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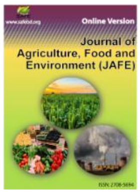

Original Article

Variation of production performance of Gulsha (*Mystus cavasius*) monoculture with variation of water and soil quality parameters

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A B S T R A C T

An on-farm experiment was carried out to evaluate the production performance of Gulsha (*Mystus cavasius*) for 120 days at different environmental conditions. Two areas were considered: one in Gazipur Sadar and another one in Narsingdi Sadar. Five ponds of almost similar size (30 decimal with an average water depth of 1.5 m) and water intensity were selected at each location with a stocking density of Gulsha 500 fry/decimal. Pre-stocking, stocking and post-stocking management had been similar in each place. The significantly lower ($p<0.05$) value of soil pH (5.5±4.1) in Gazipur location caused pond water acidic and imbalanced the water buffering system for maintaining primary productivity. After 120 days of rearing period, the average harvest weight of Gulsha 48.10 ±7.12 g was significantly ($p<0.05$) higher for Narsingdi compared to the average weight 23.18 ± 6.24 g in Gazipur. The survival rate ($p<0.05$) 68% at Narsingdi area was the highest. The estimated average production of fish in 120 days in the Gazipur and Narsingdi region was 7.55 ± 5.61 kg/dec and 16.31 ± 6.13 kg/dec, respectively**,** that differed substantialy ($p<0.05$) from one another. Ponds of Narsingdi district in general, showed almost all of its physico-chemical and biological features suitable for fish production. However, ponds in the Gazipur area were found less productive for the cultivation of Gulsha particularly with lower primary and secondary productivity.

Introduction

The production of fish through aquaculture is rapidly gaining prominence in Bangladesh due to an increase in human population and a decline in natural fishing resources. To sustain the current per capita supply of aquatic products into the future, further elevation of aquaculture production is required as the supply of fish through capture fisheries cannot grow any more. But fish culture on a small-scale basis has often been failed because inadequate knowledge about fish culture technique and feeding regime of fish are the reasons behind the failure of fish culture on a small scale basis (Reza, 2013). Pond aquaculture in Bangladesh our country has been dominated by polyculture of carps, particularly Indian major carps; Rohu (*Labeo rohita*), Catla (*Catla catla*) and Mrigal (*Cirrhinus cirrhosus*), which is backed up by a strong traditional knowledge foundation and scientific inputs in many managerial areas. However, a few non-native and native species of fish, especially Pangas (*Pangasianodon hypophtalmus*), Tilapia (*Oreochromis niloticus*), Shing (*Heteropneustes fossilis*) and Koi (*Anabas testudineus*) have been successfully brought into the culture systems in near past, which actually has turned the freshwater aquaculture a growing entrepreneurial activity. With this few species, aquaculture has evolved from the stage of a domestic or subsistence activity to that of an industry in a number of districts notably Mymensingh, Comilla, Jessore and Bogra (DoF, 2014). Tilapia is a popular and commonly cultivated fish species in Mymensingh and around Bangladesh. Tilapia which is a delicious, low priced as well as widely edible fish in many countries across the world (Mahmuda *et al*., 2020 and Nasrin *et al*., 2021). On the contrary, *Mystus cavasius* locally called Gulsha has been attracting Bangladeshi fish farmers because of its high market value, profitable culture, good taste (Saha *et al.*, 1998). For this reason, farmers of greater Mymensingh region are culturing this species to a great extent. Gulsha is a carnivorous fish, feeding on insects, larvae as well as fish fry (Islam & Azadi, 1998). The fish commands higher and more lucrative price than IMCs and other table fishes. In comparison to many other freshwater fishes, this species has a high iron concentration (226 mg 100 g^{-1}) and high calcium content. It is suggested in the diet of ill and convalescent people because of its great nutritional content as well. As a lean fish, it is an ideal protein source for persons for whom animal fats are restricted (Rahman, 1999). It is an extremely sturdy fish that can survive for several hours outside the water due to the existence of air breathing organs. This species was once widely distributed in rivers, streams, ponds, beels, ditches, and floodplains. Due to many natural and man-made consequences, this species has gradually been disappearing from the natural water systems and is listed as one of the threatened species (IUCN, 2000). With the expansion of aquaculture in Bangladesh, there has been an increasing trend in using chemicals in aquatic animal health management (Uddin *et al*., 2020).

Aquaculture pond productivity is largely location or zone-specific, depending on the local climate conditions and soil-water interactions that maintains the nutrient dynamics within the pond ecosystem. Therefore, performance of any fish culture technology is highly variable in different agro-climatic zones. This leads to the necessity that a fish culture technology to be properly standardized, with prevailing and changing environment at different locations and availability of farmer’s resource, for its sustainable adoption at wider scale. For Gulsha culture technology production trials were conducted in two locations, each in a different Agro-Ecological Zone (AEZ) *viz*. Narsingdi Sadar (AEZ 28) and Gazipur Sadar (AEZ 9). Within each zone, there has been a lot of variation in multiple variables for instance, in comparison to AEZ 9; AEZ 28 (Gazipur Sadar) has a low pH, a low amount of nitrogen, phosphorus, potassium, and calcium, but a high iron concentration (BARC, 2012). The soil in the Narsingdi region was silt loam, whereas the soil in the Gazipur region was silty clay loam. The colour of bottom soils of Narsingdi region was persisted dark gray with a thin upper layer showing a brownish tinge before drying and turned gray after drying and the soils of Gazipur region was brownish red in colour (BARC, 2012). In view of the above discussion, the purpose of this study was to see whether it was feasible to adopt Gulsha culture in two distinct sites in order to evaluate the growth and production performance of Gulsha in monoculture in Gazipur and Narsingdi.

Materials and Methods

The experiment took place in two different sites: Sadar upazila in Gazipur and Narsingdi district, which are located in AEZ 28 and AEZ 9, respectively. Within each zone, there are significant differences in various parameters.

Description of the ponds: The experimental ponds had an average area of 30 decimal with 1.5 m average water depth. All of the ponds had roughly the same size, shape, and type of bottom. The ponds were devoid of aquatic vegetation and with sufficient penetration of sunlight. Rainfall was the primary source of water in the ponds, but they also had the capacity to draw water from a large reservoir using a water pump when needed.

Design of experiment: Five ponds were considered for this experiment in each location, whereas in each location the stocking density of Gulsha was 500 fry per decimal in each pond. The experiment was conducted from May to September for duration of 120 days. The two experimental locations were treated as treatments, whereas the number of ponds in each location was considered replication.

Pond preparation and stocking: Pond preparation started with the removal of weeds as well as unwanted fish species with repeated netting and following that, the ponds were limed at a rate of 1.0 kg $decimal^{-1}$. The ponds were then left out for 7 days to allow the plankton population to emerge. On May 11, the ponds were stocked with Gulsha fry gathered from a fish hatchery in Mymensingh. All fish were housed in a hapa for conditioning before being stocked, and the length and weight of the fry were noted. Gulsha fry were stocked at a rate of 500/decimal correspondingly. During stocking, the average weight and length were 0.22 g and 3.06 cm, respectively.

Feeding: The fish were fed commercial fish feed on a daily basis. Half of the feed was applied in the morning and the remained in the afternoon. Feeds were distributed at a 20% rate for the first month, 15% for the second month, 10% for the third month, and 5% for the fourth month. After fortnightly sampling, feeding rates were changed based on the growth in fish body weight.

Analysis of water quality parameters: Fortnightly assessments of various water quality parameters were taken and evaluated. A portable digital Celsius thermometer was used to record water temperatures. A Secchi-disc (30 cm in diameter) was tied to a rope and used to measure the transparency of the water in the experimental ponds**.** After immersing the Secchi-disk in water, the visible and invisible lengths under the water that could be seen with the naked eye were measured in centimeters. A portable digital dissolved oxygen (DO) meter (Lutron, PDO-519) was used to test dissolved oxygen (mg/l) in water on the spot. The pH of water samples was determined on the spot using a digital pH meter (HANNA, HI 8428). The total alkalinity of the water samples was determined using a titrimetric approach that included the use of methyl orange as a color indicator. The following formula was used to calculate it:

Total alkalinity (mgl^{-1}) as $CaC0_3 = A \times 20$ (when amount of sample is 50 ml), where A = Total ml of titrant used.

The HACH apparatus was used to determine ammonia-nitrogen using Rochelle salt and Nessler reagent.

Plankton analysis: For the qualitative and quantitative analysis of phytoplankton and zooplankton, ten litres of water were collected at random from five different places in each of the ponds and passed through a plankton net (mesh size 55 μm) before being concentrated to 100 ml. The concentrated samples were then kept in 5 percent buffered formalin in tiny plastic bottles for subsequent research (Mahmud *et al*., 2021). The Sedgwick-Rafter Counting Cell (S-R cell) was used to count plankton following Rahman's instructions (1992). Belcher and Swale's method was used to identify plankton (phytoplankton and zooplankton) to the generic level (1978).

Soil analysis: Soil samples were taken monthly from the pond bottom's surface soil using an Ekman Dredge, which was designed to trap a column of soil 3-4 cm deep from the soil-water interface. The hue of soil samples, both wet and dry was evaluated by eye assessment (Mahmud *et al*., 2021).

The overall nitrogen was calculated using the micro Kjeldahl method (Bremner & Mulvancy, 1982). Bray and Kurtz' method was used to determine phosphorus (Olsen & Sommers, 1982). The potassium concentration was measured using the ammonium acetate extraction technique (Barker & Surh, 1982). The extraction method of ammonium acetate was used to determine this (Barker & Surh, 1982). The Atomic Absorption Spectrophotometer (AAS) was used to determine iron based on their various wave lengths (Ullah *et al*., 1993).

Estimation of growth and yield of fish: Fish were sampled every two weeks with a seine net. To check the health and growth of the fish, the weight and length of roughly 25 fish were measured. A portable balance was used to measure weight, and a centimeter scale was used to measure length**.**

The average growth in weight of fish, both gross and net, were multiplied by the total number of fish survived in each treatment at the end of the tests to estimate the gross and net yield of fish for each treatment. The following formula (Brown, 1957) was used to calculate the growth performance of fish in various treatments:

$$\text{Survival Rate} = \frac{\text{Total number of harvest}}{\text{Total number of stock}} \times 100$$

Weight gain (g) = Final body weight (g) – Initial body weight (g)

$$\%\ \text{weight gain} = \frac{\text{Final body weight (g)} - \text{Initial body weight (g)}}{\text{Initial body weight (g)}} \times 100$$

$$\text{Gross Production (Kg/decimal/120days)} = \text{Gross weight (Kg) of fish}$$

$$\text{Specific growth rate (\% per day)} = \frac{Ln\,w2 - Ln\,w1}{T2 - T1} \times 100,$$

Where W1= Initial live body weight (g) at time T1

W2= Final live body weight (g) at time T2

T2-T1= No. of days of the experiment (Islam *et al.*, 2020).

Statistical analysis: The collected data was statistically evaluated to determine the water quality parameters, plankton abundance, and fish production performance in various treatments. Using SPSS (Statistical Packages for Social Science) and MSTAT-C software, mean values of water quality indicators, plankton abundance and growth, survival, and yield data were analyzed using t-tests.

Result and Discussion

Water quality parameters were recorded and calculated every two weeks. Table 1 shows the mean SD values of various water quality parameters in experimental ponds from two different locations.

Table 1. Mean ± SD values of water quality parameters recorded from two different locations.

Water quality parameters	Locations (Treatment)		LSD	Level of significance
	Gazipur (T_1)	Narsingdi (T_2)		
Water Temperature (°C)	30.74 ± 1.19^a	30.72 ± 0.94^a	0.0502	NS
Transparency (cm)	27.49 ± 0.30^b	29.89 ± 0.21^a	0.3832	*
DO (mg l^{-1})	5.12 ± 0.14^b	7.77 ± 0.15^a	0.6079	*
pH	7.71 ± 0.09^b	8.18 ± 0.19^a	0.3853	*
Total alkalinity (mg l^{-1})	31.09 ± 0.25^b	54.10 ± 0.34^a	0.9205	*
Ammonia-nitrogen (mg l^{-1})	0.40 ± 0.20^a	0.25 ± 0.13^b	0.0347	*
Phytoplankton (cells l^{-1})	1758 ± 45^b	3908 ± 186^a	73.097	*
Zooplankton (cells l^{-1})	1210 ± 49.93^b	1506 ± 23.01^a	42.261	*

LSD = Least Significant Difference, NS= Means are not significantly different (p>0.05), * Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

In the Gazipur (T_1) and Narsingdi (T_2) regions, the mean SD values of water temperature were 30.741 and 30.720 °C, respectively. Temperature measurements measured at different places did not differ significantly (P>0.05) (Table 1).

The transparency of the water is a rough indicator of pond productivity. The transparency of pond water in the current experiment ranged from 26.2 to 28.1 cm in Gazipur (T_1) and 29 to 30.5 cm in Narsingdi (T_2), indicating that both locations' ponds were productive. In comparison to the ponds in Gazipur, the DO concentration in Narsingdi ponds was within a more appropriate range. In the Gazipur (T_1) and Narsingdi (T_2) regions, the mean pH values were 7.71±0.09 and 8.18±0, respectively. Between two separate locations, there was a significant (p<0.05) difference in pH changes.

The mean ± SD values of total alkalinity were 31.09±0.25 and 54.10±0.34 mgl^{-1} in Gazipur (T_1) and Narsingdi (T_2) region respectively. There was significant (P<0.05) difference in alkalinity values between two different locations. The plankton production higher in Gazipur than Narsingdi. According to the values of alkalinity in the present experiment and those have been reported by others researchers, ponds in Narsingdi region were more productive than Gazipur region. Throughout the present study period, the soil colour of treatment 1 (ponds of Gazipur Sadar) was reddish browny and the soil of treatment 2 (ponds of Narsingdi Sadar) remained dark gray before drying, and gray after drying. The general gray colour might be due to the presence of organic matter while the brownish red tinge provided an indication of deposition of ferric oxide. As per textural classification the bottom soil of ponds of Treatment 2 (Narsingdi Sadar) was found to be silt loam and that of Ponds of treatment 1 (Gazipur Sadar) in general clay loam throughout the present investigation.

The mean ± SD values of soils total nitrogen were 0.0884±0.0052% and 0.1604±0.0065% in the Gazipur (T_1) and Narsingdi (T_2) region respectively. There was significant difference (P<0.05) among nitrogen values recorded in two different locations (Table 2). The highest value of total nitrogen in Narsingdi region was observed (0.1604%) and the lowest value was recorded in Gazipur region (0.0884%) as has been shown in Table 2.

Table 2. Mean ± SD values of different soil parameters recorded from two different locations.

Soils Parameters	Treatments		LSD	Level of significance
	Gazipur (T_1)	Narsingdi (T_2)		
Total N (%)	0.0884±0.0052[b]	0.1604±0.0065[a]	0.0048	*
Total P (mg/100g)	3.0692±0.24[b]	7.2880±0.37[a]	0.1532	*
Total K (mg/100g)	0.2424±0.024[b]	0.4304±0.034[a]	0.012	*
Ca (mg/100g)	11.156±0.36[b]	16.640±0.25[a]	0.1296	*
Fe (µg/g)	80.652±0.38[a]	14.660±0.30[b]	0.3379	*
pH	5.5±0.41[b]	6.4±0.05[a]	0.38	*

LSD = Least Significant Difference, * Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

Total phosphorus of soil was found to vary from 2.80 and 3.6 mg/100g to 6.6 and 7.9 mg/100g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. The mean ± SD values of soils total phosphorus were 3.0692±0.24 mg/100g and 7.2880±0.37mg/100g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. There was significant difference (P<0.05) among phosphorus values recorded in two different regions (Table 2). Therefore, considering the P content, pond soil in Narsingdi was more suitable for maintaining high productivity.

Total potassium of soil was found to vary from 0.20 and 0.28 mg/100g to 0.37 and 0.47 mg/100g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. The mean ±SD values of soils total potassium were 0.2424±0.024 mg/100g and 0.4304±0.034 mg/100g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. There was significant difference (P<0.05) among potassium values recorded in two different region (Table 2). Fish can absorb calcium either from the water or from food. The mean ± SD values of soils total calcium were 11.156±0.36 mg/100g and 16.640±0.25 mg/100g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. There was significant difference (P<0.05) among calcium values recorded in two different locations (Table 2). Iron is an important soil quality variable in aquaculture. It is a dissolved nutrient required in small quantities by both aquatic plants and animals. But chemical reactions of iron in sediment and water can have negative impacts on aquatic life. The data for iron have been presented in Table 2. Soil iron was found to vary from 80.00 and 81.30 µg/g to 14 and 15.3 µg/g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. The mean ± SD values of soils total iron were 80.652±0.38 µg/g and 14.660±0.30 µg/g in the Gazipur (T_1) and Narsingdi (T_2) region respectively. But in ponds with acidic sediment, iron deposits on fish can damage gills and cause unsightly blotches on scale. Liming can reduce high iron concentrations in sediment (Boyd, 1992).

Growth and production of fish: For the evaluation of proper growth performance of Gulsha in two different locations during experimental period, initial length and weight of fry, final length and weight of fish, % weight gain, SGR (% per day), survival (%) and total fish production (kg dec^{-1}/120 days) were calculated and are shown in Table 3.

Table 3. Stocking and harvesting size, survival, SGR and gross production of Gulsha (*M. cavasius*) in two different locations during the 120 days culture period.

Growth and production parameters	Locations		LSD	Level of significance
	Gazipur (T_1)	Narsingdi (T_2)		
Initial mean weight (g)	0.22±0.08	0.22±0.07	0.00	NS
Initial mean length (cm)	3.06±0.81	3.06±0.91	0.00	NS
Final mean weight (g)	23.18±6.24[b]	48.10±7.12[a]	3.48	*
Final mean length (cm)	15.57±4.31[b]	20.70±5.23[a]	2.35	*
Mean weight gain (g)	22.96± 6.51[b]	47.88±7.13[a]	3.48	*
Mean length gain (cm)	12.51±4.31[b]	17.64±5.23[a]	2.35	*
% Weight gain	10437±611.13[b]	21764±615.11[a]	1580	*
Survival (%)	65.8±4.21[b]	68±5.32[a]	3.45	*
SGR (% wt. gain day^{-1})	2.95±0.03[b]	3.69±0.05[a]	0.05	*
Gross Production (Kgdec^{-1}per 120 days)	7.55±5.61[b]	16.31±6.13[a]	1.75	*
FCR	2.96	2.63	0.34	*

LSD = Least Significant Difference, NS= Means are not significantly different (p>0.05),* Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

There was significant variation (p<0.05) of length increment of Gulsha between two locations. Average length (cm) increment of catfish higher in Narsingdi region compare to Gazipur region. The reasons might be due to variation in water quality parameters between Gazipur and Narsingdi region. The percent weight gain of Gulsha was 10437±611.13 and 21764±615.11 for the Gazipur (T_1) and Narsingdi (T_2) region respectively (Table 3).

The average values of specific growth rate of *M. cavasius* were 2.95±0.03 and 3.69±0.05 in the Gazipur (T_1) and Narsingdi (T_2) region respectively. There were significant (p<0.01) differences in SGR value in the different locations (Table 3). The highly significant specific growth rate 3.69 was observed in Narsingdi region. In contrast, the lowest specific growth rate 2.95 was observed in Gazipur region. Mean food conversion ratio (FCR) in two locations ranged from 2.96 and 2.63 (Table 3). The highest FCR was obtained in Gazipur region and lowest FCR was obtained in Narsingdi region. The survival rate of gulsha was 65.8±4.21% and 68±5.32% in the Gazipur (T_1) and Narsingdi (T_2) region respectively. The survival rate was higher in Narsingdi region whereas the survivability rate was low in Gazipur region (Table 3).

The final weight of fish was 23.18±6.24 g in Gazipur region and 48.10±7.12g in Narsingdi region. There was significant ($p<0.01$) difference in final weight of gulsha (*Mystus cavasius*) in different locations (Table 3). The maximum final weight was observed in Narsingdi region. The minimum final weight was observed in Gazipur region. In a study, Thakur and Das, (1986) reported production range was 1642 to 7,300 kg ha^{-1} in four to eleven months culture period of gulsha (*Mystus cavasius*). Ali *et al.,* (2013) observed that the highest total production of gulsha (*Mystus cavasius*) 6.47 kg/ decimal/110 days was recorded in T_1. In T_2 and T_3 the production was 5.94 kg/ decimal/110 days and 5.47 kg/ decimal/110 days, respectively. Khan *et al.,* (2003) evaluated that the production of gulsha (*Mystus cavasius*) in different stocking densities and got the gross production range 8.42 and 13.62 $Kgdec^{-1}$. The pond productivity was significantly higher in Narsingdi region (T_2) than the Gazipur region (T_1) and subsequently the growth of fishes was better in Narsingdi region (T_2) than Gazipur region (T_1).

Conclusion

As there two major criteria primarily crucial for successful pond cultural operations are maintenance of a healthy aquatic environment and sufficient primary productions as the most important factor influencing plankton formation in fish ponds that is dependend on nutritional state of the water and soil quality parameters. In the present study, the plankton production higher in Gazipur than Narsingdi. According to the values of alkalinity in the present experiment and those have been reported by others researchers, ponds in Narsingdi region were more productive than Gazipur region. Additional research is required for development of location-precise Gulsha monoculture covering wider agroecological zones.

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