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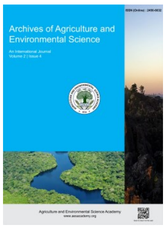

ORIGINAL RESEARCH ARTICLE

Culture technique of Tengra (*Mystus vittatus*) with short cycle fish species in the drought prone northern region of Bangladesh

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ABSTRACT

The present study was to assess and evaluate the culture potential of Tengra with short-cycle species in the seasonal water bodies of farmers' fields and disseminate the cultural technologies in a different part of the country. The study was conducted in farmers' ponds located in the northern region of Bangladesh from May 2017 to September 2018 to find out the most suitable combination of Tengra (*Mystus vittatus*) with other short-cycle fishes. For this reason, combination *viz*; tengra+pabda+magur+rajpunti+GIFT was considered for trial (with three treatments/combinations and three replications of each) in seasonal farmers' ponds at 18 upazilas of the greater Rangpur region to evaluate the growth and yield performance of tengra, *M. vittatus* under a polyculture system. Three different stocking densities of Tengra *viz.*, 500, 600, and 700 with (100 Magur+10 Rajpunti+5 GIFT) were treated as T_1, T_2, and T_3 respectively. After 5 months of the culture period, (T_1) showed significantly (P<0.05) higher production of Tengra (2,035 kg ha^{-1}), total production of fishes (5,592 kg ha^{-1}), and benefit-cost ratio (1.60) among the treatments These combinations were chosen for multi-location testing (MLT) in different locations of the northern region of Bangladesh. Three locations such as Domar (Niphamari); Kaligonj (Lalmonirhat) and Niphamari Sadar were selected for demonstration. After 5 months of multi-location testing the trials with Tengra as the main species, the highest production of Tengra (2252 kg ha^{-1}), total production of fishes (5656 kg ha^{-1}), and benefit-cost ratio (1.65) were found in Kaligonj with significant (P<0.05) difference among three locations. Thus, the results of multi-location trials clearly authenticated the previous findings. Therefore, the technologies of short-cycle fish species should be disseminated to fish farmers and entrepreneurs throughout the semi-arid zone of Bangladesh.

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INTRODUCTION

Bangladesh is ranked fourth position in Inland fishery production just after China, India, and Myanmar, and fifth position in marine water. The fisheries sector is inseparable from the life and lifestyle of the people of Bangladesh which contributes 4.37% to the national GDP and almost one-fourth (23.37%) to the agricultural GDP (DoF, 2013). About 1.5 million people are directly employed in this sector (DoF, 2012). The rich aquatic biodiversity of the country has been attributed to the world's largest wetlands (Bengal Delta) and three large river systems (Brahmaputra, Ganges, and Jamuna) that flow from the Himalayan Mountains into the Bay of Bengal. A Huge inland fisheries resource has been supplying fish and other aquatic animals and plants to millions of people living in the Delta (Hossain, 2014). The Northern region (Rangpur division) of Bangladesh is known as a drought and riverbank erosion-prone area. Most of the districts under this division have been experiencing frequent natural disasters and adverse impacts of climate change and surface water has almost disappeared from ponds and canals, even major rivers have reduced water volume for 6-8 months. As a result, the number of seasonal waters (BBS. 2000, Ahamed *et al*., 2017a) is increasing and about 55% of ponds are seasonal of which 60% retained water for 4-6 months while 40% retained for 6 to 9 months in a year and even more in some areas. These small water bodies are being used mainly for household activities, but some are still abandoned due to their derelict and marshy nature. In this semi-arid zone, fish farmers lack appropriate fish culture techniques as a result most of the farmers practice traditional way of fish culture. (Ahamed *et al*., 2018). Comprehensive scientific studies are documented on the monoculture of *M. gulio*, which is primarily grown in coastal waters, in tide-fed brackish water ponds (CIBA 2015; Hossain *et al*., 2018; Lal, Jaya, and Sherly 2016; Mondal and Mitra 2016; Siddiky *et al*., 2015), polyculture with tilapia-*Oreochromis niloticus*, mullet-*Rhinomugil corsula*, climbing perch-*Anabas testudineus* and stinging catfish-*Heteropneustes fossils* (Hossain *et al*., 2019) in Bangladesh coast. Development of climate-adaptive aquaculture techniques is necessary, but literature focusing on the technological development and diversification of *M. vittatus* culture practice in coastal waters is scarce. The polyculture attempts on short-cycle species such as Tengra (*Mystus vittatus*), Magur (*Clarias batracus*), Pabda (*Ompuk Pabda*), Rajpunti (*Barbodes gonionoutus*), and GIFT (*Oreochromis* sp) etc. might have potential in those seasonal waters. But Tengra, Magur, and Pabda were hardly attempted for polyculture in the greater northern region. To ensure proper utilization of seasonal ponds, the culture of short-cycle species should be introduced in the semiarid zone to enhance fish production. These species have high demand throughout the country due to their taste and medical values. Lack of knowledge of appropriate culture techniques and unavailability of quality fish seeds of candidate species at the required time is found to be some of the major constraints at present time to disseminate the BFRI evolved culture technologies in the northern parts of Bangladesh. Unfortunately, the proper cultural technologies of these species have yet not been optimized and evaluated, especially in the Northern part of the country. The northern region is such an area where this culture technique will be the most suitable and effective for all types of fish farmers for increasing fish production and income generation. In this context, culture techniques of these species are to be disseminated in this region. Hence, the present study was undertaken to demonstrate the research findings at farmer's ponds as well as to validate the technologies of commercially important short-cycle fish species prior to large-scale dissemination in the semiarid zone of Bangladesh.

MATERIALS AND METHODS

Pond selection and experimental design

The experiments were conducted in farmer's ponds located in the Nilphamari district of Bangladesh for a period of 5 months from mid-July to mid-December 2017 to observe the growth and yield performance of Tengra, *Mystus vittatus* under polyculture system. For this reason, nine seasonal ponds (10-15 decimal) were selected for each experiment. Six ponds were divided into three groups. Each group was used for a treatment. Ponds were selected with the concern of the levant Upazilla Fishery Officer (UFO/SUFO). The experimental designs are described as follows in Table 1.

Pond preparation

The selected ponds were prepared by dewatering and drying. Aquatic weeds were removed from the ponds manually. And then, lime was applied @ 1.0 kg decimal^{-1}. After 7 days of liming, urea @100 g decimal^{-1} and TSP @75 g decimal-1 were applied at the initial stage of pond preparation.

Stocking of fingerlings

The hatchery produced fingerlings (5-10cm) of selected fish were stocked as per experimental design (Tables 1).

Feeding regime

Commercially available fish feed (containing 30-35% protein) was fed at @15-5% BW Day^{-1} of the fish.

Sampling

Length and weight data were collected fortnightly in the morning at 8.00 am to 9.00 am. Samplings were done by a cast net. Fish length was measured using a measuring meter scale (cm) and weight was taken by a precision weighing balance (measuring range from 1.0 g to 1.0 kg).

Water quality parameters

Water quality parameters such as water temperature (°C) by Celsius thermometer, transparency (cm) by secchi disc, water pH by digital pH meter (Hanna Co. Japan), dissolved oxygen (DO) (mg l^{-1}) by digital DO meter (Lutron PDO-519, Taiwan) and ammonia (NH_3) (mg l^{-1}) by ammonia test kit (Hanna Co. Japan) of the experimental ponds were monitored fortnightly.

Table 1. Polyculture of Tengra, *M. vittatus* under different stocking densities in farmer's pond.

Treatments	Species wise stocking size (cm)	Stocking density (indi. dec^{-1})			
		Tengra	Magur	Rajpunti	GIFT
T_1	Tengra (5-7) Magur (7-10) Rajpunti (6-7)	500	100	10	05
T_2		600	100	10	05
T_3		700	100	10	05

Table 2. Experimental design of pattern-1 in different Upazila of Rungpur region.

Culture pattern	Replication (one pond/Upazila)	Species combination	Stock. density (indi. decl^{-1})
Tengra	Domar, Niphamari+Kaligonj, Lalmonirhat+NiphamariSador	Tengra+Magur+ Rajpunti+GIFT	500+100+10+5

Growth parameters

a) Weight gain was calculated as follows:

Mean weight gain (g) = {Mean final body weight (g) - Mean initial body weight (g)}

b) Percent weight gain (%) was calculated as follows:

Weight gain (%) = [{(Mean final fish weight (g)- Mean initial fish weight(g)}/ Mean initial fish weight (g)] x100.

c) Specific growth rate (SGR% per day) was calculated as follows:

Specific growth rate (SGR % day^{-1}) = [{(Log_e W_2 - Log_e W_1)/ (T_2-T_1)} ×100], Where W_1 is the initial live body weight (g) at time T_1 and W_2 is the final live body weight (g) at time T_2 (day) (after Brown, 1957, cited from Hossain, 2019).

Feed utilization

a) Apparent feed conversion ratio (AFCR) is the amount of dry feed fed per unit of live weight gain and was calculated as

AFCR = Total dry feed fed (g)/ Total live weight gain (g) (after Castell and Tiews, 1980).

b) Apparent protein efficiency ratio (APER) is the live weight gain per unit of crude protein fed and it was calculated as

Survival rate and production

a) Survival rate (%) was calculated as follows:

Survival (%) = (Final fish number / initial fish number) x 100

Production (kg $decimal^{1}$) = [{Final number of fish harvested x individual weight of fish (g)} / 1000].

Production (kg ha^{1}) = [{Final number of fish harvested x individual weight of fish (g)} / 1000] x 247.1.

Harvesting and estimation of growth parameters and BCR analysis

The ponds were completely dewatered and all the fish at the end of the experiment and counted species-wise. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR and survival rate (%), and benefit-cost ratio (BCR) were calculated and evaluated on the growth and yield of fish.

Dissemination of suitable polyculture patterns of short-cycle fish species in different parts of the semi-arid zone (northern part) of Bangladesh (2018)

Polyculture of *M. vittatus* was tested under different treatments in seasonal farmer's ponds at the adjacent areas of FSS, Saidpur from mid-July to mid-December 2017. Of them, 500 Tengra+100 Magur+10 Rajpunti+5 GIFT (indi. $dec.^{-1}$) were selected due to technically sound, socially acceptable, and economically viable polyculture patterns. These combinations were disseminated in different aqua-ecological zones of the northern region of Bangladesh from May to September 2018 through a multi-location testing (MLT) program.

Multi-location testing (MLT) program

The multi-location testing program was conducted in different Upazila of the northern region of Bangladesh to verify the research results of previously tested suitable culture patterns and exchanged views among the researcher, extension people (DoF), and farmers. A total of 06 (six) seasonal ponds were selected in 06 (six) different Upazila of the Rungpur region (Table 3). The six Upazila or ponds are divided into. two groups and each pond or Upazila is considered as one replication. The areas of ponds ranged between 10 and 15 decimals. The on-farm ponds were selected with the concern of the relevant Senior Upazila Fishery Officer (SUFO/UFO).

Pond preparation

The selected ponds were prepared by draining and drying. Aquatic weeds were removed from the ponds manually and harmful and undesirable fish species were removed by using rotenone 25-35 g $dec^{-1}ft^{-1}$ if necessary and ponds were limed @1 kg dec^{-1}. After 5 days of liming, cow-dung 6 kg dec^{-1}, urea 100 g, dec^{-1}, and TSP 75 g dec^{-1} were applied at the initial stage during pond preparation.

Stocking, feeding, and data collection: About 7-10 cm fingerlings of those fish were stocked as per experimental design (Table 3). Fish were fed commercially available fish feed 10-5% BW day^{-1}(containing 30-35% protein). Length-weight data and water quality parameters *viz.*, temperature, pH, DO, CO_2, NH_3, etc. were collected fortnightly. The experimental design is presented in Table 3.

Harvesting and growth parameters/BCR analysis

The ponds were completely dewatered and all the fish at the end of the experiment and counted species-wise. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR, survival (%), and benefit-cost ratio (BCR) were calculated.

Data analysis

Data were analyzed using MS Excel and **o**ne-way analysis of variance (ANOVA) (Duncan, 1993) and SPSS 20 (Chicago, USA) to detect significant differences among the treatments at a 5% level. The values were given with means ±SD, and differences were considered significant at the subset for alpha = 0.05 ($p \leq 0.05$).

Table 3. Growth performances of *M. vittatus* under polyculture in the farmer's pond

Parameters	Treatments		
	T_1	T_2	T_3
Stock. dens. of Tengra (indi. dec^{-1})	500	600	700
Culture period (months)	05	05	05
Initial weight (g)	2.3±.02	2.3±.02	2.3±.02
Final weight (g)	18.5 ± 1.2^{a}	16.2 ± 1.5^{b}	14.2 ± 1.7^{c}
Weight gain (g)	16.2 ± 1.1^{a}	13.9 ± 1.5^{b}	11.9 ± 1.7^{c}
SGR (% day^{1})	1.38 ± 0.02^{a}	1.30 ± 0.01^{b}	1.21 ± 0.02^{c}
FCR	2.15 ± 0.01^{c}	$2.51\pm0.01_{a}$	2.70 ± 0.02^{a}
Survival (%)	88.0 ± 2.0^{a}	87.0 ± 1.5^{ab}	85.0 ± 1.5^{ab}
Production of Tengra (kg ha^{1})	2,035±5.0	2,114±14.0	2,112±92.0
Total production (kg ha^{1})	$5{,}592\pm8.0^{a}$	$5{,}391\pm91.0^{b}$	$5{,}245\pm45.0^{c}$

Within rows values with different superscripts are significantly different (P<0.05).

RESULTS AND DISCUSSION

Growth performances of Tengra, *M. vittatus* under polyculture farmer's pond

The results of growth parameters such as weight gain, SGR, production of Tengra, and total production of experimental fish are presented in Table 3. In this experiment, the final weight of Tengra was 18.5, 16.2, and 14.2 g in T_1, $T_{,2,}$ and $T_{3,}$ respectively. The highest weight gain (16.2 g) was found in T_1 and the lowest (11.9 g) was found in T_3. The weight gain of Tengra was found significantly (P<0.05) higher in T_1 followed by T_2 and T_3. The SGR (% day^{-1}) of Tengra was 1.38, 1.30, and 1.21 respectively in T_1, $T_{2,}$ and T_3. On the basis of analysis, the SGR showed significantly (P<0.05) higher in T_1 followed by T_2 and T_3. The survival was estimated after harvesting of fish by dewatering ponds. In the case of Tengra, the values of survival were 88, 87, and 85%, respectively in T_1, $T_{2,}$ and T_3. The survival rate of Tengra was found significantly (P<0.05) different among the three treatments. The FCR values were higher in T_3 (2.70) and lower in T_1 (2.15). Analytical results showed the FCR values were directly related to the stocking density. The production (kg ha^{-1}) of Tengra was recorded at 2,035, 2,114, and 2,112, respectively in T_1, $T_{2,}$ and T_3 and there was no significant (P<0.05) difference among the three treatments on the other hand, the total production (kg ha^{-1}) was 5,592, 5,391 and 5,245 respectively in T_1, $T_{2,}$ and T_3. Based on the analysis, the production of Tengra in T_2 was found higher than that of T_1 and T_3 but total production was obtained significantly (P<0.05) higher in T_1 followed by T_2 and T_3 (Table 3). The results revealed that the final weight, weight gain, SGR, and survival were inversely related to stocking density. The present results coincide with the findings of (Mondal *et al.*, 2017) who obtained the best growth in gulsha farming at lower stocking densities. The lowest stocking densities are expected to provide more space, food, and less competition (Ahamed *et al.*, 2018). Stocking density is known to be one of the important parameters in the fish culture since directly affects growth and survival (Ahamed *et al.*, 2017b) revealed that the growth and survival of African catfish were significantly influenced by stocking density. The findings agree with the findings of the present study. However, the FCR values in the present study were acceptable levels and indicated better food utilization, which is agreed by (Hossain *et al.*, 2022). (Kohinoor *et al.*, 2009) recorded a gross production of 2,393 to 2,986 kg/ha in six months from a composite culture of Indian major with pabda and gulsha. Where the contribution of pabda and gulsha was 5.2% to 9.04%, respectively Hence, the higher growth observed in lower density could be due to space limiting effect, a stressful situation caused by supplementary feed, some variations in environmental parameters, and less availability of natural food. The present results agreed with the findings of (Mou *et al.*, 2018) who obtained the highest production from higher stocking density but individual growth higher in lower density.

Physiochemical parameters of the experimental ponds

The water quality parameters *viz.*, temperature (°C), transparency (cm), water pH, DO (mgl^{-1}) and ammonia (mg l^{-1}) of the experimental pond under 3 different treatments were studied and presented in Table 4. The water temperature varied between 28.0 and 28.6°C during the experiment and there was no significant (P<0.05) difference among the treatments. The water transparency was 26.5, 27.0, and 28.0 cm respectively, in $T_{1,}$ $T_{2,}$ and T_3. The pH was 7.7, 7.8, and 7.6 in T_1, $T_{2,}$ and T_3 respectively. The DO concentration ranged from 5.5 to 5.7 mg l^{-1}during the experiment and no significant (P<0.05) difference was observed among the treatments. The ammonia was found to vary from 0.10 to 0.13 mg l^{-1} among the treatments.

The findings of water temperature agreed with (Kader *et al.*, 2019). who stated that the temperature ranged between 28.0 and 32.0°C in the nursery pond of shing (*H. fossils*). The present findings also agreed with the findings of (Rahman *et al.*, 2018). (Boyd, 1982) reported that the range of transparency from 15 cm to 40 cm is suitable for fish culture. Thus, transparency was found to be a suitable range in the present study. According to (Swingle, 1995), pH ranges from 6.5 to 9.0 is suitable for pond culture. However, the pH range was found to be suitable in the present study which agrees well with the findings of (Mou *et al.*, 2018). (Hossain *et al.*, 2019) stated that dissolved oxygen varied between 4.23 and 5.32 mg l^{-1}in the *H. fossillis* cultured pond.

Table 4. Physiochemical parameters of the experimental ponds under polyculture of *M. vittatus*.

Water quality parameters	T_1	T_2	T_3
Water temperature (°C)	28.6±3.0	28.0±3.5	28.5±3.2
Water transparency (cm)	27.0±1.0	26.5±2.5	28.0±1.0
Water pH	7.7±0.2	7.8±0.1	7.6±0.1
DO (mg l^{-1})	5.7±0.2	5.7±0.1	5.5±0.2
NH_3 (mg l^{-1})	0.10±0.01	0.12±0.02	0.13±0.01

Among the three treatments.

Table 5. Benefit and cost analysis of Tengra under polyculture in three treatments.

Item wise expenditure	T_1	T_2	T_3
Pond preparation (Tk. ha^{1})	25,000	25,000	25,000
Fingerling cost (Tk. ha^{1})	3,03,750	3,73,750	4,03,750
Lime and fertilizer (Tk. ha^{1})	12,500	12,500	12,500
Feed cost (Tk. ha^{1})	6,17,916	7,40,916	7,79,875
Transport, labor etc. (Tk. ha^{1})	50,000	50,000	50,000
Total production costs (Tk. ha^{1})	10,09,167±2602^{c}	11,82,167±1774^{b}	12,71,125±944^{a}
Income and output			
Total production (kg ha^{1})	5,592±8^{a}	5,391±91^{b}	5,245±45^{c}
Gross return (Tk. ha^{1})	16,04,987±1273^{a}	15,50,656±558^{b}	15,31,610±348^{c}
Gross margin (Tk. ha^{1})	5,95,820±3259^{a}	3,68,490±1360^{b}	2,60,485±883^{c}
Benefit cost ratio (BCR)	1.60^{a}	1.31^{b}	1.20^{c}

Within rows, values with different superscripts are significantly different (P<0.05).

However, the DO levels were within the acceptable ranges in all the experimental ponds. Analytical results showed the pH and DO values were inversely related to the stocking density. The ammonia was found to vary from 0.10 to 0.13 mg l^{-1} among the treatments and a bit higher level might be due to higher stocking density. This finding agrees with the findings of (Ahamed *et al.*, 2018) who stated that the ammonia ranged between 0.01 mg l^{-1} and 1.55 mg l^{-1} in the monoculture of *H. fossils* in a pond condition. Based on observation and discussion, the water quality parameters were found quite friendly for fish culture and little bit higher level might be due to higher stocking density. Based on observation, the water quality parameters were found quite friendly for fish culture.

Economic analyses of the polyculture of *Mystus vittatus*

Economic analysis was performed to estimate the benefit-cost ratio from different treatments of the Tengra polyculture system (Table 5). The production costs (Tk. ha^{1}) were 1009167, 1182167, and 1271125 in T_1, T_2, and T_3 respectively. The gross return values (Tk. ha^{1}) were 1604987, 1550656, and 1531610 respectively in T_1, T_2, and T_3 with significant differences (P<0.05) among the treatments. Furthermore, the gross margins (Tk. ha^{1}) were 595820, 36849,0, and 260485 respectively in T_1, $T_{,2}$, and T_3 and the gross margin was found significantly higher in T_1 followed by T_2 and T_3. The highest BCR was achieved in T_1 (1.60) followed by T_2 (1.31) and T_3 (1.20). The BCR was found significantly difference (P<0.05)

The production in the present study was like the findings of (Kohinoor *et al.*, 2015) who stated that the production (kg ha^{1}) of Gulsha, *Mystus cavacius* in polyculture varied between 4050 and 4650 in 06 months of culture. The BCR in the present study was similar to the findings of (Ahamed *et al.*, 2018) who stated that the BCR of Vietnamese koi in polyculture varied between 1.64 and 1.40 where the stocking density of koi ranged from 300 to 500 indi dec^{-1}in polyculture for 04 months culture. (Chakraborty *et al.*, 2005) and Kunda *et al.*, 2014) also found results in the case of small indigenous fish species. Based the on discussed results and economic point of view it can be concluded that T_1 (500 Tengra+100 Magur+10 Rajpunti +5 GIFT indi. dec.$^{-1}$) was the best combination for Tengra polyculture in seasonal ponds at the Semi-arid zone of Bangladesh.

Dissemination of the best polyculture patterns in different Semi-arid zones in the Northern part of the country

Polyculture of *M. vittatus* was carried out under different treatments in seasonal farmer's mini ponds at the adjacent areas of FSS, Saidpur during the first year of the project. 500 Tengra+100 Magur+10 Rajpunti+5 GIFT (indi. dec-^{1}) combination from Tengra polyculture was selected for multi-location testing due to the highest yield and economic viability. For this reason, the two combinations were demonstrated in different upazila of the northern region of Bangladesh as per methodology from May 2018 to September 2018.

Polyculture of Tengra, *M. vittatus* in multi-location testing

After the culture of 05 months, the growth parameters and production of Tengra; the total production of cultured fish, and their economics in different locations are presented in Table 6. The final growth (18.2 g) was found significantly (p<0.05) higher in Kaligonj upazila followed by Nilphamari sadar and Dumar upazila. The weight gain (16.2 g) and SGR (1.47) were also significantly (p<0.05) higher in Kaligonj followed by Nilphamari Sadar and Dumar. The highest survival (86%) was recorded in Nilphamari sadar but there was no significant difference among the three locations.

Table 6. Growth performances, production, and economic analysis of *Mystus vittatus* under polyculture in multi-location of the northern part of Bangladesh.

Parameters	Multi-location			Average
	Kaligonj	Domar	Sadar, Nilphamari	
Stock. dens of Tengra (indi. dec^{-1})	500	500	500	500
Culture period (months)	05	05	05	5
Initial weight (g)	2.0±0.0	2.0±0.0	2.0±0.0	2±0.0
Final weight (g)	18.20±0.40^{a}	15.76±0.32^{b}	15.77±0.40^{b}	16.58±1.4
Weight gain (g)	16.20±0.40^{a}	13.76±0.32^{b}	13.77±0.51^{b}	14.58±1.4
SGR (% day ^{1})	1.47±0.02^{a}	1.38±0.01^{b}	1.37±0.02^{b}	1.41±0.1
FCR	2.20±0.01	2.21±0.015	2.19±0.01	2.2±0.01
Survival (%)	84.00±1.0	85.00± 1.0	86.00±2.5	85±1
Production of Tengra (kg ha ^{1})	2,250±2.0	2,252±3.5	2,240±3.1	2247.3±6.4
Total production (kg ha ^{1})	5,656±70.3	5,625±40.0	5,650±2.5	5643.7±16.4
Total cost (Tk ha ^{1})	10,12,000±15	10,30,000±10	10,09,870±10	1017290±11059
Gross return (Tk ha ^{1})	16,65,400±5.7	16,58,750±5.0	16,63,000±7.6	1662383.3±3368
Gross margin (Tk ha ^{1})	6,53,400±18.5	6,28,750±8.1	6,53,130±10.4	645093.3±14154
BCR	1.65	1.61	1.64	1.63

Similarly, the production of Tengra (kg ha^{-1}), the total production (kg ha^{-1}) of cultured fish, gross return (Tk. ha^{-1}), gross return (Tk. ha^{-1}), and BCR were found identical in three locations. Based on multi-location results, the production of Tengra, total fish production, and BCR were higher and found satisfactory than that of 1st year, which may be due to suitable stocking density and a suitable culture period. Thus, it can be concluded that the combination of 500 Tengra+100 Magur+10 Rajpunti+5 GIFT indi. Dec. 1 is suitable for dissemination in the northern region of Bangladesh. However, in terms of survivability, the present study showed better results when compared with other research (Hossain *et al*., 2019, 2018; Islam *et al*., 2007). Unlike Siddiky *et al.* (2015).

Conclusion and recommendation

The result of the study reveals that the Polyculture of Tengra (*Mystus vittatus*) in seasonal waters at the semi-arid zone is economically viable, considering the growth and survival, 500 indi. Dec.-^{1}Tengra was found as the most suitable stocking density for the polyculture system. Fish farmers can be suggested to follow the combination of 500 Tengra+100 Magur+10 Rajpunti+5 GIFT indi. Dec. 1 in the case of Tengra polyculture. In context to fish production, appropriate culture periods during April to August and overwintered fingerlings were identified as the key to successful fish culture in seasonal ponds. Moreover, this type of polyculture combination is appropriate for utilizing the seasonal mini ponds. It is concluded that these fish culture technologies can ensure the best utilization of the semi-arid zone in southern Bangladesh for enhancing fish production and as well as to improve farmer's livelihood status.

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