Research in

ISSN : P-2409-0603, E-2409-9325

AGRICULTURE, LIVESTOCK and FISHERIES

An Open Access Peer-Reviewed International Journal

Article Code: 416/2023/RALF

Article Type: Research Article

Res. Agric. Livest. Fish.

Vol. 10, No. 2, August 2023: 219-228.

DETERMINATION OF SUITABLE SPECIES COMBINATION OF TWO SMALL INDIGENOUS FISH SPECIES (SIS) PABDA (*Ompok pabda*) AND GULSHA (*Mystus cavasius*) WITH ROHU (*Labeo rohita*) IN FARMERS POND

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ARTICLE INFO

Received
25 July, 2023

Revised
24 August , 2023

Accepted
26 August, 2023

Online
September, 2023

Key words:

Pabda
Gulsha
Species combination
Benefit cost ratio

ABSTRACT

An experiment was carried out from May to September, 2018 to determine the suitable species combination of two indigenous fish Pabda (*Ompok pabda*) and Gulsha (*Mystus cavasius*) with Rohu in farmer's pond. Three species combinations (% of total stocking densities) Gulsha: Pabda = 60: 40 at T_1, 40: 60 at T_2, and 50: 50 at T_3 were tested. Stocking of Rohu were similar (2964/ha) for all the treatments. Similar stocking density (200564/ha) was maintained in all the treatments. The production obtained were 7138.30±63, 6977.75±78 and 7037.03±84 kg/ha from T_1, T_2 and T_3 respectively. The highest production was obtained from T_1 compared to other treatments. A straightforward economic analysis showed that treatment T_1 (BCR -1.94, net profit: Tk.12,94,576/ha/6 months) had the highest benefit cost ratio (BCR) and net profit, subsequent to treatment T_3 (BCR -1.87, net profit: Tk.12,74,685/ha/6 months) and treatment T_2 (BCR-1.93, net profit: Tk.12,02,956/ha/6 months). Therefore, it might be concluded that the species combination of pabda, gulsha and rohu followed by T_1 may be a better option considering the production and economic benefits to farmer's ponds in our country.

To cite this article: Nahiduzzaman M., M. S. Islam, S. S. Mely, M. M. Rahman, M. R. Awal and A. H. M. Kohinoor, 2023. Determination of suitable species combination of two small indigenous fish species (SIS) pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) with rohu (*Labeo rohita*) in farmers' pond. Res. Agric. Livest. Fish. 10(2): 219-228.

DOI: https://doi.org/10.3329/ralf.v10i2.68785

www.agroaid-bd.org/ralf, E-mail: editor.ralf@gmail.com

INTRODUCTION

Aquaculture provides 57.10 percent of the overall fish production in Bangladesh, one of the world's top producers of fish, which produced 46.21 lakh MT in FY 2020–2021 (Yearbook of Fisheries Statistics of Bangladesh 2020–2021). With a very stable average increase in fisheries of 4.82% and consistent average growth in aquaculture of about 8.59% over the past 12 years. With a per capita consumption of 62.58 g/day vs the desired 60 g/day, Bangladesh is now a self-sufficient fish-producing nation that supplies nearly 60% of its population's daily animal protein needs. In terms of inland open-water capture output and global aquaculture production, Bangladesh came in third and fifth, respectively, in the FAO study The State of World Fisheries and Aquaculture 2020. Inland fisheries and marine fisheries make up the bulk of the country's enormous as well as various fisheries resources. The two sub-groups of inland fisheries are again inland capture and inland culture fisheries. More than 55% of the world's fish are produced by inland culture, which mostly consists of ponds, ditches, baor, shrimp and prawn farms, seasonal cultured waterbodies, etc. on an area of roughly 7.89 lakh hectares. This production mostly results from the implementation of better farming techniques. The production of tilapia (*Oreochromis niloticus*), pangas (*Pangasianodon hypophthalmus*), and Thai/Vietnamese koi (Anabas spp.) in inland aquaculture systems has significantly increased. Besides, new interest grew in farming of indigenous species like koi (*Anabus testudineus*), singh (*Heteropneustes fossilis*), magur (*Clarias batrachus*), pabda (*Ompok pabda*), gulsha (*Mystus cavasius*), mola (*Amblypharyngodon mola*) etc. because they are getting infrequent on open water areas however have high market demand besides better involvement to household level nutrition supply.

Small freshwater fish native to Bangladesh include the catfish Pabda and Gulsha. Due to their excellent flavors, these two fish have a strong customer preference, which leads to high market demand and prices. The most prized carp species with a high market price is rohu, which is virtually entirely grown in polyculture. Bangladesh is the most widely cultivated carp species, with 386 thousand tons produced during a 12-month period in 2019-2020 (DoF and FAO, 2020). It is an important aquaculture species with an annual production of approximately 2.0 MT (DoF and FAO, 2020).

In Bangladesh, Pabda and Gulsha monoculture in farmer's ponds is a widespread practice (Kohinoor et al., 2018; Nahar et al., 2019 and Rahman et al., 2021). The monoculture of these species isn't always ideal from an economic standpoint. Because of this, various studies have shown a polyculture of Pabda, Gulsha, and mono-sex Tilapia in farmers' ponds (Kohinoor et al., 2011 and Mondal et al., 2022). However, there was never any attempt made in the past to develop pabda and gulsha with rohu added to pond aquaculture. Therefore, the goal of the current experiment was to assess the productivity of pabda, gulsha, and rohu in on-farm management in order to track environmental variables; to assess the growth, yield, and economics of pabda, gulsha, and rohu fish; and to suggest a suitable species combination in farmers' ponds.

METHODOLOGY

Location and duration of study

The experiment was carried out from May to September 2018 during a six-month period in nine experimental ponds in the Fulpur upazila (Mokamia, Fulpur) within the Mymensingh district of Bangladesh (mean area: 0.06 x 0.04 hectare; depth: 1.42 x 0.07 m). The experimental ponds were well-lit and equipped with an efficient inlet-outlet system that allowed for an addition or removal of water as needed. In addition, the pond embankments were maintained at a high level to prevent runoff from nearby neighborhoods.

Experimental design

The experimental ponds were stocked with one carp species, Rohu, two SIS species, Pabda and Gulsha. All of the treatments kept the same stocking density (200564/ha). The current experiment used a randomised completely block design (RCBD) and three different treatments of species combinations (% of total stocking densities), such as Pabda: Gulsha = 60: 40 at T_1, Pabda: Gulsha = 40: 60 at T_2, and Pabda: Gulsha = 50: 50 at T_3, respectively. For all of the treatments, the rohu stocking was the same (2964/ha). Table 1 details the species mix and stocking density. Under various conditions, fry from hatcheries was employed to stock the ponds.

Figure 1. Location of study area indicated with red circle at Phulpur upazila of Mymensingh district, Bangladesh

Table 1. Layout of experimental design with species combination and stocking density under three treatments

Treatments	Species combination	Stocking densities/ha	Average weight (g)
	Pabda	118560/ha	3.61 ± 0.46^{a}
T_1	Gulsha	79040/ha	2.74 ± 0.36^{a}
	Rohu	2964/ha	30.76 ± 1.25^{a}
	Pabda	79040/ha	3.80 ± 0.33^{a}
T_2	Gulsha	118560/ha	2.65 ± 0.42^{a}
	Rohu	2964/ha	33.21 ± 1.51^{a}
	Pabda	98800/ha	3.75 ± 0.36^{a}
T_3	Gulsha	98800/ha	3.32 ± 0.49^{a}
	Rohu	2964/ha	30.65 ± 1.53^{a}

Pond management

Experimental ponds had aquatic weeds carefully removed from them. Rotenone (12.50 kg/ha) was used to get rid of predators as well as weed fishes before the experiment was conducted. To keep the water depth in all the ponds at or near 1 m, shallow tube well water was utilized as necessary. Then, 250kg/ha of lime was used to cure ponds. Ponds received 2,000 kg/ha of cow dung as fertilizer after 5 days of liming. The experimental ponds were stocked with hatchery seeds of O. pabda, M. M. cavasius, and L. rohita. Rohu seeds were overwintered; while pabda and Gulsha fish seeds were transferred from nursery rearing to farmer-managed grow out ponds for stocking. To improve the growth performance of the fish, additional feed was continued on a regular basis. Fish were fed commercial feed twice daily (at rates of 10% at first, 8% at second, 6% at third and fourth, and 5% at fifth and sixth month) that contained 35% crude protein. All of the treatments included twice-daily feedings (morning and evening). Through fortnightly sampling, the feed ration was changed.

Monitoring of water quality parameters

On each sample day, the experimental ponds' water quality measurements were checked between 9:00 AM and 10:00 AM. Each sample date resulted in the collection of 500ml of surface water in black-coded bottles. The water's temperature (°C), pH, and DO were all measured using a Multi-Parameter Water Quality Metre (HANNA, HI 98194, pH/EC/DO multi-parameter). A black and white-coded Secchi disc was used to measure the water clarity (in cm). Alkalinity (mg/l) and ammonia-nitrogen (mg/l) were measured using a spectrophotometer (DR-1900).

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Fish growth monitoring

Fish was sampled every two weeks to check on growth and adapt the feeding schedule. 10% of the supplied fish from each pond were sampled by seining with a seine net on each sampling day. The fish were then instantly released into the ponds after having their weight accurately determined to within 0.001g in a computerized electronic scale. Following Brett and Groves (1979), the growth, survival, and production abilities of fish were examined as follows:

- Initial weight (g) = Weight of fish (individual) at the beginning of experiment
- Final weight (g) = Weight of fish (individual) at the end of the experiment
- Total weight gain (g) = Mean final weight (g) - Mean initial weight (g)
- Specific growth rate (%) $= \frac{\text{(Ln final wt.) - (Ln initial wt.)}}{\text{Culture period}} \times 100$
- Survival rate (%) $= \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$
- Fish production (kg) = Final weight of fish (individual) × total no. of fish harvested
- Feed conversion ratio = Feed fed dry weight/ Fish weight gain

Economic analysis

The cost of lime, ash, fertilizer, fish fry (average fry cost 2.25, 2.75, and 5 BDT/individual and labor employed), as well as the revenue from selling fish, were used to determine the cost-benefit analysis of various treatments. For Pabda, Gulsha, and Rohu, the average selling price per kilogram of fish was 350, 450, and 185 BDT. To get the net return, the easy calculation shown below was used:

R = I - (FC+VC+Ii)

Where, R = net income, I = income when fish sale, FC = fixed costs, VC = variable costs and Ii = interest on inputs.

Benefit-cost ratio = Total income when fish sale/Total cost for fish production

Statistical Analysis

The SPSS version 20.0 will be used for all of the analyses. To determine whether there were any significant differences between the treatments, ANOVA and DMRT were used. The statistical analysis of growth and production was carried out using one-way analysis of variance (ANOVA). Finally, the data were prepared for statistical processing and analysis using the Microsoft Excel programme and statistical tools.

RESULTS

Water quality parameters

Along with water temperature, transparency, dissolved oxygen, pH, NH3-N, and alkalinity, other physical and chemical characteristics of the pond water under the three treatments were also measured. Table 1 displays the findings of a one-way analysis of variance that was conducted. (p>0.05) The experimental ponds' temperature differences were not statistically significant. Depending on the sample date, the water transparency values of several ponds with the treatments varied. The average transparency was determined to be 28.75 0.18, 31.40 0.22, and 32.07 0.18 cm in treatments 1, 2, and 3, respectively. When an ANOVA was conducted (P 0.05), significant differences between the treatments were found. The experimental ponds' pH, dissolved oxygen, NH_3-N content, and alkalinity were unaffected by the treatments' differences in any meaningful way.

Table 1. Water quality parameters under different treatments during study period

Parameters	T_1	T_2	T_3	F value	P value
Temperature (◦C)	27.15±0.29[b]	28.07±0.51[ab]	28.38±0.75[a]	4.075	0.046
Transparency (cm)	28.75±0.18[c]	31.40±0.22[b]	32.07±0.18[a]	244.715	0.000
pH	8.08±0.51[ab]	7.67±0.58[a]	8.85±0.25[a]	4.971	0.053
DO (mg/l)	5.24±0.90[b]	5.15±0.82[b]	6.85±0.32[a]	5.225	0.049
NH3-N (mg/l)	0.03±0.01[a]	0.03±0.01[a]	0.01±0.01[a]	2.667	0.148
Alkalinity (mg/l)	113.71±3.60[b]	121.46±6.66[b]	135.66±6.57[a]	11.105	.010

Values are mean ± standard deviation (SD). Values in the same row having different superscripts are significantly different ($P < 0.05$) by Duncan's post-hoc tests. T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3

Growth performance

Table 2 provides specifics on growth and production outcomes under various conditions. In T1, T2, and T3, the average final weight increase of pabda was 29.11±2.9, 38.60±2.3, and 32.87±1.44g, respectively. The FBW weight increase in the final sample was highest at T2 when compared to the other treatments. When compared to the other treatments, the ultimate weight gain for gulsha was higher at T1 (39.11±4.42). The mean weight gains that rohu gained in T1, T2, and T3 was 711.37±21, 700.40±20.95, and 689.94±10.58g, respectively. T1, nevertheless, was shown to be substantially superior to T2 and T3. Among the various treatments, T3 had the greatest FCR (Fig. 4). The amount of biomass attained was 7138.30±63, 6977.75±78, and 7037.03±84 kg/ha from T1, T2, and T3, respectively, according to the per-hectare ultimate production of the fish after six months of culture period as shown in (Fig. 3). Comparing T1 to other treatments, the maximum production was attained.

Table 2. Fish growth under different treatments of farmer's pond

Species	Treatment	IW (g)	FW (g)	WG (g)	SGR (%/day)	Survival rate (%)
Pabda	T1	3.61±0.46[a]	32.72±2.50[b]	29.11±2.96[b]	1.23±0.11[a]	73.96±1.04[b]
	T2	3.80±0.33[a]	42.40±2.04[a]	38.60±2.34[a]	1.34±0.08[a]	76.77±1.26[a]
	T3	3.75±0.36[a]	36.62±1.36[b]	32.87±1.44[b]	1.27±0.06[a]	78.75±1.25[a]
F value		0.19	17.38	12.60	1.49	12.30
P value		0.83	0.00	0.01	0.30	0.01
Gulsha	T1	2.74±0.36[a]	41.85±4.09[a]	39.11±4.42[a]	1.52±0.12[a]	82.81±1.57[a]
	T2	2.65±0.42[a]	31.69±0.75[b]	29.04±0.71[b]	1.38±0.09[a]	73.96±1.04[c]
	T3	3.32±0.49[a]	35.43±3.15[b]	32.11±2.97[b]	1.32±0.08[a]	79.08±2.57[b]
F value		2.18	8.73	8.31	3.24	17.58
P value		0.19	0.02	0.02	0.11	0.00
Rohu	T1	30.76±1.25[a]	742.13±20.14[a]	711.37±21.24[a]	1.77±0.03[a]	69.44±12.73[a]
	T2	33.21±1.51[a]	733.61±21.95[a]	700.40±20.95[a]	1.72±0.02[a]	75.00±8.33[a]
	T3	30.65±1.53[a]	720.59±10.67[a]	689.94±10.58[a]	1.75±0.03[a]	66.67±8.34[a]
F value		2.18	8.73	8.31	3.24	17.58
P value		0.19	0.02	0.02	0.11	0.00

Values are mean ± standard deviation (SD). Values in the same row having different superscripts are significantly different ($P < 0.05$) by Duncan's post-hoc tests.

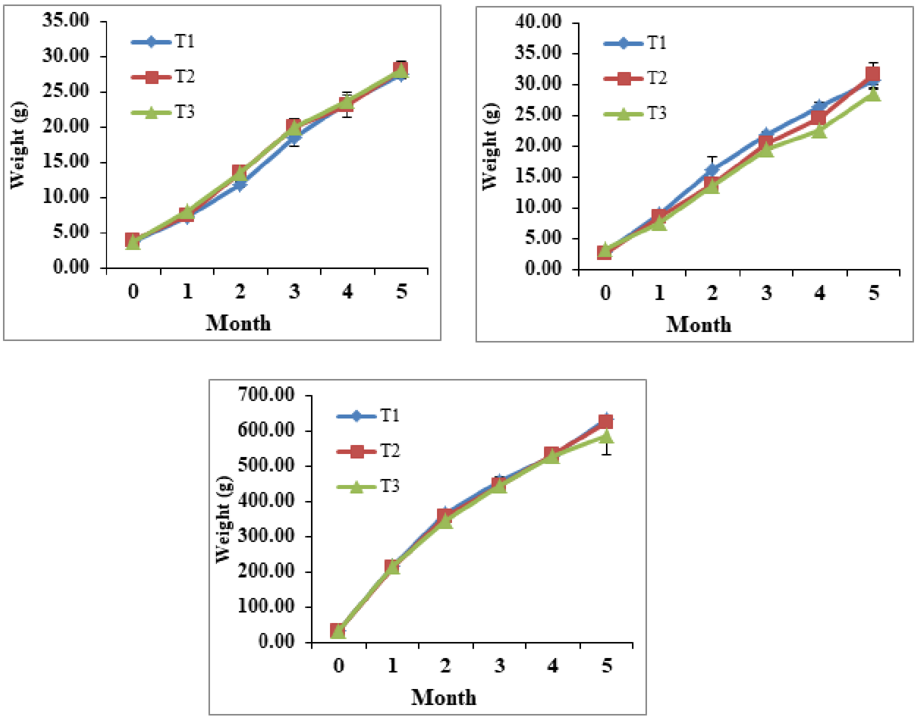

Figure 2. Growth increment of Pabda, Gulsha tengra and Rohu at different sampling period

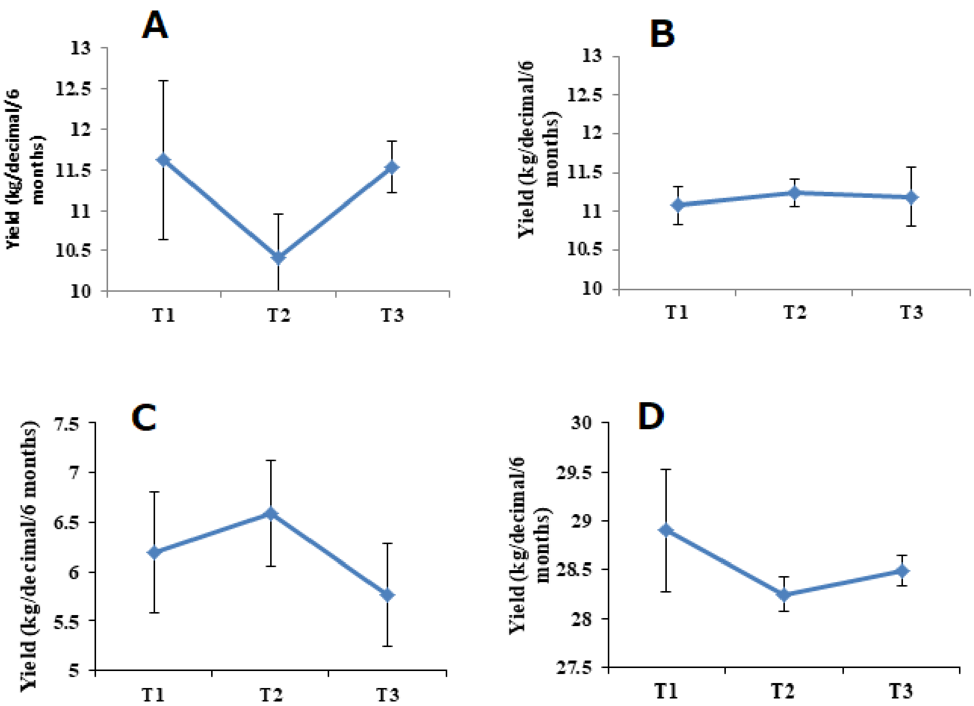

Figure 3. Fish yield (kg/decimal/6 months) under different treatments in ponds. A = *Ompok pabda* , B = *Mystus tengra*, C = *Labeo rohita*, D = All species

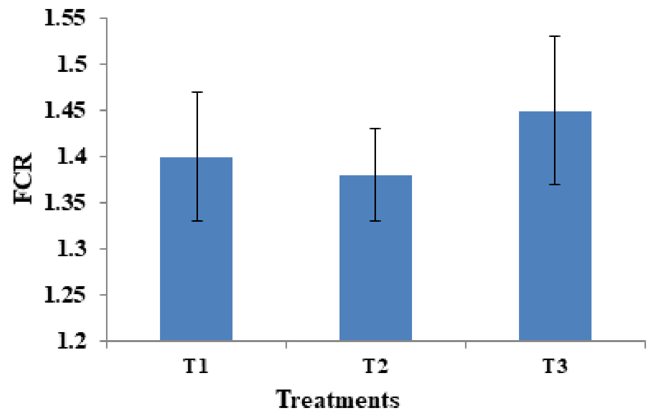

Figure 4. Relationships between feed conversion ratio (FCR) of different treatments

Economics of different species combination in pond

Table 3 displays the economic efficiency of Pabda, Gulsha, and Rohu under various conditions. The cost of the fish fry was a significant treatment in the current experiment. The T1 treatment had the highest feed cost. Feed costs at treatments T2 and T3 did not, however, differ considerably throughout the course of the trial. Feed costs were the largest area expense in the current experiments. The primary area-related cost in the present research was the cost of feed. Additional fixed costs included leasing value, lime, fertiliser, and harvesting costs, which were similar for all treatments. However, the overall return from selling fish had an inverse relationship with the total cost, with a noticeably larger total return observed at treatment T1. Additionally, treatment T1 obtained a greater net benefit, which led to a higher BCR at treatment T1 as revealed by the economic analysis.

Table 3. Economics of different species combination in pond (1 ha and 180 days of culture period)

Items	Treatments			F value	P value
	T_1	T_2	T_3		
Fixed cost (BDT/ha)					
Lease value	370500	370500	370500	-	-
Variable cost (BDT/ha)					
Seed	380380.41±405.13^b	390260.38±450.92^a	385320.60±401.92^b	122.24	0.03
Feed	531297.68±81.92^a	530062.31±17.01^a	529815.66±22.15^b	143.30	0.04
Lime	7410.00	7410.00	7410.00	-	-
Fertilizer	17290.00	17290.00	17290.00	-	-
Total cost (BDT/ ha)	1368627.73±81.92^a	1377272.31±17.01^a	1372085.66±22.15^a	12.61	0.72
Total return (BDT/ ha)	2663154.80±814.48^a	2580162.59±118.46^b	2646852.32±251.42^a	154.11	0.03
Net benefit (BDT/ ha)	1294576.40±947.98^a	1202956.69±421.03^b	1274685.67±548.74^a	111.59	0.02
BCR	1.94±0.12^a	1.87±0.02^a	1.93±0.04^a	109.63	0.09

Values are mean ± standard deviation (SD). Values in the same row having different superscripts are significantly different (*P* < *0.05*) by Duncan's post-hoc tests. T_1 = Treatment 1, T_2 = Treatment 2, T_3 = Treatment 3, BCR = Benefit-cost ratio

DISCUSSION

The overall water parameters in a water body have a significant impact on the growth and productivity of aquatic species. In the current experiment, measurements of water quality parameters including water temperature, transparency, pH, oxygen concentration, ammonia, and total alkalinity were performed. These data indicated a slight difference among the treatments. When an analysis of variance (ANOVA) was performed, the results showed no statistically significant variation ($p>0.05$) among the treatments in water temperature. According to Kohinoor et al., (2011), temperature was found to fluctuate between 24.12°C and 32.8°C in ponds, making it a crucial indicator of water quality. According to Rahman et al., 1982; Roy et al., 2002 ; Begum et al., 2003, and Kohinoor et al., 2004, the temperature fluctuations among the treatments were similar as well as the range necessary for fish growth in tropical ponds. Kohinoor, 1997 found that temperatures ranged from 25.80 to 34.70°C in semi-intensive cultivation in micro ponds, with means of 27.20±2.42, 27.10±2.61, and 27.72±2.33°C, respectively. This study is somewhat comparable to that of (Kohinoor, 1997). On various sample dates, the water transparency of several ponds with three treatments revealed variances. In T_1, T_2, and T_3, the average values of water transparency were 28.75±0.18, 31.40±0.22, and 32.07±0.18 cm, respectively. While an ANOVA was performed, it revealed significant differences ($p<0.05$) among the treatment means. Transparency levels occasionally changed, which may have been caused by variations in plankton abundance. Boyd, 1982 suggested that the ideal transparency for fish culture be between 15-40 cm. In their experiment, (Haque et al., 1984) observed transparency ranging from 12-37 cm, which is more or less in line with the findings of the current investigation. The measured average pH values for the treatments T_1, T_2, and T_3 were 8.08±0.51, 7.67±0.58, and 8.85±0.25, respectively. Several researchers have found pH changes in fertilized fish ponds that are comparable to the experiment, ranging from 7.18-9.24 (Kohinoor et al., 1998), 7.03-9.03 (Roy et al., 2002), 6.8- 8.20 (Begum *et al.,* 2003), and 7.50-8.20 (Chakraborty et al., 2005). The alkaline pH values recorded in the current experiment showed that the ponds were productive. According to Rahman (1992), an ideal body of water for fish cultivation would have a pH between 6.5-8.5. In the treatments T_1, T_2, and T_3, the observed average DO levels were 5.24±0.90, 5.15±0.82, and 6.85±0.32 correspondingly. From fish ponds in Gouripur, Mymensingh, Bangladesh, Kohinoor et al., (2016) measured dissolved oxygen levels ranging from 5.91-6.03 mg/L. In a different investigation, dissolved oxygen levels were measured from 3.80-6.12 mg/L by (Chakraborty and Nur, 2012). Although dissolved oxygen concentrations as low as 0.50 mg/L are possible for fish to live, the best range for fish culture is between 5.0-8.0 mg/L. The DO contents in all ponds, nevertheless, remained within the producing range for the entire time when the trial was running (Boyd, 1982). In the treatments T_1, T_2, and T_3, the average levels of ammonia were 0.03±0.01, 0.03±0.01, and 0.01±0.01, respectively. On the BAU campus in Mymensingh, (Kohinoor et al., 2000 and Wahid et al., 1997) also found levels of 0.01-0.99 mg/l, which corresponded with the current findings. T_3 had the highest total alkalinity (135.66±6.57 mg/l), whereas T_1 had the lowest (113.71±3.60 mg/l). In polyculture systems in ponds, Uddin (2002) observed total alkalinity levels between 45-140 mg/l, which are somewhat analogous to the current result. It was noted that Pabda, in T_1, T_2, and T_3, respectively, attained a mean final weight of 29.11±2.90 gm, 38.60±2.33 gm, and 32.87±1.44 gm. Pabda was harvested in T_2 at a higher weight than it was in T_1 or T_3, when compared. The mean final weight that Gussha obtained in T_1, T_2, and T_3, respectively, was 39.11±4.42, 29.04±0.71, and 32.11±2.97 gm. Nevertheless, it was found that the mean final weight of the Gulsha was higher compared to those of the other treatments. The final weights of Rohu in T_1, T_2, and T_3 were, respectively, 711.37g, 700.40g, and 689.94g, at the time of harvest. In contrast to the different treatments (T_2 and T_3), T_1 was shown to be considerably superior. There was no discernible difference between the treatments in the specific growth rates (SGR) of Pabda, Gulsha, and Rohu. The T_1 treatment produced the fish with the greatest SGR values. The highest survival rate is likely what caused Pabda and Gulsha to gain the maximum weight in T_1. On the other hand, T_3, which has the lowest survival, had the lowest weight growth. The current findings are in good accord with those of Kohinoor et al., (2004) who found that Gulsha farming performed best at lower stocking densities. While Kohinoor et al., (2012) observed that *Heteropneustes fossilis* grew larger and had a greater survival rate in different research, a lower density led to these results. Treatment 1 was shown to have the highest harvest weight and survival rate in the current experiment. The stocking density was 118560 for Gulsha and 79040/ha for Pabda in T1 and T2, respectively, and these was the time periods with the best survival rates. The survival rates among the treatments varied significantly ($p<0.05$). The current findings support those of (Samad et al., 2020 and Kohinoor et al., 2004), who found that in Gulsha farming; the best survival was achieved at lower stocking densities. Following six months of upbringing, the overall production from T_1, T_2, and T_3 was 7138.30±63, 6977.75±78, and 7037.03±84 kg/ha/6 months, respectively. Comparing T_3 to other treatments, FCR was highest in T_3. (Samad et al., 2020 and Hossain et al., 2019) have more in common with these study's production performances. In the current investigation, it was discovered that the experimental ponds had no discernible impact on the overall production costs or net benefits. Additionally, the farmer benefited from the present experiment's stocking of additional Pabda fish (with treatment T_1). The main expense area during the research period was feed. Studies by Hossain et al., 2020; Sayed et al., 2020 and Talukder et al., 2017) have revealed that feed costs account for more than 50% of the overall cost of aquaculture expenditures. In contrast to previous treatments, increased BCR at treatment T_1 brought to higher production and a higher survival rate.

CONCLUSION

The current experiment, which involved choosing the ideal species combination for two (SIS) species alongside rohu, revealed that treatment T_1, which contained a species combination of 60% pabda and 40% gulsha, performed exceedingly well with regard to environmental parameters, growth, production, and profitability in the farmer's pond. By including rohu species, the overall production can be greatly increased. It was found from this study that cultivating the highly valuable fish Pabda and Gulsha with Rohu might be a good polyculture technique for people living in rural areas. Additional work is also necessary, with particular emphasis on the optimization of stocking density, embracing ethical culture practices, and administration of high-quality feed.

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