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Fish culture in ponds under drought prone Barind area of Bangladesh

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ABSTRACT

Efforts for the evaluation of performances and development of innovation were taken through fish culture in ponds (mean area of 0.038 ha and water depth of 1.19m) by the poor and extreme poor farmers (average annual income of 10,000-40,000 Tk) during October, 2009 to January, 2010 at Nachole upazila of Chapainawabgonj district, a drought prone Barind area of Bangladesh. The study was conducted under three treatments of monoculture of fishes (T_1: bighead carp, *Aristichthys nobilis*; T_2: sarpunti, *Puntius gonionotus* and T_3: tilapia, *Oreochromis niloticus*), each with two replications. Mean initial stocking weight (g) of fish was 20.00±0.00, 16.00±5.83 and 40.00±3.00 with the treatments T_1, T_2 and T_3, respectively. Total stocking biomass (400 kg/ha) of fishes were found same for all the treatments. Ponds under different treatments were found with same liming (1kg/decimal as basal dose only), fertilization (basal dose: urea-200g/decimal, T.S.P.-200g/decimal, cowdung: 5kg/decimal and periodic dose: urea-150g/decimal/month, T.S.P.-150g/decimal/month, cowdung: 6kg/decimal/month) and feeding (mustard oil cake 50% and rice bran 50% at 3% of fish body weight for first 5 weeks and 2% for next 5 weeks). Water quality parameters were monitored monthly. Temperature, transparency, depth, dissolved oxygen, pH, alkalinity and ammonia-nitrogen of water varied from 22.66±0.65–23.06±1.13°C, 9.66+2.22–16.06±6.28cm, 0.77±0.02–1.20±0.04m, 3.76±0.16–4.77±0.38mg/l, 6.53±0.10–6.92±0.09, 16.61±0.36–20.56±1.18mg/l and 0.003±0.001–0.005±0.002mg/l, respectively under different treatments. Mean final weight (g), weight gain (g), SGR (%,bwd^{-1}) and survival rate (%) of fishes significantly ($P<0.05$) varied from 85.10±0.00 (T_2) to 182.00±1.00 (T_3), 69.10±2.00 (T_2) to 142.00±1.00 (T_3), 1.30±0.00 (T_3) to 1.38±0.00 (T_1 and T_2) and 62.00±2.00 (T_2) to 95.00±1.00 (T_3), respectively. Mean fish yield (kg/ha/4 months) significantly varied from 1058.19±97.81 (T_2) to 1332.81±22.43 (T_3). Net benefit (Tk/ha) significantly varied from 11750.45±366.75 (T_2) to 32103.60±815.10 (T_3). This study indicated that better performance was found with treatment T_3 for pond farming by the poor and extreme poor farmers under drought prone Barind area.

INTRODUCTION

Aquaculture is the fastest growing food-producing sector in the world. It is developing, expanding and intensifying in almost all regions of the world. The global population is increasing, thus, the demand for aquatic food products is also increasing. Production from capture fisheries has leveled off and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food and aquaculture is considered to be an opportunity to bridge the supply and demand gap of aquatic food in most regions of the world. However, with the different efforts taken to achieve this potential, the sector is facing significant challenges. Thus, water is extremely valuable to farmers in the poorest countries of the world. In particular, the value of water should therefore be well recognized for food production under drought prone areas.

Drought prone areas are located in greater Dinajpur and Rajshahi of our country which are considered as Barind region. Climate change will moderately affect these areas. However, the extent of damages might multiply if availability of surface water drops dramatically. Malnutrition will also increase in these areas. Changes in surface

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water availability are the most obvious threats to farmers in drought prone areas. Barind tract is considered as one of the low output zones in terms of agricultural production. In addition to the quality of soil (less organic matter) and water (high turbidity and low alkalinity), climate change aspects (drought, lack of sufficient surface water for fisheries production) leads the farmers of this region more vulnerable as compared to other parts. Effort on necessary adaptive capacity is found minimum as compared to the maximum level of vulnerability expected in this region. Therefore, it is the high time to explore all sorts of potentialities of this zone while improving the livelihood especially of the poor farmers (Hossain, 2008). The Barind tract, situated in the north-western part of Bangladesh, is an anomaly in the major landscape of deltaic flat lands. Natural conditions such as its higher elevation, clayey soil, limited rainfall and lack of water sources in the dry season provide a different foundation for the development of cropping patterns in comparison with those in the deltaic areas of Bangladesh.

Monoculture is a type of culture, which involves growing or culturing of only one kind of species in the culture system (Mono, i.e., one, single). The major advantages of monoculture are easier to perform and manage. Compared to polyculture, monoculture does not require great deal of attention and can be carried out at small scale also. In monoculture system, the grower has a greater control over the age and sex of the fish. Monoculture involves culture of only single species of organisms and so separation of fish into different age, sex, and size is much easier than polyculture (Jadhav, 2009). The concept of polyoculture specially of carps in based on the utilization of natural foods of different layers of the waterbody. In this regard, the polyculture ponds require sufficient water level for production and distribution of natural food for the fishes. Therefore, seasonal ponds or shallow ponds under drought prone Barind area are more suitable for monoculture of fishes than that of polyculture. Barind is historically rich in water bodies like natural depressions (Beels), ponds, tanks and numerous kharis (canals). Seasonal pond based monoculture of fish by poor and extreme poor farmer can be a good option to improve the livelihood of the poor farmer. Unfortunately, with a few exceptions, no sufficient work is found to explore the opportunity for the poor and extreme poor farmers in the Barind region. Therefore, the present effort was aimed to evaluate the performance of fish darmers and to develop an innovation for fish culture in ponds under drought prone Barind area.

MATERIAL AND METHODS

Study ponds

A total of six ponds (Table 2**)** at Nijampur union under Nachole upazila of Chapai- Nawabgonj district, a drought prone Barind area of Bangladesh were selected for the present study. The mean area and water depth of the ponds were 0.038 ha and 1.19m, respectively. Water source of the ponds were rainfall and deep tube well. Spatial locations of the ponds were determined by GPS (Etrex, made in Taiwan) and pond management was done by poor and extreme poor farmers (Table 1).

Experimental design

The experiment was carried out under three treatments of monoculture of fishes, each with two replications. The treatment assignment was as follows:

T_1: monoculture of bighead carp, *Aristichthys nobilis*;

T_2: monoculture of sarpunti, *Puntius gonionotus* and

T_3: monoculture of tilapia, *Oreochromis niloticus*

Pond Management

Aquatic weeds were removed manually from the ponds. Lime was used in the ponds at the rate of 1 kg/decimal only as basal dose. After 3 days of liming the ponds were fertilized with Urea, T.S.P. and cowdung at the rate of 200g, 200g and 5kg/decimal, respectively as basal dose. The individual stocking weight of *Aristichthys nobilis, Puntius sarana* and *Oreochromis niloticus* was 20.00±0.00g, 16.00±5.83g and 40.00±3.00g, respectively. The main source of the cultured fish seeds was hatchery. The stocking number of fishes per decimal was 80, 100 and 40 for bighead, sarpunti and tilapia, respectively. The stocking biomass was same (1600 g/decimal) for all ponds under different treatments.

The pond was fertilized with Urea, T.S.P. and cowdung at the rate of 150g, 150g and 6kg/decimal/month, respectively as periodical dose. No liming was done at periodic dose. During the culture period, supplementary feeds (mustard oil cake : 50% and rice bran: 50%) were used weekly by the fish farmer at 3% of fish body weight for first 5 weeks and 2% of fish body weight for next 5 weeks.

Table 1
Profile of the selected ponds.

Pond No.	Spatial Location Latitude	Longitude	Elevation	Water Area (ha)	Water Depth (m)	Water Source
01	24°41.37 N	88°26.65 E	32 m	0.0445±0.01	0.985±0.5	Rainfall and Deep tube well
02	24°4.26 N	88°25.040 E	40 m	0.0364±0.01	0.991±0.15	Rainfall and Deep tube well
03	24°41.308 N	88°26.63 E	40 m	0.0364±0.005	1.21±0.02	Rain fall and Deep tube well
04	24°40.04 N	88°25.044 E	43 m	0.0404±0.005	1.19±0.02	Rain fall and Deep tube well
05	24°41.39 N	88°26.61 E	35 m	0.0328±0.005	0.761±0.08	Rain fall and Deep tube well
06	24°41.446 N	88°28.92 E	41 m	0.0364±0.005	0.772±0.04	Rain fall and Deep tube well

Water quality

Physico-chemical parameters viz., water temperature, water depth, water transparency, hydrogen ion concentration (pH), dissolved oxygen (DO), ammonia-nitrogen (NH_3-N) and total alkalinity were studied monthly between 09.00 and 10.00 h on each sampling day.

Fish production

Sampling was done at monthly basis for monitoring fish production 10% of stocked fishes were caught during each sampling from each pond by a cast net. Final weight (g), Weight gain (g), Specific Growth Rate (SGR, % bwd-1), Survival rate (%) and Fish yield (kg/ha/4 months) were used to determine production of fishes under different treatments. At the end of the experiment, fish were sold locally and the total return was estimated.

Statistical analysis

Data related on water quality, fish production, and economics under different treatments were subjected to One way ANOVA (Analysis of Variance) using computer software SPSS (Statistical Package for Social Science, version-11). The mean values were also compared to see the significant difference from the Duncan Multiple Range Test (Gomez and Gomez, 1984 and Zar, 1974).

RESULTS AND DISCUSSION

Water quality

Water temperature

There was no significant difference was found for the different parameters under different treatments at different months. Water temperature varied from 15.60±2.90 to 30.00±0.00^{o} C. The minimum value was recorded in treatment T_3 at 4th month whereas the maximum value was recorded in treatment T_3 at 1st month (Table 2). The mean value of water temperature during the study period was found to be ranged from 22.66±0.65 to 23.06±1.13 ^{0}C. The minimum value was recorded in treatment T_1 whereas the maximum value was recorded in treatment T_3 (Table 3).

In general, increasing water temperature results in greater biological activity and more rapid growth. All aquatic organisms have preferred temperature in which they can survive and reproduce optimally. Water temperature of 25 to 32 ^{0}C is considered suitable for fish culture (Boyd and Zimmermann 2000). This finding of the present study is more or less similar to the findings recorded by Hossain and Bhuiyan (2007) in the ponds under the red soil zone of northern Bangladesh. In the present study, the water temperature was found to vary from 15.60±2.90 to 30.00±0.00^{o} C. Lower water temperature (15.60±2.90^{o} C) with treatment T_3 at 4th month (i.e. January, 2010) might be due to winter season. Higher water temperature (30.00±0.00^{o} C) with treatment T_3 at 1st month (i.e. October, 2009) might be due to bright sunlight and reduced water level. Boyd (1998) and Hossain and Bhuiyan (2007) stated water temperature for pond fish culture 29.72-30.49 ^{0}C and 20.4-33.2^{0}C, respectively which are more or less similar to the present findings. However, the water temperature of the study ponds decreased gradually towards the end of the study which was influenced by the gradual decrease in temperature at the winter season.

Water depth

Water depth of the pond varied from 0.53±0.08 to 1.37±0.00 m. The minimum value was recorded in treatment T_3 at 4th month whereas the maximum value was recorded in treatment T_2 at 1st month (Table 2). The mean value of water depth varied from 0.77±0.02 to 1.2±0.04 m. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_2 (Table 3). Reduced water depth in the study pond might be due to the reduced water level in the winter season.

Water transparency

Water transparency was found to vary from 5.50±1.50 to 21.75±11.25 cm. The minimum value was recorded in treatment T_3 at 3rd month whereas the maximum value was recorded in treatment T_2 at 1st month (Table 2). The mean value of water transparency varied from 9.66±2.22 to 16.06±6.28 cm. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_2 (Table 3). Rai and Rathore (1993) stated that low values of water transparency which could be attributed to rich phytoplankton density and higher budgets of suspended and particulate matter. The lower transparency observed in the present study might be due to the higher clay turbidity in the red soil zone of northern Bangladesh (Hossain and Bhuiyan, 2007).

pH

pH of pond water differed from 5.80±0.10 to 7.60±0.10. The minimum value was recorded in treatment T_3 at 2nd month whereas the maximum value was recorded in treatment T_3 at 4th month (Table 2). The mean value of pH during the study period varied from 6.53±0.10 to 6.92±0.09. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_1 (Table 3). pH values are almost close to the neutral value indicating more or less suitable condition for fish culture which are more or less similar to the recommendation of Boyd, 1998. Singh and Singh (1975) stated that, pH range of 6.0 to 7.8 is favorable for growth and survival of major carps. In the present study, slightly lower pH value with all the all treatments indicated the slightly acidic condition of water under Barind ecosystem. Almost similar assumption was made by Hossain and Bhuiyan (2007).

Dissolved oxygen

Dissolved oxygen of pond water varied from 2.58±0.33 to 5.50±0.00 mg/l. The minimum value was recorded in treatment T_3 at 3rd month whereas the maximum value was recorded in treatment T_1 at 1st month (Table 2). The mean value of dissolved oxygen during the study period varied from 3.76±0.16 to 4.77±0.38 mg/l. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_1 (Table 3). The low value might be due to high temperature, respiration, decomposition of bottom organic matter and inorganic reductions such as NH_3. The range of dissolved oxygen contents obtained by Chakraborty et. al., (2005) in ponds as 3.20–6.10 mg/l was somewhat closer to that of the range of present study. The range of dissolved oxygen (3.7-6.0 mg/L) reported by Uddin (1998) was also closer to the range found in the present study. The value of the present study is more or less similar to the findings of. Factors that contribute to low DO values might be due to biological oxygen demand from the decomposition of organic matter and cold water temperature.

Alkalinity

Total alkalinity of pond water varied from 15.50±0.50 to 22.25±2.75 mg/l. The minimum value was recorded in treatment T_3 at 1st month whereas the maximum value was recorded in treatment T_1 at 4th month (Table 2). During the study period, the mean value of total alkalinity varied from 16.61±0.36 to 20.56±1.18 mg/l. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_1 (Table 3). It is desirable to have an alkalinity of above 20 mg/l for optimal fish production. Comparatively lower alkalinity level with the ponds might be due to the special characteristics of soil-water quality under the red soil zones of Barind area. And this statement strongly agreed with Hossain and Bhuiyan (2007).

Table 2
Variation in mean values of water quality parameters under different treatments at different months (October 2009 to January, 2010).

Parameter	Months	T_1	T_2	T_3
Water Temperature (^{0}C)	1st	28.50±0.50a	29.40±1.40a	30.00±0.00a
	2nd	26.00±0.00a	27.00±1.00a	27.00±1.00a
	3rd	20.00±0.00a	20.00±0.00a	18.50±0.50a
	4th	16.13±2.13a	15.83±2.13a	15.60±2.90a
Water Depth (m)	1st	1.22±0.15a	1.37±0.00a	0.99±0.08a
	2nd	1.07±0.15a	1.28±0.00a	0.87±0.05a
	3rd	0.91±0.15a	1.14±0.07a	0.70±0.03a
	4th	0.76±0.15a	0.99±0.08a	0.53±0.08a
Transparency (cm)	1st	15.00±4.00a	21.75±11.25a	14.00±3.00a
	2nd	14.00±2.00a	17.00±7.00a	11.50±4.50a
	3rd	8.75±1.25a	13.00±5.00a	5.50±1.50a
	4th	10.13±0.38a	12.50±2.00a	7.63±0.13a
D.O. (mg/l)	1st	5.50±0.00a	5.43±0.43a	4.88±0.13a
	2nd	5.19±1.07a	3.50±0.83a	3.24±0.04a
	3rd	3.09±0.34a	3.43±0.43a	2.58±0.33a
	4th	5.30±0.20a	4.93±0.48a	4.35±0.35a
pH	1st	7.30±0.10a	7.40±0.40a	6.70±0.10a
	2nd	6.50±0.30a	6.20±0.00a	5.80±0.10a
	3rd	6.30±0.10a	6.30±0.10a	6.00±0.10a
	4th	7.58±0.08a	7.58±0.08a	7.60±0.10a
Alkalinity (mg/l)	1st	20.00±3.00a	17.65±4.35a	15.50±0.50a
	2nd	20.50±0.50a	17.00±8.00a	15.50±5.50a
	3rd	19.50±1.50a	18.50±0.50a	17.50±1.50a
	4th	22.25±2.75a	18.45±0.55a	17.95±5.05a
NH_{3-} N (mg/l)	1st	0.003±0.0001a	0.006±0.0005a	0.005±0.0004a
	2nd	0.002±0.0000a	0.004±0.0002a	0.006±0.0002a
	3rd	0.003±0.0022a	0.003±0.0000a	0.005±0.0001a
	4th	0.004±0.0005a	0.004±0.0005a	0.005±0.0005a

Figures in a row within a parameter bearing common letter(s) do not differ significantly ($p<0.05$)

Table 3
Variation in mean values of water quality parameters under different treatments during study.

Parameter	Treatment		
	T_1	T_2	T_3
Water Temperature (^{0}C)	22.66±0.65a	23.06±1.13a	22.78±0.85a
Water Depth (m)	0.99±0.15^{ab}	1.2±0.04^{a}	0.77±0.02^{b}
Transparency (cm)	11.97±1.09a	16.06±6.28a	9.66±2.22a
D.O. (mg/l)	4.77±0.38a	4.32±0.09a	3.76±0.16a
pH	6.92±0.09a	6.87±0.06a	6.53±0.10a
Alkalinity (mg/l)	20.56±1.18a	17.90±0.60a	16.61±0.36a
NH_3 -N (mg/l)	0.003±0.001a	0.004±0.002a	0.005±0.002a

Figures in a row bearing common letter(s) do not differ significantly ($p<0.05$)

Ammonia-Nitrogen (NH_3-N)

Ammonia-nitrogen was found to be ranged from 0.002±0.0000 to 0.006±0.0005 mg/l. The minimum value was recorded in treatment T_1 at 2nd month whereas the maximum value was recorded in treatment T_2 at 1st month (Table 2). The mean value of ammonia-nitrogen during the study period varied from 0.003±0.001 to 0.005±0.002 mg/l. The minimum value was recorded both in treatment T_1 and T_2 whereas the maximum value was recorded in treatment T_3 (Table 3). Higher concentration of ammonia is the result of ammonification of organic matter. In the present study, the ammonia-nitrogen content of water was observed between 0.002±0.0000 mg/L with the treatment T_1 at 2nd month to 0.006±0.0005 mg/L with the treatment T_2 at 1st month. Wahab et al. (1996) recorded NH_3-N in his study of 0.007 to 0.023 mg/l. NH_3-N the values of present study might be due to high organic load, high turbidity and surface run-off from surroundings.

Fish production

Weight gain (g)

The monthly value of weight gain varied from 14.25±0.25 g (T_2) to 35.50±0.50 g (T_3) at 1st month, 28.85±0.15 g (T_2) to 75.25±0.25 g (T_3) at 2nd month, 46.13±0.13 g (T_2) to 106.55±0.45 g (T_3) at 3rd month and 69.10±0.40 g (T_2) to 142.00±0.75 g (T_3) at 4th month (Table 4). In the present study, mean weight gain (g) was found to vary from 69.10±2.00 (T_2) to 142.00±1.00 g. (T_3) (Table 5). Comparatively higher weight gain of fishes in the treatment T_3 might be due to the larger stocking size and type of species stocked (Hussain, 2004). However, the comparatively higher weight gain was found in treatment T_3 might be due to higher stocking size and this statement was strongly supported by Uddin et al., 2002.

Specific growth rate (%, bwd^{-1})

The monthly value of specific growth rate (%, bwd^{-1}) varied from 2.12±0.03%, bwd^{-1} (T_2) to 2.38±0.03%, bwd^{-1} (T_1) at 1st month, 1.30±0.02%, bwd^{-1} (T_2) to 1.41±0.01%, bwd^{-1} (T_3) at 2nd month, 0.92±0.005 g (T_3) to 1.08.±0.0005%, bwd^{-1} (T_2) at 3rd month and 0.71±0.01%, bwd^{-1} (T_1) to 1.04±0.01%, bwd^{-1} (T_2) at 4th month (Table 4). Higher mean specific growth rate was found in the treatment T_1 and T_2 (1.38±0.05) for bighead and sarpunti culture (Table 5). Comparatively higher SGR was found T_1 and T_2. The present findings agreed with Litli et.al. (2005) who found specific growth rate (%, bwd^{-1}) of 1.5 in growth and economic performance of nile tilapia.

Table 4
Variation in mean values of fish production parameters (weight gain and SGR) under different treatments at different months.

Months	Parameter	Treatment		
		Bighead carp (T_1)	Sarpunti (T_2)	Tilapia (T_3)
1st month (October'2009)	Weight gain (g)	20.88±0.38[b]	14.25±0.25[c]	35.50±0.50[a]
	S.G.R. (%,bwd^{-1})	2.38±0.03[a]	2.12±0.03[b]	2.12±0.02[b]
2nd month (November, 2009)	Weight gain (g)	42.50±0.50 b	28.85±0.15 c	75.25±0.25 a
	S.G.R. (%,bwd-1)	1.41±0.00 a	1.30±0.02 b	1.41±0.01 a
3rd month (December, 2009)	Weight gain (g)	64.75±0.75 b	46.13±0.13 c	106.55±0.45 a
	S.G.R. (%,bwd-1)	1.01±0.005 b	1.08±0.005 a	0.92±0.005 c
4th month (January, 2010)	Weight gain (g)	85.00±1.25 b	69.10±0.40 c	142.00±0.75 a
	S.G.R. (%,bwd-1)	0.71±0.01 b	1.04±0.01 a	0.72±0.00 b

Figures in a row bearing common letter(s) do not differ significantly ($p<0.05$)

Table 5
Variation in means of production parameters of fishes under different treatments during study period.

Parameters	Treatment		
	Bighead carp (T_1)	Sarpunti (T_2)	Tilapia (T_3)
Stocking weight (g)	20.00±0.00[b]	16.00±5.83[c]	40.00±3.00[a]
Stocking density (no./dec)	80±0.00a	100±0.00a	40±0.00a
Stocking biomass(g/dec)	1600.00±0.00a	1600.00±0.00a	1600.00±0.00a
Final weight (g)	105.00±0.50[b]	85.10±0.00[c]	182.00±1.00[a]
Weight gain (g)	85.00±0.50[b]	69.10±2.00[c]	142.00±1.00[a]
S.G.R. (%, bwd^{-1})	1.38±0.00 [a]	1.38±0.00 [a]	1.30±0.00 [b]
Survival rate (%)	65.00±1.00 [b]	62.00±2.00[c]	95.00±1.00 [a]
Yield (kg/ha/4 months)	1091.74±9.44 [b]	1058.19±97.81 [c]	1332.81±22.43 [a]
yield (kg/ha/year)	3275.22±28.32 [b]	3174.57±293.42 [c]	3998.43±67.27 [a]

Figures in a row bearing common letter(s) do not differ significantly ($p<0.05$)

Final weight (g)

The mean final weight of fishes at harvest was found to be ranged from 85.10±0.00 g to 182.00±1.00 g (Table 5). The maximum final weight recorded in treatment T_3 might be due to the stocking of larger fingerling of tilapia (Hussain, 2004).

Survival rate (%)

The mean survival rate of fishes was found to be varied from 62.00±2.00 to 95.00±1.00 %. The maximum survival rate was found in treatment T_3 whereas minimum survival rate was found in treatment T_2 (Table 5). However, treatments under pond fish farming showed significant variation for the survival rate of fishes. Comparatively higher survival rate with the treatment T_3 (95.00±1.00 %) might be due to the higher adaptability of tilapia with abnormal environmental condition like low oxygen, high turbidity, high temperature etc. Almost similar rate was observed by Hassan (2007),) and Presente findings almost agreed with Azad et.al. (2004) who reported the survival rate of tilapia as 91.74% and khatun et. al. *(*2006) who reported this rate as 95%. Mostaque (1995) also reported the survival rate of tilapia as 86-95%.

Yield

The mean yield (kg/ha/4 months) of fishes varied from 1058.19±97.81 to 1332.81±22.43 (Table 5). Fish yield varied significantly under the different treatments of pond fish farming. Higher fish yield was found in the treatment T_3, because of the higher adaptability in abnormal environmental condition, high metabolic activity, fast growing characteristics and stocking of larger size fish. This statement was strongly supported by Hossain et al. (2010) who worked for tilapia in rice field under the red soil zone of northern Bangladesh. The production of *Puntius sarana* was found low in the present study. Chakraborty et. al. (2005) stated that, the survivability and production of *Puntius sarana* was related with stocking density of fry. As the stocking density will high, growth performance become low and vice-versa. Kohinoor et.al. (1998) found that the gross fish production of 3,218 kg/ha and 3,017 kg/ha were obtained from *O. niloticus* and red tilapia ponds, respectively. Siddik et. al. (2008) reported the yield of monosex tilapia as 3723.10 kg/ha. They also reported the yield of GIFT as 2776.28 kg/ha.

Table 6
Economics of different treatments of monoculture of fishes (based on 4 months culture period for 1 ha research pond).

Parameter	Treatment		
	Bighead carp (T_1)	Sarpunti (T_2)	Tilapia (T_3)
Total cost (Tk/ha)	47505.00±449.75a	46450.00±372.90a	47865.00±430.20a
Total return (Tk/ha)	60045.70±408.25[b]	58200.45±339.65[b]	79968.60±815.10[a]
Net benefit (Tk/ha)	12540.70±261.75[b]	11750.45±366.75[b]	32103.60±815.10[a]

Figures in a row bearing common letter(s) do not differ significantly (p<0.05)

Table 7
Performance of the farmers in terms of pond management.

Items	Performances
Weed removed	Manually done
Liming (Basal)	1 kg/ decimal
Fertilization (Basal)	Urea :200g/decimal, T.S.P : 200g/decimal , Cowdung : 5kg/ decimal .
Stocking Stocking weight Stocking density Stocking biomass	Bighead carp: 20.00±0.00g, 80 fishes/decimal, 1600g /decimal Sarpunti : 16.00±5.83g, 100 fishes / decimal, 1600g / decimal Tilapia: 40.00±3.00g, 40 fishes / decimal, 1600g / decimal
Feeding (Supplementary feed)	Feed types: Mustard oil cake 50% and rice bran 50%. Feeding rate: 3% of fish body weight for first 5 weeks and 2% of fish body weight for next 5 weeks.
Fertilization (Periodic)	Urea 150g/ decimal/month T.S.P. 150g/ decimal /month Cowdung 6kg/ decimal/month
Liming (Periodic)	Not done

Economics

The total cost was estimated lowest (46450.00±372.90) in treatment T_2 and highest (47865.00±430.20) in the treatment T_3 (Table 6). The total return was estimated lowest (58200.45±339.65) in treatment T_2 and highest (79968.60±815.10) in the treatment T_3. The highest net benefit was estimated in treatment T_3 (32103.60±815.10) while the moderate was found in treatments T_1 (12540.70±261.75) and lowest was found in treatment T_2 (11750.45±366.75). Total return and net benefit varied significantly with the treatments. The economics in the present study clearly indicates that, tilapia culture in pond under drought prone Barind tract is more profitable than others.. Fish yield resulted higher net benefit in the treatment T_3. However the present study proved again that tilapia is a suitable species for pond fish farming under the red soil zone of northern Bangladesh. This statement was strongly supported by Halwart (1998) that tilapia feed low in the food chain and are therefore preferred species in the culture systems. Net benefit of tilapia was higher than that of sarpunti and bighead carp in the present study. Almost similar findings were found by Carole et.al. (1999) who reported that monoculture of bighead carp was non profitable.

Performance of the farmers

Performances of the farmers in terms of pond management are shown in Table 7. Mainly fertilizer based fish culture was found among the farmers. Feed management for the stocked fishes was found very poor. Farmers also failed to mitigate the problems of high clay turbidity and low alkalinity in their ponds.

Present findings indicated that farmers choose 3 different species for monoculture in pond. Due to their poor status regular feeding and fertilization was not found for the present study. Even they failed to mitigate the common problems of low alkalinity and high turbidity in ponds under drought prone Barind area which was reflected by their inappropriate liming and fertilization strategy. For better pond management in Barind area use of lime including and ash treatment is found very helpful (Hossain and Bhuiyan, 2007). Present findings also indicate that the hardy fish like tilapia performed better than that of others with the poor pond management by the poor and extreme poor farmers. This statement agrees with Hussain (2009) stating that tilapia can be a promising candidate for aquaculture in suitable seasonal water bodies.

CONCLUSION

Based on the production, economics and pond management, treatment T3 (i.e. larger size tilapia with lower stocking density) was found as innovation for fish farming in drought prone Barind area. Further study on the optimizing of stocking density of tilapia for seasonal pond based farming along with emphasis on the mitigation of high clay turbidity and low alkalinity problems are needed.

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