Research Article

Open Access CrossMark

Performances of bottom dwelling carpsin polyculture ponds under drought prone *Barind* area of Bangladesh

Abstract

Selection of appropriate bottom dwelling species is considered important to address the problem of increased temperature and reduced culture period for carp polyculture in ponds under drought prone Barind area (with characteristic soil and water quality) in Bangladesh. This experiment evaluated the performances of bottom feeding carps for polyculture ponds in Tanoreupazila of Rajshahi district, Bangladesh. Three different combinations of bottom feeding carps were tested under three treatments (T1: polyculture involving Cyprinuscarpio as bottom dwelling carp; T2: polyculture involving *Cirrhinus mrigala* as bottom dwelling carp; and T3: polyculture involving Labeocalbasu as bottom dwelling carp).Each treatment had three replications. Fish growing period (July-December), mean weight (100±0.4g) and density of the stocked species (Catla catla-741/ha, *Hypopthalmichthys molitrix*-1,976/ ha, Aristichth is nobilis-741/ha, Labeo rohita-1,976/ha and *Cyprinus carpio/ Cirrhinus mrigala/Labeo calbasu* -1,976/ha; all species-7,410/ha), lime and ash treatment, fertilization and supplementary feeding were same for all treatments. Water quality parameters were monitored monthly and mean values were found within the suitable range. Treatment T1 (with *Cirrhinus carpio* as bottom dwelling carp) varied more significantly (P<0.05) than other treatments for the mean values of growth (Final weight, weight gain, specific growth rate and survival rate), yield and net benefit.

Keywords: bottom feeder, carp polyculture, drought

Volume 7 Issue 1 - 2018

Mohammad Golam Sarowar Talukder, AkhtarHossain, Mohsin ABM, Rafiqual Islam Khan

Department of Fisheries, University of Rajshahi, Bangladesh

Correspondence: Mohammad Golam Sarowar Talukder, Department of Fisheries, University of Rajshahi, Bangladesh, Tel +937303591116, Email sarowar1967@gmail.com

Received: January 6, 2018 | **Published:** January 17, 2018

Introduction

Importance of pond based carp polyculture as a popular technique for fish production in Bangladesh is well documented. [1] It has further potentials to improve the livelihood of the poor and marginal peoples.[2] Potentials of pond based fish production towards livelihood improvement are also explored well by Hossain et al.[3] for Barind area having characteristic soil-water qualities like lower pH and organic matter content in soil along with lower alkalinity and higher turbidity level in pond water.[4] Apart from these potentials of pond polyculture and constraints for fish production associated with soil-water qualities, promotion of aquaculture is found to be affected by climate change aspects. Studies indicate that climate change may result in decline of groundwater level[5] and thus remodelling of carp polyculture is felt necessary in terms of insufficient water level in ponds under drought prone area. Fish production in polyculture is largely affected by species combination, stocking density, pond fertilization, supplementary feeds as well as ecological conditions. Stocking of comparatively larger size of carps can solve the problem of fish production for lower water column in polyculture ponds under drought prone area. [2] However all species do not play equal role in terms of water quality and fish production. The knowledge of fish-fish and fish-environment relationships enables choosing adequate combinations of fish species, stocking rates, input types and rates, and other management decisions according to the specific local conditions; climate, quality of water supply and pond fertility, availability of fish fry and fingerlings, availability of feeds and fertilizers, and market requirements.[6] Polyculture is the system in which fast growing compatible species of different feeding habits are stocked in different proportions in the same ponds Chakraborty et al., 2005. The bottom dwelling carps help re-suspension of bottom nutrients to water while stirring the bottom mud in search of food. Such an exercise of bottom dwellers also aerates the bottom sediment. Techniques to mitigate the low alkalinity and high turbidity problems are found to be addressed well but guidelines are not found for selecting appropriate bottom dwelling species for profitable carp polyculture in ponds under drought prone area. This study evaluated the performances of bottom dwelling species in carp polyculture ponds under *Barind* area of northern Bangladesh. The specific objectives of this study were to monitor the water quality and fish growth; to evaluate the yield and economics of carp polyculture; and thereby to recommend best performing species combination for profitable carp polyculture in ponds under drought prone *Barind* area.

Materials and Methods

Study duration and location

The study was conducted in nine ponds (mean water area of 0.025±0.003 ha and depth of 1.66±0.096 m) for a period of six months (July to December) in Rajshahi district, Bangladesh (24.3545^{0}N, 088.3200^{0}E to 24.3553^{0}N, 088.3222^{0}E; elevation: 21 to 23m). All the ponds were rain-fed and well exposed to sunlight of average 8 hours per day.

Experimental design

Randomized Completely Block Design (RCBD) was followed for the present experiment with three treatments of combinations of bottom dwelling species (T_1: polyculture involving *Cyprinuscarpio* as bottom dwelling carp; T_2: polyculture involving *Cirrhinusmrigala* as bottom dwelling carp; and T_3: polyculture involving *Labeocalbasu*as bottom dwelling carp). Each treatment had three replications. Stocking density (*Catla catla*-741/ha, *Hypopthalmichthys molitrix*-1,976/ha, *Aristichthis nobilis*-741/ha, *Labeo rohita*-1,976/ ha and *Cyprinuscarpio*/ *Cirrhinusmrigala*/*Labeocalbasu* -1,976/ha;

all species-7,410/ha) and mean individual stocking weight of fish (100±0.4g) were same for all treatments.

Pond management

Weeding was done manually and predatory fish and other unwanted species were removed through repeated netting. In order to maintain good water quality, liming (CaO @ 750kg/ha as basal dose and 125kg/ha/month as periodic dose) with ash (2500kg/ha/month) treatment was followed after Hossain (2011) for all the ponds. To enhance the natural feed production in the experimental ponds, fertilization was also done by cow dung (Basal dose: 2500kg/ha; periodic dose: 2500kg/ha/month), urea (Basal dose: 50kg/ha; periodic dose: 50kg/ha/month) and TSP, Triple Super Phosphate (Basal dose: 50kg/ha; periodic dose: 25kg/ha/month). Basal fertilization was done after three days of liming. Selected species of carp fingerlings were purchased from a private nursery and stocked in the morning (Table 1) (Table 2). Home-made feed prepared with rice bran (50%) and mustered oil cake (50%) was administered into the ponds at 4% of fish body weight (6% for July-August, 5% for September-October, 3% for November and 2% for December) once a day between 10:00 and 11:00 AM using feeding tray. Quantity of feed was adjusted every month according to total biomass of fish obtained from the sampling.

Monitoring of water quality parameters

Water quality parameters like temperature, transparency, dissolved oxygen (DO), pH, and alkalinity were monitored monthly between 09:00 and 10:00 AM for the present study. Water temperature was recorded with the help of a Celsius thermometer, transparency was measured by a Secchi disk. Dissolved oxygen (DO), pH and alkalinity were determined by the help of a HACH kit (FF-2, USA).

Table 1 Experimental layout for carp polyculture in ponds under different treatments.

Parameters	Treatments and Replications								
	T_1: Ponds Stocked *C. carpio* as bottom feeder)			T_2: Ponds stocked with *C. mrigala* as bottom feeder			T_3: Ponds stocked with *L. calbasu* as bottom feeder		
Replications	T_1R_1	T_1R_2	T_1R_3	T_2R_1	T_2R_2	T_2R_3	T_3R_1	T_3R_2	T_3R_3
Pond area (ha)	0.022	0.025	0.021	0.027	0.025	0.030	0.025	0.023	0.028
Pond depth (m)	1.60	1.55	1.65	1.80	1.73	1.68	1.50	1.65	1.75
Total fish stocked	163	185	156	200	185	222	185	170	207

Table 2 Variations in the mean values of water quality parameters under different treatments during the study period.

Parameters	Treatments			F value	P value
	T_1	T_2	T_3		
Water temperature (°C)	27.60±0.99^a	27.31±1.04^a	27.19±1.00^a	0.042	0.959
Dissolved oxygen (mgL^{-1})	6.76±0.23^a	6.74±0.22^a	6.71±0.24^a	0,011	0.990
Turbidity (cm)	28.81±0.45^a	28.62±0.59^a	28.57±0.55^a	0.056	0.945
pH	7.12±0.08^a	7.10±0.08^a	7.19±0.07^a	0.413	0.664
Alkalinity (mgL^{-1})	61.43±1.76^a	60.24±1.87^a	60.48±1.69^a	0.126	0.882

Figures bearing common letter(s) in a row as superscript do not differ significantly (P <0.05).

Determination of fish growth and yield

Fish growth was monitored by weighing at least 10% of the individual species caught from each pond using a cast net, and sampled fishes were released into the ponds unharmed immediately after sampling. Growth and yield of fishes were calculated after Brett and Groves (1979) as follows:

Initial weight (g)=Weight of fish at stock

Final weight (g)=Weight of fish at harvest

Weight gain (g)=Mean final weight (g) - Mean initial weight (g)

Specific Growth Rate: SGR (%, bwd^{-1})=$[(\ln W_2 - \ln W_1)\times100]/(t_2-t_1)$

Where, W_1 and W_2 are the mean start and end weight (g fish^{-1}) and t_1 and t_2 (days) are the start and end of the period.

Survival rate (%)=(Number of fish harvested/Number of fish stocked)×100

Fish yield (kg ha^{-1})=Fish biomass at harvest – Fish biomass at stock

Economics of Carp Polyculture

Simple cost-benefit analysis was done to explore the economics of carp polyculture in ponds under different treatments. At the end of the study, all the fishes were sold in a local market. The prices of inputs and fish corresponded to the market prices in Rajshahi, Bangladesh in 2012 and were expressed in Bangladesh currency (Taka) as BDT (1 US $=80 BDT). Data on both fixed and variable costs were recorded to determine the total cost (BDT/ha). Total return determined from the market price of fish sale was expressed as BDT/ha. Net benefit and cost benefit ratio (CBR) were calculated as follows:

R=I –(Fc+Vc +Ii)

Where, R refers to net benefit; I, total income from fish sold; Fc for fixed costs, Vc for variable costs and Ii for interests on input costs.

$$Cost - Benefit\ Ratio\ (CBR) = \frac{Net\ benefit}{TotalInvestment}$$

Statistical Analysis

Before analysis, the normality of data were verified and then analyzed by one-way ANOVA using SPSS software version 16). Different treatments were compared. The mean values were also compared by Duncan Multiple Range Test (DMRT) after Gomez and Gomez (1984) at 5% level of significance. All data were expressed as mean±standard error (S.E.).

Results

Water quality

The ANOVA and Duncan's test showed that there was no significant (P <0.05) difference of mean value of water quality parameters among the treatments (Table 3) (Figure 1). Mean value of water temperature (°C), dissolved oxygen (mgL^{-1}), transparency (cm), pH and total alkalinity (mgL^{-1}) varied from 27.19±1.00 (T_3) to 27.60±0.99 (T_1), 6.71±0.24 (T_3) to 6.76±0.23 (T_1), 28.57±0.55 (T_3) to 28.81±0.45 (T_1), 7.10±0.08 (T_2) to 7.19±0.07 (T_3) and 60.24±1.87 (T_2) to 61.43±1.76mgL^{-1} (T_1), respectively.

Table 3 Growth and yield of fishes under different treatments.

Species	Treatments	SGR (%, bwd^{-1})	Weight Gain (g)	Final Weight (g)	Survival Rate (%)
Labeorohita	T_1	0.88±0.01^a	66.67±0.96^a	500.00±5.7^a	85.50±0.87^a
	T_2	0.85±0.02^a	61.67±2.55^a	470.67±15.26^a	86.50±0.29^a
	T_3	0.85±0.02^a	65.00±2.93^a	490.00±17.56^a	85.33±10.44^a
F value		1.271	1.217	1.217	1.162
P value		0.347	0.360	0.360	0.374
Catlacatla	T_1	0.94±0.01^a	75.83±2.21^a	555.00±13.^{a}	86.33±0.44^a
	T_2	0.92±0.02^a	73.33±2.41^a	540.00±14.43^a	87.17±0.44^a
	T_3	0.90±0.02^a	70.00±2.55^a	490.00±17.56^a	86.50±0.29^a
F value		1.527	1.500	1.500	1.235
P value		0.291	0.296	0.296	0.355
Hypopthalmichthysmolitrix	T_1	1.09±0.02^a	105.00±4.19^a	730.00±25.^{a}	85.33±0.60^a
	T_2	1.07±0.02^a	102.50±3.63^a	715.00±21.79^a	86.67±0.93^a
	T_3	1.04±0.03^a	95.83±5.20^a	675.00±31.23^a	86.83±0.67^a
F value		1.164	1.164	1.164	1.217
P value		0.374	0.374	0.374	0.360
Aristichthisnobilis	T_1	1.11±0.02^a	111.67±4.41^a	770.00±26.46^a	85.67±0.44^a
	T_2	1.09±0.02^a	106.67±3.85^a	740.00±23.09^a	87.17±0.73^a
	T_3	1.07±0.01^a	102.50±2.10^a	715.00±12.58^a	85.50±0.29^a
F value		1.644	1.635	1.635	3.138
P value		0.274	0.271	0.271	0.117
Cyprinuscarpio	T_1	1.08±0.03^a	105.00±6.74^a	730.00±40.42^a	87.17±0.88^a
F value		12.437	16.842	16.305	0.530
P value		0.007	0.003	0.001	0.615
Cirrhinusmrigala	T_2	0.94±0.02^b	75.83±3.76^b	555.00±22.55^b	86.83±0.17^a
F value		9.133	11.412	23.698	0.526
P value		0.005	0.003	0.002	0.620

Table Continued

Species	Treatments	SGR (%, bwd^{-1})	Weight Gain (g)	Final Weight (g)	Survival Rate (%)
Labeocalbasu	T_3	0.87±0.02^{b}	65.83±2.21^{b}	495.00±13.23^{b}	87.67±0.44^{a}
F value		22.312	9.842	18.218	0.528
P value		0.003	0.002	0.001	0.610
All species	T_1	1.02±0.02^{a}	92.83±3.70^{a}	657.00±22.21^{a}	86.00±0.65^{c}
	T_2	0.97±0.02^{b}	84.00±3.24^{b}	604.13±19.35^{b}	86.87±0.51^{b}
	T_3	0.95±0.02^{b}	79.83±2.99^{b}	573.00±18.42^{b}	88.37±2.42^{a}
F value		7.069	6.230	9.105	1.188
P value		0.002	0.187	0.186	0.435

Figures bearing common letter(s) in a column as superscript do not differ significantly (P<0.05).

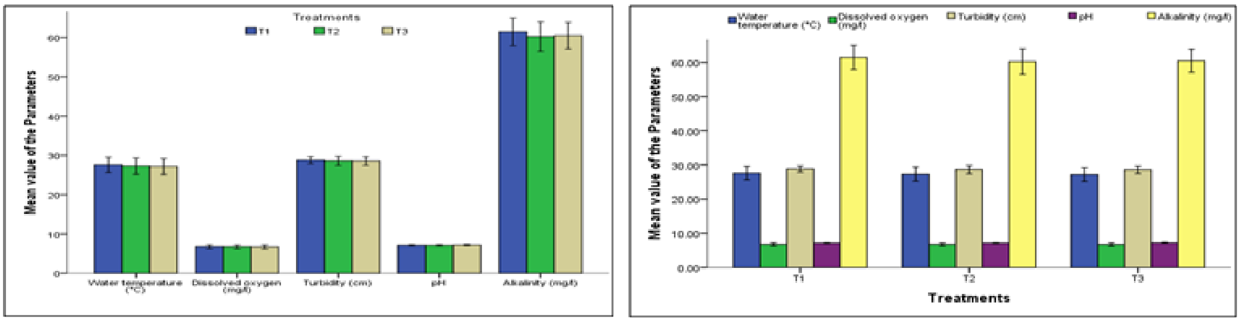


Figure 1 Variation in the mean value of the water quality parameters a_1: treatment-based presentation of water quality parameters, and b_1: treatment-based comparison of water quality parameters.

Fish growth

Results showed no significant (P<0.05) differences in the mean value of SGR, weight gain and final weight for all fish species except *C. carpio* (T_1), *C. mrigala* (T_2), and *L. calbasu* (T_3). Duncan's test revealed that mean value of SGR, final weight and weight gain in treatment T_1 (with *C. carpio* as bottom feeder) was significantly (P<0.05) higher compared to T_2 and T_2, where *C mrigala* and *L calbasu* were stocked as bottom feeder, respectively. The examined treatments were statistically similar in the estimation of survival rates for all fish species under three treatments (Table 4).

Table 4 Fish yield (kg/ha/6 months) under the treatments.

Species	Treatments T_1	T_2	T_3	*F* value	*P* value
L. rohita	675.69 ±8.70^{a}	632.55±27.82^{a}	657.83±32.20^{a}	0.747	0.513
C. catla	291.16±9.87^{a}	284.11±7.92^{a}	269.27±10.66^{a}	1.368	0.324
H. molitrix	1062.40±44.19^{a}	1052.99±35.59^{a}	986.01±48.44^{a}	0.935	0.443
A. nobilis	425.22±15.85^{a}	413.23±13.24^{a}	389.63±7.93^{a}	2.011	0.215
C. carpio	1083.93±61.10^{a}			24.960	0.001
C.mrigala		780.78±39.56^{b}		22.621	0.001
L. calbasu			684.04±19.73^{b}	20.638	0.001
All species	3538.41±64.17^{a}	3163.66±22.12^{b}	2986.77±94.89^{b}	17.484	0.003

Figures bearing common letter(s) in a row as superscript do not differ significantly (P<0.05).

Fish yield

The present study revealed significant (P <0.05) difference in the yield under different treatments with highest in T_1 and lowest in T_3. The study also revealed that the mean value of yield for *C. carpio* (T_1), *C. mrigala* (T_2) and *L. calbasu* (T_3) were significantly different, whereas mean value of yield of other fish species were statistically similar (Table 5 & Figure 2).

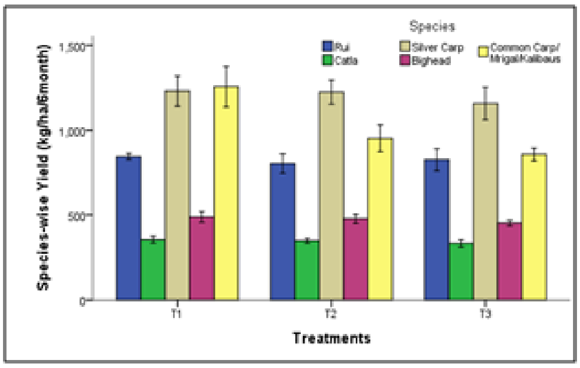
Table 5 Economics of carp polyculture under different treatments.

Treatments	Treatments (mean value in BDT/ha/6 months)			F Value	P value
Parameters	**T_1**	**T_2**	**T_3**		
Variable Costs					
Pond preparation*	9000.00±0.00[a]	9000.00±0.00[a]	9000.00±0.00[a]	-	-
Fertilizer	17500.00±0.00[a]	17500.00±0.00[a]	17500.00±0.00[a]	-	-
Fish seed	90400±11.25[c]	95000.00±8.25[b]	96250±14.23[a]	-	-
Feed	110150.00±563.00[c]	112330.00±0.00[b]	115715±0.00[a]	239.958	0.000
Harvesting cost	2000.00±0.00[a]	2000.00±0.00[a]	2000.00±0.00[a]	-	-
Fixed Costs					
Pond Rental	1500.00±0.00[a]	1500.00±0.00[a]	1500.00±0.00[a]	-	-
Total cost	230550.00±0.00[c]	237330.00±944.39[b]	241965.00±0.00[a]	678.183	0.000
Total return	530252.32±8232.07[a]	478623.01±3274.96[b]	466219.40 ±12414.15[c]	43.874	0,005
Net benefit	299702.32±8232.06[a]	241293.01±3274.96[b]	224254.40±10993.24[c]	23.563	0.001
Cost Benefit Ratio (CBR)	1.30±0.036[a]	1.02±0.114[b]	0.93±0.040[c]	37.234	0.000

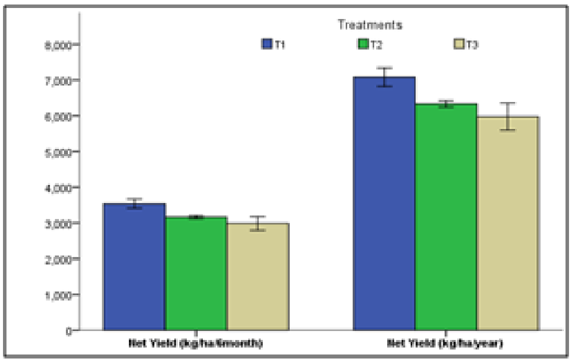
Figures bearing common letter(s) in a row as superscript do not differ significantly (P <0.05)

Note: Currency is given in Bangladeshi Taka (BDT); (80 BDT = 1 USD, 2012)

* includes lime, ash and labor cost



a1



b1

Figure 2 a_1: individual fish yield (kg/ha/6 months) and b_1: treatment based yield for six months and one year under different treatments.

Discussion

Water quality

Lower temperature recorded in the later stage of the study might be gradual approach to the winter that might have impact on the seasonal variation of the water quality.[7] Lower value of water transparency found in all treatments might be due to higher clay turbidity caused by heavy rainfall in monsoon. Periodic application of ash minimized high turbidity during the high rainy season. Hossain[4] reported high turbidity during monsoon and followed ash treatment to maintain suitable water turbidity. Saran & Rathore[8,9] stated lower transparency due to rich phytoplankton density and higher budgets of suspended and particulate matter. Boyd[10] recommended 30 to 40cm transparency appropriate for fish culture. Similar to the current results, Dewan & Swingle[11,12] recorded mean pH value of water from 6.60-8.60 and 6.5 to 9, respectively. Boyd[10] suggested over 20ppm, and Michael & Verma[13,14] suggested over 40ppm total alkalinity for productive pond that aligned with present results. However, Asadujjaman and Hossain[4] recorded relatively higher total alkalinity (113.28 to 114.36 mgL^{-1}) in feed and weed based pond polyculture that might be due to low dissolved oxygen and more production of free CO_2 that enhanced by increasing fish biomass.

However, above findings indicated that the mean value of the water quality parameters in the present study were within the suitable range for aquaculture. The findings from resent studies also supported the above statement. Talukder et al.[2] found water temperature 26.57 to 26.68°C, dissolved oxygen 6.81 to 6.86mgL^{-1}, water transparency 29.90 to 30.17cm, pH 6.88 to 6.96 and alkalinity 51.29 to 52.26 mg L^{-1} in carp polyculture ponds. Asaduzzaman et al.[15] reported water temperature, dissolved oxygen, transparency, pH and total alkalinity as 27.57 to 28.13^{0}C, 6.51 to 6.73mgL^{-1}, 32.83 to 32.28cm, 7.38 to 7.18, 61;51 to 63.17mgL^{-1}. Ahmad et al. reported temperature from 27.08 to28.66°C, DO from 5.15 to 5.91 mgL^{-1}, transparency from 18.17 to 25.50cm and pH from 8.04 to 8.23 in polyculture pond. The mean water temperature, pH, DO, CO_2 and total alkalinity was recorded as 19.6 to 32^{o}C, 6.6 to 8.0, 1.1 to 4.9mgL^{-1}, 3.5 to 4.0mgL^{-1} and 92.0 to 167mgL^{-1}, respectively in polyculture pond.[16] Hossain et al.[17] recorded dissolved oxygen ranging from 5.33 to 5.51mgL^{-1}.

Fish growth

Significant (P <0.05) differences in mean values of fish growth parameters were found among the treatments (Table 4). However, variations in growth might be due to the different combination of fish species under treatments.

Comparatively higher mean value of SGR, final weight, weight gain indicated the positive influence of *C. carpio* as bottom feeder on overall growth parameters compared to *C mrigala* and *L calbasu* in carp polyculture. Rahman et al.[18] recorded mean SGR of rohu, catla and mrigal as 1.12, 1.09 and 1.13 to 1.13, 1.12 and 1.14 respectively in different treatments under pond polyculture system. Majhi et al.[19] recorded SGR value of carp as 1.65% in fish pond. Hossain[4] found weight gain of *L. rohita*, *C. catla*, *C. mrigala*, *H. molitrix*, *A. nobilis*and *C. carpio* as 125.7, 170.2, 120.8, 400.2, 402, 400g, respectively with stocking weight of 7.5 to 10.0g in polyculture under *Barind* area which were lower than the findings from present study. Comparatively higher mean monthly weight gain (g/month) was observed at mid time of the study might be due to influence of air temperature on water temperature resulting fast metabolic activity and thereby higher weight gain of fishes at the mid-stage of the experiment. Boyd[20] expressed similar opinion while working on pond carp polyculture.

No significant (P <0.05) variations in survival rate (%) under different treatments possibly due to similar stocking weight and stocking density of fishes including similar feed and management of all ponds. Talukder et al.[2] reported similar survival rates (83.17±0.58, 84.13±0.58, 85.33±0.58, 84.13±1.00, 85.33±0.58, 84.42±0.66%) for *L. rohita,C. catla*, *C. mrigala, H. molitrix and A. nobilis*, respectively in carp polyculture ponds. Asadujjaman and Hossain [15] recorded similar range of survival rate (%) of *L. rohita, C. catla*, *C. mrigala*, *H. molitrix* and *C. idella.* Kabir & Talukdar et al.[3,21] recorded survival rate of *C. carpio* from 83.2 to 86and 82%, respectively in carp polyculture system. Roy et al.[22] reported survival rate (%) of grass carp, rohu, catla and mrigal 76.6%, 87.8%, 84.0% and 88.6%, respectfully, which are likely findings of present study.

Azad et al.[23] reported weight gain of *H. molitrix* as 72.87g and *C. mrigala* as 70.42g in carp polyculture ponds which were lower than the present findings. Kabir et al.[3] found final weight (g/6 months) of *H. molitrix*, *C. mrigala* and *C. carpio* as 300, 210 and 211.20g, respectively which were lower than the present findings. Higher final weight (g/6 months) achieved in the present study might be due to optimum species composition, larger stocking weight and better management of water quality, proper utilization of both natural and supplementary feed.

Fish yield

Yield significantly (P <0.05) varied among all three treatments. The study revealed that the combined yield of *L. rohita*, *C. catla*, *H. molitrix* and *A. nobilis* under three treatments were not significantly varied; but yield significant (P <0.05) varied in case of three different bottom feeders e.g. *C. Carpio*: 1083.93±61.09kg/ha/6 months (T_1), *C. mrigala*: 780.78±39.562kg/ha/6 months (T_2), and *L. calbasu*: 684.04±19.733kg/ha/6 months (T_3), respectively. That might be due to difference in first growing nature of three bottom feeders as well as effects of combination of other fish species. Yield of *C. carpio* was found significantly high compared to other two bottom feeders which finally contributed to overall variation in net yield.

Siddiquei[24] reported that the gross fish production of 40.4kg/dec/yr from mixed culture which is a bit higher than the present findings. Noman et al.[25] reported that comparatively higher yield and net benefit were observed when *C. carpio* was used in carp polyculture. Net yield of the present study was higher in T_1, compared to T_2 and T_3 might be due to first growing nature of *C. carpio* and larger stocking weight with better pond management and suitable range of water quality parameters. Asadujjaman & Hossain[15] recorded total yield of 4,403.51kg/ha/6 months with conventional feed applied and lower production of 2,541.00 kg/ha/6 months where only banana leaf was supplied. Miajae[26] reported the total production of fish from 2,934 to 3,318 kg/ha/4 months in polyculture of Indian major carps which was similar to the findings from present study. Azim et al.[27] recorded total fish yield of 2,020kg/ha/4 months in pond which was lower than the findings from the present study possibly due to higher stocking weight in present study. Such variations in growth and yield among the treatments were the usual phenomenon of fish growth form which was strongly supported by Grover et al.[28]

Economics

Economic analysis of current study showed significant (P <0.05) variations in total cost, return, net benefit and CBR among treatments (Table 5) (Figure 3). Comparatively higher cost was involved in treatment T_3 might be due to the higher fish seed cost for *L. calbasu* compared to *C. carpio* (T_1) and *C. mrigala* (T_2).

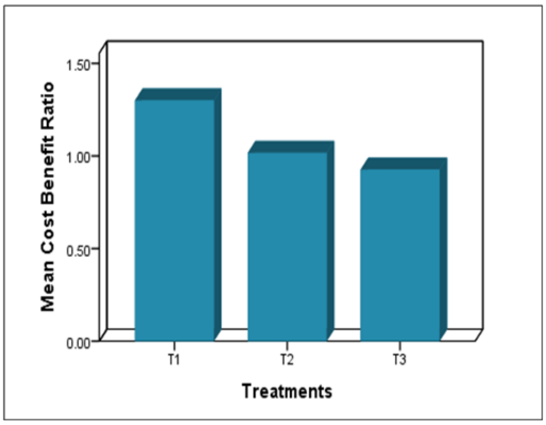


Figure 3 Variation in the mean values of CBR under different treatments.

Talukder et al.[2] recorded total cost and net benefits as 253,768.00±5146.04 and 337,629.45±7295.36 BDT/ha/6 months, respectively and cost benefit ratio as 1.33. Asadujjaman & Hossain[15] recorded 123,430.50±0.00 to 235,930.50±0.00 BDT/ha/6 months; net benefit as 111,639.90±2056.87 to 206,744.85±3221.73 BDT/ha/6 months; and cost benefit ratio as 0.77±0.02 to 1.67±0.18, respectively in carp polyculture system. Khan et al.[29] reported CBR value of 1.22 in pond polyculture system; and Abou et al.[30] found CBR as 1.3 in carp polyculture system which was similar to the present findings.

Overall findings from the current study revealed that treatment T_1 with *C. carpio* as bottom feeder performed better in terms of total cost, net benefit and CBR compared to treatment T_2 and T_3 stocked with *C. mrigala* and *L. calbasu,* respectively. Milstein et. al.[6] certify *C. carpio* as a first growing and high tolerant to environmental hazards.

According to Jain *C. carpio* has the ability to survive under various climatic conditions and found to be the most suitable for many fish farming systems. Da Silva et al. concluded that *C. carpio* has the potential to improve conditions in pond bottom soil, as a result soil perturbation increases the oxygen transfer to the soil, decreases the concentration of toxic compounds and enables more efficient food web recycling and nutrient release.[31–38]

Conclusion and Recommendation

Considering the water quality, growth and yield of fish and economic viability of carp polyculture in pond under three treatments, treatment it can be concluded that stocking of *C. carpio* as bottom dwelling species can be a suitable option for carp polyculture in ponds under drought prone *Barind* area. One of the major limitations of this study was to use equal stocking density of all three bottom dwelling species. Therefore, it is necessary to see the effect of different stocking density of *C. carpio* as bottom dwelling species in carp polyculture as further step.

Acknowledgment

None.

Conflict of Interest

None.

References

1. DoF (Department of Fisheries). *National Fish Week 2017 Compendium (in Bengali)*. Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. 2017; 160 p.
2. Talukder MGS, Mohsin ABM, Hossain MA, et al. Optimization of stocking weight in carp polyculture ponds under drought prone Barind area of Bangladesh. *Journal of Fisheries*. 2017;5:3.
3. Kabir ANMA, Hossain MA, Rahman MS. Use of duckweed as feed for fishes in polyculture. *Journal of Agriculture and Rural Development*. 2009;**7**(1–2):157–160.
4. Hossain MA. Effect of fertilization techniques on fish growth in ponds under red soil zone of northern Bangladesh. *Journal of Progressive Science and Tech*. 2011;9(2):192–196.
5. Mishra AK Singh VP. A review of drought concepts. *Journal of Hydrology*. 2010;391(1–2):202–216.
6. Milstein A, Wahab MA, Rahman MM. Environmental effects of common carp *Cyprinus carpio* (L.) and mrigal *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polycultures. *Aquaculture Research*. 2002;33(14):1103–1117.
7. Halwart M Gupta MV. *Culture of fish in rice fields*. FAO and the World Fish Center. 2004; 83 p.
8. Saran WM, Adoni AD. Studies on seasonal variation on pH and dissolved oxygen contents in Sagarlake. *Acta Botanica India.* 1982;10:324–326.
9. Rai JPN, Rathore VS. Pollution of Nainital Lake water and its management. In: *Ecology and pollution of Indian Lakes and reservoirs*, Ash. Pub House, India. 1993. p. 1–247.
10. Boyd CE . *Water quality management of pond fish culture*. Elsevier Science Publications Company, Amsterdam–Oxford, USA. 1982. 318 p.
11. Dewan SM, Wahab MA, Beveridge MCM, et al. Food selection, electivity and dietary overlap among planktivorous Chinese and Indian major carp fry and fingerlings grown in extensively managed, rain–fed ponds in Bangladesh. *Aquaculture and Fisheries Management*. 1991;12 (3):227–294.
12. Swingle HS. *Standardization of chemical analysis from water and pond muds*. FAO, Fish Rep. 1967; 494, p. 397–421.
13. Michael R. Seasonal trends in physico–chemical factors and plankton in a fresh water fish pond and their role in fish culture. *Hydrobiol*. 1968;33:144–158.
14. Verma NM. Hydro–biological study of a tropical impoundment, Gualior, India, with special reference to the breeding of Indian carps. *Hydrobiology*. 1969;34(3–4):358–368.
15. Asadijjaman M, Hossain MA. Fish growth, yield and economics of conventional feed and weed based polyculture in ponds. *Journal of Fisheries.* 2016;4(1):353–360.
16. Mamun AA, Mahmud AI. Study on growth perfomence and production of juvenile Indian major carp (*Catla catla, Labeo rohita and Cirrhinus cirrhosus*) and their hybrids. *Journal of Fisheries and Aquatic Science*. 2014;9(3):92–108.
17. Asadujjaman M, Azad MAK, Ali MR, et al. Optimization of stocking density for Azolla based carp polyculture pond. *International Journal of Fisheries and Aquaculture Studies*. 2016;4(4):273–279.
18. Rahman MA, Hossain MK, Azad MAK. Culture potential of Thai Sharpunti, *Barbodesgonionotus* (Bleeker) with major carps in seasonal ponds. *Pakistan Journal of Biological Science*. 2006;9(10):1891–1897.
19. Majhi SK, Das A, Mandal BK. Growth Performance and Production of Organically Cultured Grass Carp Ctenopharyngodonidella (Val.) Under Mid–Hill Conditions of Meghalaya; North Eastern India. *Turkish Journal of Fisheries and Aquatic Sciences*. 2006;6:105–108.
20. Boyd CE. *Water quality for fish pond*. Aquaculture Research and Development Series No. 43.Aburn University, Alabama, USA. 1998; p. 37.
21. Talukdar MZH, Shahjahan, Rahman MS. Suitability of duckweed (*Lemna minor)* as feed for fish in polyculture system. *International Journal of Agricultural Innovation & Technology*. 2012;2(1):42–46.
22. Roy NC, Kohinoor AHM, Wahab MA, et al. Evaluation of performance of carp–SIS polyculture technology in the rural farmers' pond.*Asian Fisheries Science*. 2002;15(2002):43–52.
23. Azad MAK, Rahman MR, Rahman Z, et al. Polyculture of carp, tilapia and pangas using low cost inputs. *Pakistan Journal of Biological Science*. 2004;7(11):1918–1926.
24. Siddiquei IR. Notun Niyame Maccherchas O UtpadonPadhoti. Salahuddin Bai Ghar, Dhaka. 2001; p. 80.
25. Noman M, Ashraf M, Abbas S, et al. Growth performance of common carp (*Cyprinus carpio*) in response to organic fertilizers and supplementary feed. *Greener Journal of Agricultural Sciences*. 2011;1(2):032–040.
26. Miajae MAH. Effect of supplementary feed on the growth of Indian major carps with Thai sarputi in polyculture. *Bangladesh Journal of Training and Development*. 1999;13:117–124.
27. Azim ME, Wahab MA. Development of a duckweed–fed carp polyculture system in Bangladesh. *Aquaculture*. 2003;18(1–4): 425–438.
28. Grover JH, Islam MA, Shah WA, et al. *Training manual for extension personnel on low cost environment friendly sustainable aquaculture practices*. ICLARM, India. 2000; p. 101.

29. Khan S, Hossain MS, Haque MM. Effects of feeding schedule on growth, production and economics of pangasiid catfish (*Pangasiushypophthalmus*) and silver carp (*Hypophthalmichthysmolitrix*) polyculture. *Journal of Bangladesh Agricultural University*. 2009;**7**(1): 175–181.

30. Abou Y, Fiogbe ED, Micha J. Effects of stocking density on growth, profitability of farming Nile tilapia, *Orechromisniloticus* L., fed *Azolla* diet, in earthen ponds. *Aquaculture Research*. 2007;38:595–604.

31. Alam MJ, Kohinoor AHM, Islam MS, et al. Polyculture of carps using over–wintered fingerlings under different stocking densities. *Bangladesh Journal of Fisheries Research* .2002;6(2):117–124.

32. Azim ME, Wahab, MA, Kamal AHM, et al. Feeding relations of silver barb, *Barbodesgonionotus* (Bleeker) with major Indian and common carp and its effect on fish production in a polyculture system. *Journal of the World Aquaculture Society.* 2004;35(1):100–108.

33. Boyd CE, Zimmermann S. Grow–out systems–water quality and soil management. Blackwell Science. Oxford, UK.2000; p. 221–238.

34. Brett JR, Groves TDD. Physiological energetics. In: *Fish Physiology.* vol. VIII, Bioenergetics and Growth, WS Hoar, DJ Randall, JR Brett, editors, Academic Press, USA.1979; p. 280–352.

35. DoF (Department of Fisheries) Fish Fortnight Compendium. Department of Fisheries, Ministry of Fisheries & Livestock, Government of the People's Republic of Bangladesh, India. 2016;148 p.

36. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research. 2nd ed, John Wiley & Sons, USA. 1984. 697 p.

37. Hossain MY. Effects of iso–phosphorus organic and inorganic fertilizer on water quality parameters and biological production. M.S. Thesis, Department of Fisheries Management, BAU, Mymensingh, Bangladesh. 2000. 74 p.

38. Wahab MA, Ahmed ZF, Islam A, et al. Effects of introduction of common carp, *Cyprinus carpio* on the pond ecology and growth of fish in polyculture. *Aquaculture Research*. 1995;26(9):619–628.

Citation: Talukder MGS, Hossain A, Mohsin ABM, et al. Performances of bottom dwelling carpsin polyculture ponds under drought prone Barind area of Bangladesh. *J Aquac Mar Biol.* 2018;7(1):13–20. DOI: 10.15406/jamb.2018.07.00178