depth, to maintain acceptable water quality. In addition, materials like dried coir, fronds, jute bags, and bamboo branches were set up on the lower edge of the pond to protect prawns and other fish while simultaneously assisting in lowering the water's temperature.

Monitoring of water parameters

Ten days in advance between 9:00 and 10:00 am, various water quality parameters were assessed in the ponds. A hand refractometer (ATAGO) was used to measure salinity. On-site measurements of surface water temperature were conducted using a conventional Celsius thermometer. A Secchi disc was used to measure transparency. A dissolved oxygen meter (YSI 58, HANNA, USA) used for measuring the concentration of DO. A pH meter (HANNA, USA) used to determine the pH. The APHA (2000) standards were followed in order to assess alkalinity using titrimetric method. For the measurement of ammonia nitrogen content, a test kit for ammonia was utilized. To monitor and maintain the ponds' water quality, these assessments were carried out.

Sampling, harvesting and production parameters

Every two weeks, a portion of the stocked prawn and carp, amounting to 10-15% of the population, was sampled to estimate their biomass. This sampling served the dual purpose of fine-tuning the feeding amounts and assessing the corporal condition of the provided species. Cast nets were employed to capture both prawn and carp for sampling. To assess their growth, the length and weight of thirty from prawn and carps species were measured. Weight (g) and length (cm) were calculated using movable balance and measuring scale, respectively. This sampling routine persisted until the time of harvesting.

The woody bamboo poles and plants were taken down immediately following 120 days, ponds were drained, and all prawn and carp were captured using frequent netting (cast net and encircling net). To assess the growth, survival, and production, every carp as well as prawn harvested from each pond underwent individual counting, measuring, and weighing. The equation presented by Pechsiri and Yakupitiyage (2005) was used to compute the daily weight increase/growth (g), specific growth rate (SGR), survival (%) and yield. Here are the equivalents:

$$\text{Weight increase(g)/ day} = \frac{\text{Mean harvesting weight (g)} - \text{mean initial/beginning weight (g)}}{\text{Total number of days on feed}}$$

$$\text{Rate of specific growth (\%/day)} = (\text{Ln (harvesting body weight)} - \text{Ln (beginning body weight) x 100)/cultured period (days)}$$

$$\text{Survival rate (\%)} = (\text{Number of prawn/fish obtained} \div \text{total number of prawn/ fish released) x 100}$$

$$\text{Yield of fish/prawn} = \text{No. of prawn/fish obtained x (average harvesting weight of prawn/fish} - \text{average beginning weight of prawn/fish)}$$

Economic analysis

To evaluate the efficiency and cost-effectiveness of prawn besides fish cultivation across unlike treatments, a fundamental economic analysis was conducted using algebraic equations. The formula accustomed to determine the productivity of prawn and carps cultivation in pond systems is as follows: NR = TR - (FC + VC + li). In this equation, "NR" represents the net return, "TR" stands for the total returns generated from prawn and carp sales, "FC" represents the fixed or average expenses, "VC" illustrates the varying expenses, and "li" represents the awareness on inputs. Cost-benefit ratio (BCR) was computed by full input cost divided by net return overall. Prices assigned to various inputs, prawns, and carps were based on the wholesale market rates in Bagerhat for the year 2022. Prawns were priced between BDT 530.00 and 560.00, while carps were priced between 110.00 and 130.00 BDT, respectively.

Statistical analysis

To assess the differences in means among the treatment groups concerning growth, production, net returns, and benefit-cost ratios, an analysis of variance (ANOVA) in one direction was applied. While a noticeable influence was observed, post hoc testing using Tukey HSD was carried out. All ANOVA tests were conducted using Statistix-10 and a 5% level of significance was used.

Results and Discussion

Characteristics of water quality

Temperature, transparency, dissolved oxygen, salinity, pH, alkalinity, and ammonia were among the water quality indicators of the pond that were measured. The water's temperature was measured between 27.51 to 33.93°C. These results align with the research conducted by Akter *et al.* (2019), Islam *et al.* (2016) and Islam and Mahmud (2012) where water temperature ranges of 26.39−32.97°C, 27.0 to 32.3°C and 28.0 to 35.5°C, respectively. The range of transparency measured was 28.75 to 36.95 cm. These findings are consistent with the research conducted by Akter *et al.* (2019) and Islam *et al*. (2016), where transparency of farmers' ponds water in Bagerhat was reported to range from 29.11 to 36.83 cm and 28.0 to 44.0 cm. Dissolved oxygen (DO) concentrations oscillated from 4.11 to 5.67 mg/l, supporting with the results of Akter *et al.* (2019) and Islam *et al.* (2016), who reported DO levels ranging from 4.30–5.36 mg/l and 4.0 to 5.1 mg/l in farmers' shrimp ponds. Salinity levels across all ranged from 3.42 to 6.41 ppt. These results align with the research conducted by Akter *et al.* (2019) and Islam and Mahmud (2012, 2011, and 2010) who reported water salinity levels of 3.50−6.14, 2.5−10.6, 3.0−10.3, and 1.2−11.0 ppt, respectively. The pH range of the water was 6.52 to 7.46, which is fairly near the results of Akter *et al*. (2019) and Islam *et al*. (2016), who found that pH ranged in farmers' shrimp ponds from 6.68 to 7.35 and 7.1 to 7.7. Overall alkalinity values ranged from 92.25 to 101.33 mg/l. These agree with the outcomes of Akter *et al.* (2019) and Islam *et al*. (2016), who found alkalinity ranging from 90.51 to 103.34 mg/l and 90.0 to 106.5 mg/l in farmers' ponds. Islam and Mahmud (2012 and 2011) recorded total alkalinity as 61.0 to 78.01 and 61.0 to 85.10 mg/l, respectively. The outcomes of Akter *et al*. (2019) and Islam and Mahmud (2012, 2011, and 2010) who observed ammonia levels ranging from 0.004−0.092, 0.002−0.093, 0.002−0.090, and 0.002−0.080 mg/l, respectively, are close to the nitrogen absorptions from ammonia, which were between 0.006 to 0.098 mg/l.

Growth and production performance of prawn and carp species

The initial average body weights (ABW) of fingerlings of catla, rui, and mrigal and juvenile prawns were 3.10 g, 3.40 g, 4.10 g, and 4.50 g, respectively, and were similar in all ponds. However, T_1 had the highest mean ultimate weight of prawns (42.00 g), followed by T_2 (40.00 g) and T_3 (37.00 g), in that order. Regarding the carp species, T_1 (108.00 g) had a higher recorded peak final weight of catla than T_2 (94.00 g) and T_3 (90.00 g). Rui's highest recorded final weight (124.00 g) came in T_1, followed by T_2 (120.00 g) and T_3 (117.00 g). T_1 had the greatest final weight of mrigal, weighing 114.00 g, compared to T_2 (110.00 g) and T_3 (108.00 g) (Table 1). Islam *et al*. (2016) noted that after a 150-day period in shrimp ponds owned by Bagerhat farmers, the average conclusion weight of tilapia and prawn in mixed cultures was 149−199 g and 58−63 g, respectively. According to Islam and Mahmud (2012), the final weights of tilapia and prawn in mixed culture were 163.5−168.5 g and 63−73 g, respectively after 180 days in the ponds of the Shrimp Research Station, Bagerhat. A little higher than the current findings, Islam and Mahmud (2011) also determined the harvesting weights of prawn and tilapia under same culture practice after 180 days in the same research ponds, weighing 74 to 85 and 99 to 149 g, respectively.

Table 1. Production performance (mean±SD) of *Macrobrachium rosenbergii, Catla catla, Labeo rohita* and *Cirrhinus mrigala* under three treatments.

Species and production Parameters	**Treatments** T_1 **(3:1:1:1/m^2)**	T_2 **(4:1:1:1/m^2)**	T_3 **(5:1:1:1/m^2)**
Macrobrachium rosenbergii			
Average beginning weight (g)	3.10 ± 0.14	3.10 ± 0.15	3.10 ± 0.12
Average harvesting weight (g)	42.00 ± 3.26^{a}	40.00± 3.53^{b}	37.00 ± 4.12^{c}
Weight increase (g)/day	0.32 ± 0.04	0.30 ± 0.03	0.26 ± 0.05
Survival rate (%)	75.00 ± 2.31^{a}	73.00 ± 2.01^{b}	56.00 ± 1.5^{c}
Rate of specific growth (%/day)	2.21 ± 0.11	2.15 ± 0.13	2.10 ± 0.12
Production (kg ha^{-1})	945.00 ± 30.10^{c}	1168.00 ± 32.8^{a}	1036.00 ± 30.4^{b}
Catla catla			
Average beginning weight (g)	3.40 ± 0.18	3.40 ± 0.22	3.40 ± 0.21
Average harvesting weight (g)	108.00 ± 3.15^{a}	94.00 ± 3.07^{b}	90.00 ± 2.88^{c}
Weight increase (g)/day	0.80 ± 0.03	0.74 ± 0.03	0.73 ± 0.03
Survival rate (%)	68.00 ± 2.1^{a}	62.00± 1.74^{b}	54.00 ± 1.4^{c}
Rate of specific growth (%/day)	2.75 ± 0.07	2.74 ± 0.07	2.71 ± 0.07
Production (kg ha^{-1})	734.40 ± 20.1^{a}	582.81 ± 16.62^{b}	486.00 ± 13.64^{c}
Labeo rohita			
Average beginning weight (g)	4.10 ± 0.26	4.10 ± 0.24	4.10 ± 0.23
Average harvesting weight (g)	124.00 ± 4.15^{a}	120.00 ± 3.82^{b}	117.00 ± 3.68^{c}
Weight increase (g)/day	1.02 ± 0.02	0.97 ± 0.04	0.94 ± 0.03
Survival rate (%)	67.00 ± 3.0^{a}	68.00 ± 1.76^{a}	60.00 ± 2.0^{b}
Rate of specific growth (%/day)	2.88 ± 0.08	2.82 ± 0.08	2.81 ± 0.07
Production (kg ha^{-1})	830.00 ± 37.5^{a}	816.00 ± 21.2^{a}	702.00 ± 23.6^{b}
Cirrhinus mrigala			
Average beginning weight (g)	4.50 ± 0.29	4.50 ± 0.27	4.50 ± 0.25
Average harvesting weight (g)	114.00 ± 3.14^{a}	110.00 ± 3.88^{b}	108.00 ± 3.57^{c}
Weight increase (g)/day	1.10 ± 0.03	1.08 ± 0.05	1.06 ± 0.02
Survival rate (%)	66.00 ± 2.0^{a}	67.00 ± 1.75^{a}	65.00 ± 1.86^{b}
Rate of specific growth (%/day)	2.77 ± 0.07	2.73 ± 0.06	2.71 ± 0.08
Production (kg ha^{-1})	752.40 ± 38.6^{a}	737.00 ± 20.3^{a}	702.00± 21.5^{b}
Combined production (kg ha^{-1})	3261.80±71.5	3303.80±66.4	2926.00±59.7

Values with different superscript letters denote significant different ($p<0.05$).

Over a 120-day period, the weight gain of prawn, catla, rui, and mrigal was recorded in the range of 0.26-0.32, 0.73-0.80, 0.94-1.02, and 1.06-1.10 g, respectively. A noticeable variation was found in daily weight gain of the three treatments for the carp species. In the ponds of the Shrimp Research Station, Islam and Mahmud (2012) found that, the daily weight values of tilapia and prawn were, respectively, 0.91-0.94 g and 0.35-0.41 g, depending on the stocking density. In the shrimp-growing region of Bagerhat, Islam *et al*. (2016) estimated the daily weights of tilapia and prawns to be 0.99-1.33 g and 0.39-0.42 g, respectively. Additionally, Islam and Mahmud (2011) demonstrated that over the course of 180 days in brackishwater ponds of the Shrimp Research Station, the daily weights of tilapia and prawn with mixed culture at various stocking densities were 0.55-0.83 g and 0.41-0.47 g, respectively. Lower daily weight values of 0.55 g for silver barb and 0.20 g for shrimp were noted by Shofiquzzoha and Alam (2008) during a 120-day period of simultaneous culture in the ponds of the Brackishwater Station in Khulna. In the same ponds, they also recorded daily weight values of 1.34 g for tilapia and 0.21 g for shrimp over the same time period, which agrees with the findings of the current investigation. Statistically ($p<0.05$), T_1 (75.00±2.31%) and T_2 (73.00±2.01%) had higher prawn survival rates than T_3 (56.00±1.5%) (Table 1). Conversely, in T_1, T_2, and T_3, the survival rate of catla was 68.00 ± 2.1, 62.00 ± 1.74, and 54.00 ± 1.4, respectively. T_1 had the highest survival rate

(68.00±2.1%), whereas T_3 had the lowest (54.00±1.54%). In addition, in T_1, T_2, and T_3, the survival rate of rui was 67.00 ± 3.0, 68.00 ± 1.76, and 60.00 ± 2.0%, respectively. T_2 had the highest survival rate (68.00±1.76%), whereas T_3 had the lowest (60.00±2.00%). In T_1, T_2, and T_3, the survival rate of mrigal was 66.00±2.0, 67.00±1.75, and 65.00±1.86%, respectively. T_2 had the highest survival rate (67.00 ± 1.75%), whereas T_3 had the lowest (65.00 ± 1.86%). Significant variations in the survival of mrigal, rui, and catla under the three treatments were found. According to a study by Islam *et al*. (2016), tilapia & prawns lived for 66-72% and 56.2-65.5%, respectively; in mixed culture over 150 days in the ponds of Bagerhat shrimp growers. Similar to this, Islam and Mahmud (2012) found that under a mixed culture of one eighty days with varying densities in ponds of the Shrimp Research Station, 68–71.5% and 62–70%, respectively, were survival rates for tilapia and the prawn. They (2011) also found the survival of prawn and tilapia was 66-73% and 58-65%, respectively, which is in keeping with the results of the current work. Moreover, the survival percentage of only *P. monodon* mentioned by the same authors (2010) ranges from 58% to 72.5%, which is in line with the findings of the present investigation. Against the results of this work, however, shrimp (57.03%) and Thai saropunti (58.10%) had lower survival rates in concurrently farming over 120 days in the ponds of the Brackishwater Station in Khulna, as shown by Shofiquzzoha and Alam (2008). They did, however, also report shrimp and tilapia survival rates of 65.50% and 78.43%, respectively, over a period of twenty days in the same ponds, which closely match with the results of the present investigation.

According to Table 1, T_1 had the highest prawn SGR rate (2.21%) and T_3 had the lowest (2.10%). Conversely, in T_1, T_2, and T_3, catla's mean SGR was measured at 2.75 ± 0.07, 2.74 ± 0.07, and 2.71 ± 0.07, respectively. Rui's mean SGR was determined to be 2.88 ± 0.08, 2.82 ± 0.08, and 2.81 ± 0.07, correspondingly, under T_1, T_2, and T_3. Under T_1, T_2, and T_3, mrigal's mean SGR was calculated as 2.77 ± 0.07, 2.73 ± 0.06, and 2.71 ± 0.08, respectively. SGR for prawn and tilapia in mixed culture, at different stocking densities, were found to be 1.13 to 1.21% and 3.07 to 3.34%, respectively, in the ponds of SRS by Islam and Mahmud (2011). According to them (2012), the SGRs for tilapia and prawn in the SRS ponds were 3.13 to 3.15% and 1.71 to 1.80%, respectively, at various stocking levels. In addition, SGRs for tilapia and prawn in the shrimp growing region Bagerhat were reported by Islam *et al*. (2016) to be 3.98 to 4.13% and 1.52 to 1.65%, respectively. Interestingly, the results for tilapia are greater and the results for prawns are lower in earlier trials than they are in the current one. For shrimp (6.90%) and silver barb (2.56%), Shofiquzzoha and Alam (2008) found greater SGR values in simultaneous cultivation for a period of one twenty days in the ponds of the BS; the results for silver barb, however, are consistent with the current study. Additionally, in the comparable pond complex, they reported SGR for tilapia and shrimp over 120 days as 6.94% and 4.26%, respectively, showing greater values compared to the present study's findings.

Production (kg ha^{-1}) of prawn and carp species

After 120 days of culture, the three treatments' variation in prawn production was 945.00-1168.00 kg ha^{-1}. The maximum prawn production (1168.00 kg ha^{-1}) was observed in T_2, which differed significantly ($p<0.05$) from T_1 (945.00 kg ha^{-1}) but did not significantly differ from T_2 (1168.00 kg ha^{-1}) and T_3 (1036.00 kg ha^{-1}). T_1 had the largest production of catla (734.40 kg ha^{-1}) compared to T_3 (486.00 kg ha^{-1}), with a statistically significant variation ($p<0.05$) between two. However, there was a substantial variance between T_1 (734.40 kg ha^{-1}) & T_2 (582.80 kg ha^{-1}). The highest rui production (830.00 kg ha^{-1}) occurred in T_1, and it differed considerably ($p<0.05$) from T_3 (702.00 kg ha^{-1}) production; however, the output of T_1 (830.00 kg ha^{-1}) and T_2 (816.00 kg ha^{-1}) did not differ significantly from one another. When compared to treatment T_3, which produced 702.00 kg ha^{-1}, mrigal produced the most at 752.40 kg ha^{-1}, a significant statistical variation ($p<0.05$). But little variation was found between T_1 (752.40 kg ha^{-1}) and T_2 (737.00 kg ha^{-1}). The total output of carp and prawn species in T_1, T_2, and T_3 was 3261.80, 3303.80, and 2926.00 kg ha^{-1}, respectively. Table 1 shows that T_2 achieved a substantially ($p<0.05$) higher total production (3303.80 kg ha^{-1}) compared to T_1 (3261.8 kg ha^{-1}) and T_3 (2926.00 kg ha^{-1}). These findings closely correspond with those of Islam and Mahmud (2012) and Islam *et al*. (2016), who reported that over 150 days, the combined production figures for prawn and tilapia in shrimp growers' ponds and the SRS pond complex were 2491.80 to 2510.60 kg ha^{-1} and 2191.39 to 2441.47 kg ha^{-1}, respectively. The current study's findings, however, are superior to those of Islam and Mahmud (2011), who observed a range in the SRS pond complex of 1105.0 to 2133.4 kg ha^{-1} over 180 days. When compared to the existing research, Islam and Mahmud (2010) likewise reported decreased shrimp production in growers' farms, varying from

416.9 to 641.7 kg ha^{-1}. In comparison to the current findings, Shofiquzzoha and Alam (2008) reported lower production statistics for tilapia (1272.95 kg ha^{-1}) and shrimp (162.13 kg ha^{-1}) in a relevant culture over one twenty days in the ponds of the BS, as well as shrimp (136.77 kg ha^{-1}) and Thai saropunti (402.73 kg ha^{-1}).

Profit of prawn and carps polyculture

The total net profit of T_2 (BDT 277,305.00 ha^{-1}) compared to T_3 (BDT 229,686.00 ha^{-1}) and T_1 (BDT 177,393.00 ha^{-1}) for the carp and prawn species (catla, rui, and mrigal) was considerably ($p<0.05$) greater (Fig. 1). The BCR in T_2 (1.57) was greater than in T_3 and T_1, which were 1.48 and 1.40, respectively. Islam *et al*. (2016) estimated earnings ranging from BDT 147,819.00 to 238,923.00 ha^{-1} in farmers' ponds for prawn and tilapia aquaculture; the revenue margin was marginally higher than their findings. Likewise, Islam and Mahmud (2011) reported lower-than-present study earnings in the farming of prawn and tilapia, with BDT 137,021.00 to 236,797.00 ha^{-1} in the ponds of the SRS. The profits found in the current study are much higher than those as mentione by Islam and Mahmud (2010), who reported a net profit for shrimp production in farmers' farms in Bagerhat over 120 days, using commercial and BFRI feeds, ranging from BDT 45,086.33 to 181,182.35. Because polyculture has a greater overall influence on fish output than monoculture, it has become increasingly popular worldwide. The growth and survival rates of carp species and prawns were higher in T_1 (3:1:1:1/m^2) than in T_2 (4:1:1:1/m^2) and T_3 (5:1:1:1/m^2). Furthermore, comparing T_2 (4:1:1:1/m^2) to T_1 (3:1:1:1/m^2) and T_3 (5:1:1:1/m^2), the combined production, benefit-cost ratio (BCR), and net profit from the cultivation of prawn and carp species were better. Therefore, it can be inferred from these results that farmers in Bangladesh's coastal regions should embrace prawn and carp species polyculture at a 4:1:1:1/m^2 ratio for greater yields and net profit.

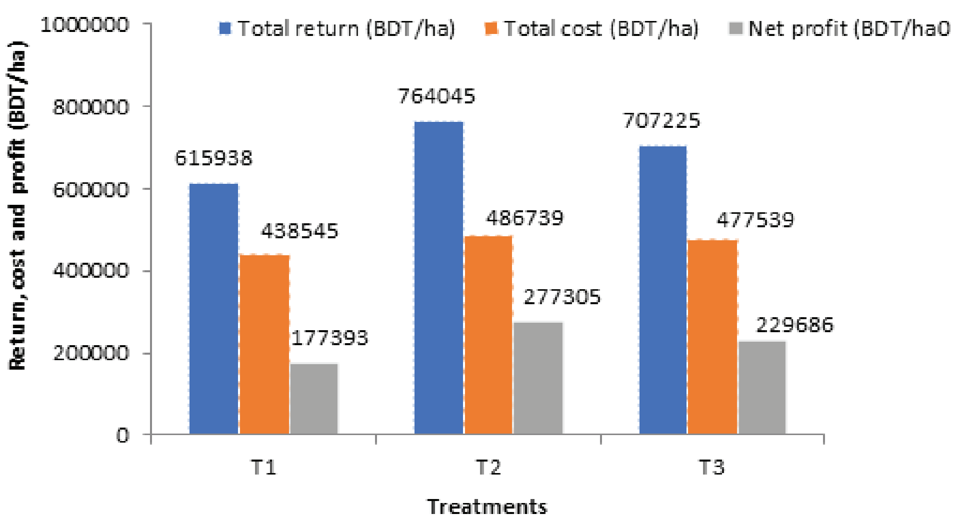

Figure 1. Cost and financial return of prawn and carp farming under three treatments

Conclusion

Around the globe, polyculture has gained significant prominence over monoculture due to its positive impact on overall fish production. In T_1 (3:1:1:1/m^2), the growth and survival rates of prawns and carp species were higher compared to T_2 (4:1:1:1/m^2) and T_3 (5:1:1:1/m^2). Additionally, the combined production, benefit-cost ratio (BCR), and net profit derived from prawn and carp species farming were superior in T_2 (4:1:1:1/m^2) when contrasted with T_1 (3:1:1:1/m^2) and T_3 (5:1:1:1/m^2). Based on these findings, it can be concluded that, for enhanced production and net profit, adopting polyculture of prawns and carp species at a ratio of 4:1:1:1/m^2 is recommended for farmers in the coastal areas of Bangladesh.

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