Research article

GROWTH PERFORMANCE OF DIFFERENT FISH SPECIES DURING DRY PERIOD IN CHITWAN, NEPAL

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ABSTRACT

In order to assess the growth and yield of different fish species during dry period, an experiment was conducted in the Aquaculture Farm of Agriculture and Forestry University, Rampur, Chitwan from 1 April to 10 July, 2021. The experiment included three treatments: T1 (Carp polyculture), T2 (Common carp *Cyprinus carpio* monoculture) and T3 (Nile tilapia *Oreochromis niloticus* monoculture), each with three replications. Silver carp (*Hypophthalmichthys molitrix* 7%), Bighead carp (*Aristichthys nobilis* 20%), Grass carp (*Ctenopharyngodon idella* 13%), Rohu (*Labeo rohita* 30%), Mrigal (*Cirrhinus mrigala* 10%) and Common carp (20%) were stocked at densities of 1,400, 4,000, 2,600, 4,000, 6,000 and 2,000 fish/ha, respectively. Stocking density of Common carp and Nile tilapia was 20,000 fish/ha. Fish were fed with sinking pellet (28% crude protein) at the rate of 3% of body weight. Gross and net fish yield was significantly higher in T3 (89.89±0.67 t/ha/yr,16±0.25 t/ha/yr) than in T2 (4.88±0.38 t/ha/yr, 4.05±0.35 t/ha/yr) due to higher ($p<0.05$) survival in T3 (72.5±11.3 %) than in T2 (40.6±4.5 %). Gross margin was significantly higher in T3 (1,257,482±186,600 NRs./ha/yr) than in T2 (434,250±124,753 NRs./ha/yr). Based on higher survival, yield and gross margin, Nile tilapia monoculture is suitable for dry season.

Keywords: Carp, common carp, Nile tilapia, drought, yield

INTRODUCTION

Globally, Nepal ranks second in the water resources. Approximately 5 % of the total area of the country is occupied by different freshwater habitats (Bhandari, 1992). In Nepal, 252 fish species are reported to thrive in different aquatic habitats (Shrestha, 2019). Aquaculture is one of the fastest growing sector of food production in Nepal since last ten years. Fish production increased from 28,000 mt to 76,271 mt in one decade whereas capture fisheries production is almost constant at around 21,000 mt (MoALD, 2021). Agriculture Perspective Plan has categorized fisheries and aquaculture in Nepal as a small but important and promising sub-sector of agriculture contributing about 4.18 % of agricultural gross domestic product and 1.13 % of gross domestic product (CFPCC, 2019). Carp polyculture is the established culture system accounting 90 % of the total pond fish production. While Rainbow trout culture, African catfish monoculture, Pangas monoculture, and Nile tilapia culture are emerging aquaculture in the country.

Droughts are caused by a variety of hydrometeorological phenomena that reduce precipitation and limit surface or groundwater availability, resulting in markedly drier conditions than normal. Precipitation is the primary factor controlling the persistence of drought conditions. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate its severity (Kundzewicz, 1997). South Asian regions, including Nepal, have been often affected by severe drought since the beginning of the twenty-first century (Miyan, 2015). Drought is a common occurrence in the Terai region of Nepal and the month from October to May is considered as dry months, while June to September is considered as monsoon months (Sharma et al., 2021). Between 1971 and 2007, out of 8,50,000 ha of agricultural crops lost, droughts accounted for 38.9% (UNDP, 2009). During drought the temperature of the surrounding water varies and affects the body temperature, growth rate, food consumption, feed conversion ratio, and other physiological processes of fish (Kausar & Salim, 2006) while low water depth affects growth and survival of fish. Freshwater fish have an ideal temperature of 25-30°C for growth, at which they grow swiftly (El-Shebly & Hossain, 2007). Temperature changes caused by climate change also affects the spatial distribution of fish species and aquaculture activities. In Terai, Nepal farmers either make early harvest or do not stock the ponds in such dry period (Adhikari et al., 2018) to avoid this situation. Suitable species for culture in a given location should be chosen so that their temperature and water level tolerance ranges are compatible with the local climate. Understanding the effects of drought on fish growth, production and water quality is essential so that farmers will be able to select suitable fish species for dry period in Terai, Nepal.

MATERIALS AND METHODS

The experiment was conducted at the Aquaculture Farm, Fisheries Program, Faculty of Animal Science, Veterinary Science and Fisheries (FAVF), Agriculture and Forestry University (AFU), Rampur for 100 days from 1 April to 10 July, 2021. The ponds with average size of 145±5 m^2 ranging from 114 to 169 m^2 were used. The experiment was conducted in Completely Randomized Design. There were three treatments each with three replications: T1 - Carp polyculture, T2 - Common carp monoculture and T3 - Nile tilapia monoculture.

Prior to stocking, predatory fish were eradicated by applying bleaching powder to ponds at the rate of 300 kg/ha. After 15 days of bleaching powder application, ponds were fertilized with Urea and DAP at the rate of 47 and 35 kg/ha, respectively. Fingerlings were stocked after 7 days of fertilization and the stocking density was 20,000 fish/ha for all treatments. Fingerlings of Silver carp (7.43 ± 0.45 g), Bighead carp (8.68 ± 0.31 g), Grass carp (7.25 ± 0.54 g), Common carp (9.34 ± 0.47 g), Rohu (6.88 ± 0.33 g) and Mrigal (5.81 ± 0.35 g) were stocked at ratios of 7:20:13: 20:30:10 (DoFD, 2074), respectively in T1 and Common carp (8.17 ± 0.45 g) in T2 and Nile tilapia (6.23 ± 0.37 g) in T3. Fish were fed with commercially produced sinking pellet containing 28 % CP twice daily at 10 a.m. and 4 p.m. The feeding rate was 3 % of body weight (Laudari et al., 2015). Feeding tray was used for feeding the fish. Feed rations were adjusted monthly based on sampled weight of fish.

Water temperature, dissolved oxygen (DO) and pH were recorded in situ twice a day at 6 to 7 a.m. and 3 to 4 p.m. at surface (5-10 cm) and bottom (25-35 cm) layers of each pond using DO meter and pH meter, respectively. Similarly, water depth and transparency were recorded weekly using wooden staff and Secchi disk, respectively. Water samples were collected by using column sampler biweekly to analyze total alkalinity, ammonia, nitrite, soluble reactive phosphorus and chlorophyll-a. These water quality paremeters were analyzed at laboratory of Fisheries Program using standard methods (APHA, 2012).

At least 20 % of each fish species were sampled monthly for growth check and the ration was adjusted accordingly. Fish were harvested after 100 days of stocking by partially draining the pond and netting fish. Since the ponds were not drained completely due to seepage and rain, bleaching powder was applied at the rate of 300 kg/ha to recover all fish from each pond. The fresh and live fish collected from netting were sold while the remaining fish collected after applying bleaching powder were used for fish meal. Extra fish such as Small indigenous Fish Species (SIS) and tilapia recruits were collected by net and hand picking, weighed in bulk to calculate yield from extra fish. During stocking and harvesting, fish were counted and weighed individually. Daily weight gains (DWG), total weight gain (TWG), gross fish yield (GFY), net fish yield (NFY) and survival were calculated using following formulae.

DWG (g/fish/day) = (Mean final wt. – Mean initial wt.) × 100/ Experimental period
TWG (kg/ha) = Final total wt. – Initial total wt.
Survival (%) = Number of fish harvested x 100/Number of fish stocked
GFY (t/ha/yr) = Total harvest weight (kg) x 10 x 365/Culture area x Culture days
NFY (t/ha/yr) = Total harvest weight (kg) – Total stocked weight (kg) x 10 x 365/Culture area x Culture period
Apparent food conversion ratio (AFCR) = Quantity of feed supplied (kg)/Total weight gain (kg)

Gross margin analysis was performed to determine the economic returns from each treatment. Variable costs and income was based on current local market prices and farm gate price for the stocked and harvested fish in Chitwan, Nepal.

Gross Margin = Total income - Total variable costs

Water budget was calculated using following formula.
Overall water loss = Precipitation - (Evaporation loss + Seepage loss)

Data of rainfall was obtained from National Maize Research Program, Rampur, Chitwan.
Evaporation loss from pond = Pan evaporation (Ep) × Pan coefficient (Cp)
Evaporation loss from the pond was calculated by measuring pan evaporation by Class A Pan evaporation method.
Pond seepage when there is no rainfall = (Water depth at stage 1 - Water depth at stage 2) – Evaporation
Pond seepage when there is rainfall = [{(Stage at time 1 + Rainfall) - Stage at time 2}- Pond evaporation }]

Water quality parameters, fish growth, yield and economic parameters among treatments were compared by using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test. All statistical analyses were performed using SPSS-v 25.0. Alpha level was set at 0.05 ($p<0.05$) for all comparisons and means were given with ± S.E.

RESULTS

Water quality parameters measured in situ

Water quality parameters such as temperature, DO, pH, water depth and Secchi disk visibility were recorded in situ and results are given in the Table 1. Temperature, DO and pH were recorded in the morning and afternoon from the pond surface and bottom. There was no significant difference ($p>0.05$) in average temperature, DO and pH among the treatments at both water depths and times, except for the DO at the bottom layer in the afternoon. Dissolved oxygen in the afternoon at bottom was significantly higher ($p<0.05$) in T2 than T3. Dissolved oxygen was 4.2±0.8 mg/L in T2, 4.1±0.9 mg/L, in T1 and 3.7±0.8 mg/L in T3, respectively.

Table 1. Water quality parameters (mean±SE, range in parenthesis) recorded in situ in different treatments during the experimental period

Time	Depth	Treatments		
		T1	T2	T3
Temperature (ºC)				
Morning (6:00 to 7:00 a.m.)	Surface	25.3±1.8[a] (18.7‒30.4)	25.3±1.9[a] (19.1‒30.8)	25.3±1.8[a] (18.9‒30.5)
	Bottom	25.1±1.8[a] (18.6‒30.3)	25.2±1.9[a] (18.8‒30.7)	25.2±1.8[a] (18.8‒30.5)
Afternoon (3:00 to 4:00 p.m.)	Surface	31.5±1.7[a] (24.7‒38.8)	31.6±1.6[a] (25.1‒39.0)	31.5±1.7[a] (24.9‒38.7)
	Bottom	30.9±1.6[a] (24.5‒38.3)	31.0±1.6[a] (24.8‒38.5)	30.9±1.6[a] (24.5‒38.3)
Dissolved oxygen (mg/L)				
Morning (6:00 to 7:00 a.m.)	Surface	2.3±0.5[a] (1.1‒4.9)	2.4±0.6[a] (1.2‒5.3)	2.4±0.6[a] (1.2‒5.0)
	Bottom	2.1±0.6[a] (0.9‒4.8)	2.1±0.5[a] (0.9‒5.2)	2.1±0.5[a] (0.9‒4.9)
Afternoon (3:00 to 4:00 p.m.)	Surface	5.8±0.8[a] (2.3‒9.2)	5.7±0.7[a] (2.3‒9.8)	5.6±0.8[a] (2.3‒9.6)
	Bottom	4.1±0.9[ab] (1.4‒7.1)	4.2±0.8[a] (1.4‒7.5)	3.7±0.8[b] (1.2‒6.9)
pH				
Morning (6:00 to 7:00 a.m.)		7.4 (7.2‒7.9)	7.4 (7.2‒8.0)	7.4 (7.1‒7.6)
Afternoon (3:00 to 4:00 p.m.)		8.2 (7.5‒8.9)	8.2 (7.4‒8.9)	8.1 (7.4‒8.8)
Water depth (cm)		47.7±9.4[a] (29‒95)	52.25±9.1[a] (29‒95)	48.0±10.0[a] (30‒90)
Secchi disk visibility (cm)		27.0±4.3[a] (19‒43.8)	29.1±3.6[a] (20.3‒41.8)	28.7±4[a] (18.8‒41.8)

Mean values with different superscript letters in the same row are significantly different ($p<0.05$).

Water quality parameters analyzed in the lab

Water quality parameters such as total alkalinity, SRP, TAN, nitrite and chlorophyll-a were analyzed in the lab and results are given in Table 2. Those water quality parameters were not critical and did not differ ($p>0.05$) among the treatments.

Table 2. Water quality parameters (mean±SE, range in parenthesis) analyzed in the lab in different treatments during the experimental period.

Parameters	Unit	Treatments		
		T1	T2	T3
Total alkalinity	mg/L as $CaCO_3$	85.7±5.5[a] (70.3–99.3)	76.4±10.0[a] (48.6–95.2)	90.0±6.4[a] (67.9–101.2)
SRP	mg/L	0.042±0.011[a] (0.013–0.067)	0.041±0.015[a] (0.000–0.074)	0.034±0.006[a] (0.027–0.054)
TAN	mg/L	0.042±0.013[a] (0.069–0.070)	0.050±0.013[a] (0.006–0.078)	0.048±0.015[a] (0.006–0.090)
Nitrite	mg/L	0.007±0.004[a] (0.001–0.021)	0.007±0.004[a] (0.000–0.020)	0.008±0.004[a] (0.000–0.022)
Chlorophyll- a	mg/m^3	34.7±5.2[a] (24.9–50.7)	20.9±7.3[a] (9.8–47.2)	28±4.9[a] (17.8–41.8)

Mean values with different superscript letters in the same row are significantly different ($p<0.05$).

Growth and yield of fish species in different treatments

Growth and yield of different fish in different treatments are given in Table 3. Average individual and total stocking weight of carp, Common carp and Nile tilapia differed significantly ($p<0.05$) between treatments. Average stocking weight and total stocking weight were higher ($p<0.05$) in T1 and T2 than in T3. Total harvest weight was significantly ($p<0.05$) higher in T3 than T2 but it was statistically similar with T1. Total weight gain was also significantly ($p<0.05$) higher in T3 than in T1 and T2. Survival was significantly higher in T3 (72.5±11.3 %) and lower in T2 (40.7±4.5 %) but was statistically similar with T1 (59.0±6.2 %). GFY was significantly ($p<0.05$) higher in T3 than T2 but there was no significant difference between T1 and T3. NFY was also significantly ($p<0.05$) higher in T3 than in T1 and T2, respectively.

Table 3. Growth and yield (mean ± SE) of fish species in different treatments during the experimental period

Species	T1						T1	T2	T3
	Silver carp	Bighead carp	Grass carp	Rohu	Mrigal	Common carp	Carp polyculture (Average/Total)	Common carp monoculture	Tilapia monoculture
Initial mean wt. (g/fish)	7.4±0	8.6±0	7.2±0	6.8±0	5.81±0	9.34±0	7.5±052^{a}	8.17±0.41^{a}	6.19±0.43^{b}
Initial total wt. (kg/100 m^2)	0.11±0.0	0.38±0.0	0.21±0.0	0.45±0.0	0.13±0.0	0.41±0.0	1.71±0.0^{a}	1.8±0.09^{a}	1.30±0.15^{b}
Final mean wt. (g/fish)	204.9±28.9	83.4±26.37	179.78±26.6	84.8±11.91	165.6±48.73	220.3±44.79	156.4±24.17^{a}	145.33±7.94^{a}	157.79±13.45^{a}
Final total weight (kg/100m^2)	2.01±0.22	1.26±0.35	2.47±0.75	3.03±0.55	2.94±0.68	6.41±1.39	18.45±2.02^{ab}	12.89±0.97^{b}	23.7±0.52^{a}
Weight gain (g/fish)	197.5±28.9	74.7±26.3	172.5±26.6	77.9±11.9	159.8±48.7	210.9±44.7	148.9±24.1^{a}	137.1±8.31^{a}	151.6±13.0a
TWG (kg/100m^2)	1.90±0.22	0.88±0.35	2.26±0.75	2.57±0.55	2.81±0.68	6.0±1.3	16.4±2.0^{b}	11.09±0.9^{b}	22.3±0.6^{a}
DWG (g/fish/day)	1.9±0.29	0.7±0.26	1.7±0.27	0.7±0.12	1.6±0.49	2.1±0.45	1.4±0.24^{a}	1.3±0.08^{a}	1.5±0.1a
Survival rate (%)	67.1±15.08	41.1±13.01	45.3±6.91	53.3±4.19	81.7±5.29	65.4±2.21	59.0±6.22^{ab}	40.6±4.49^{b}	72.5±11.26^{a}
GFY (t/ha/yr)	0.74±0.08	0.46±0.13	0.90±0.27	1.11±0.20	1.07±0.25	2.34±0.51	6.62±0.7^{ab}	4.71±0.36^{b}	8.63±0.19^{a}
NFY (t/ha/yr)	0.69±0.08	0.32±0.13	0.83±0.27	0.94±0.20	1.03±0.25	2.19±0.51	6.0±0.7^{b}	4.05±0.35^{b}	8.16±0.25^{a}
AFCR							1.16±0.02^{a}	1.46±0.24^{a}	1.18±0.03^{a}

TWG = Total Weight Gain, DWG = Daily Weight Gain, GFY= Gross Fish Yield, NFY= Net Fish Yield.

Mean values with different superscript letters in the same row are significantly different ($p<0.05$).

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Contribution of extra fish to total fish yield in different treatments

Controbution of self recruited extra fish such as SIS (Dedhuwa and Pothi) and tilapia recruits to gross and net fish yield in different treatments are presented in Table 4. SIS contributed 0.27±0.04 t/ha/yr and 0.31±0.0 t/ha/yr to T1 and T3 whereas tilapia recruits contributed 1.10±0.63 t/ha/yr in T3. The combined GFY was significantly higher in T3 than T2 and T1 ($p<0.05$) but it was statistically similar between treatments T1 and T2.

Table 4. Combined yield of fish (mean ± SE) in different treatments

Parameter	Treatments		
	T1	T2	T3
GFY excluding extra fish (t/ha/yr)	6.62±0.7^{ab}	4.71±0.36^{b}	8.63±0.19^{a}
GFY of SIS (t/ha/yr)		0.27±0.04^{a}	0.31±0.0^{a}
GFY of tilapia recruits (t/ha/yr)			1.10±0.63
Combined GFY (t/ha/yr)	6.62±0.7^{b}	4.88±0.38^{b}	9.89±0.67^{a}
AFCR	1.16±0.02^{a}	1.39±0.22^{a}	1.03±0.01^{a}

SIS= Small Indigenous fish Species

Mean values with different superscript letters in the same row are significantly different ($p<0.05$).

Gross margin analysis

Gross margin analysis of different treatments in 100 days of culture period is given in Table 5. Fingerling cost and total variable costs were significantly ($p<0.05$) higher in T3 than in T1 and T2 whereas feed cost was higher ($p<0.05$) in T3 than T1. Total income was significantly ($p<0.05$) higher in T3 than in T1 and T2. Gross margin was significantly ($p<0.05$) higher in T3 than in T2 but it was statistically similar with T1. Although feed cost, total variable cost was significantly ($p<0.05$) higher in T3 than rest treatments, all the treatments were found profitable.

Table 5. Gross margin analysis of different treatments in NRs./100 m^2 pond (mean±SE)

Variables	Treatments		
	T1	T2	T3
Bleaching Powder	616	616	616
Urea	17.5	17.5	17.5
DAP	22	22	22
Seed	775.7±0.9^{b}	771.2±1.2^{b}	1102.8±1.0^{a}
Feed	1138.6±126.7^{ab}	900.1±50.5^{b}	1382.1±46.5^{a}
Feeding tray	200	200	200
Total variable cost	2769.8±127.4^{b}	2526.8±62.6^{b}	3340.4±45.6^{a}
Total income	4974.1±564.9^{b}	3609.7±270.2^{b}	5920.2±130.9^{a}
Gross margin (NRs./100 m^2)	2204.4±439.2^{ab}	1082.8±332.6^{b}	2579.8±85.4^{a}
Gross margin (NRs./ ha/yr)	804588.9±160291.1^{ab}	395252.2±121407.5^{b}	941634.2±31155.0^{a}

Mean values with different superscript letters in the same row are significantly different ($p<0.05$).

Water budgets of experimental pond

Water budget was calculated weekly to assess the drought and results are summarized in Table 6. There was both loss and gain of water from fish pond. Overall water loss was high in April whereas water gain was high in June. Water loss was highest (54.4 mm) at the 2nd week of April and gain was highest (191.1 mm) at the 3rd week of June. Pond seepage was both positive and negative due to ground water seepage. High pond seepage was found from the 2nd week of June after precipitation. Total pond evaporation and precipitation was 651.2 mm and 999.8 mm, respectively.

Table 6. Water budgets of fish ponds at Aquaculture Farm

Week	Evaporation (mm)	Precipitation (mm)	Pond seepage (mm)	Overall loss/gain (mm)
5-13 April	20.2±0.3	-	- 74.6	-54.4
13-21 April	30.8±0.3	-	- 72.9	-42.1
21-29 April	52.6±0.9)	31.4±0	9.8	31.0
29 Apr-7 May	43.7±1.7	59.1±2.0	63.2	47.8
7-15 May	42.9±0.8	21.7±1.4	26.5	47.8
15-22 May	73.7±4.6	24.7±2.5	56.6	105.6
22-28 May	25.1±0.4	73.2±5.8	85.8	37.8
28-5 June	166.8±16.2	156.5±37.4	- 49.2	-38.9
5-12 June	32.4±1.2	4.6±0	- 68.9	-41.1
12-19 June	12.9±1.6	288.6±24.1	460.0	184.4
19-26 June	142.5±16.5	144.2±12.9	192.7	191.1
26-3 July	7.3±0.7	195.8±7.9	137.41	-51.1
Total	**651.2 ±14.6**	**999.8±26.8**	**766.4**	**417.8**

Negative sign in the table indicates the water loss and positive sign indicates water gain.

DISCUSSION

Water quality parameters were within the normal range except water depth. Water depth was less than 52 cm which was not appropriate for carp growth. Carp grows well in deeper water. Hosen et al. (2019) found higher survival and growth of carp (Rohu, Catla and Mrigal) at 2.8 m water depth than 1.2 m. Water quality parameters did not differ significantly among the treatments except DO at bottom in the afternoon. Lower DO in tilapia pond might be due to increased oxygen consumption by recruits.

In this study, widely adopted Carp polyculture system recommended by government of Nepal was used as a control to compare it with two monoculture systems of Common carp and Nile tilapia (mixed sex). Gross fish yield of Nile tilapia was higher than that of Common carp which was probably due to higher total weight gain resulted by higher survival. Lower total weight gain of Common carp in T2 was due to higher mortality caused by predation from birds. Since Common carp stocked ponds were relatively shallower than rest ponds, birds easily spotted fish and preyed on them. Higher survival of Nile tilapia could be due to their adaptability in abnormal environmental condition and stocking of old fingerlings (Das et al., 2017; Hossain et al., 2010). Stocking old fingerlings results in faster growth and higher yield (Al-Humairi et al., 2020). Das et al. (2017) found that Nile tilapia monoculture to be an appropriate fish farming in drought-prone areas compared to Bighead carp and Puntius. Gross fish yields of tilapia and carp was statistically similar. The gross fish yield of carp was higher than the national average fish production (4.96 t/ha/yr) which was probably fish ate pellet containing 28% CP. Generally semi-intensive fish farmers feed carp with farm made low protein suplementary feed made from rice bran and mustard oil cake. Commercial pellet feed contains concentrated nutrients and nutrients waste is minimum which increases feed efficiency. Net fish yield of tilapia was higher than that of carp and Common carp. The reason could be large sized fingerlings were stocked in T1 and T2 so that total stocking weight of carp and Common carp was higher. Since the NFY is derived by deducting total stocking weight from total harvesting weight, higher total stocking weight decreased NFY in T1 and T2. When NFY of carp in T1 in the present study was compared with carp polyculture research conducted during wet period in the Aquaculture Farm at AFU, it was found that NFY of carp was similar to that reported by Mandal et al. (2018) fed with pellet (24% CP) and higher than Jha et al. (2018) fed with farm made supplementary feed. This indicated that pellet is appropriate for dry period over supplementary feed. Apparent feed conversion ratio was better as it was less than 1.5 in all treatments which indicated that pellet with 28% CP is appropriate for both carp and tilapia. AFCR was 1.1±0.0 in carp polyculture, which was similar to the finding of Laudari et al. (2015). Jhingran (1991 stated that food conversion rate besides depending upon the nutrient contents of feed, also varies with the method of feeding, environmental factors such as temperature, dissolved oxygen, and size of fish. Probable explanation of improved feed efficiency of fish maintained at higher temperature might be the increased feed intake of the fish which increases with increase in water temperature, which resulted in better growth of the fish, leading to better feed conversion ratio. Goolish and Adelman (1984) stated that an increase in temperature resulted in better utilization of feed in fish than those kept under lower temperature (20.9-24.3 °C).

Gross margin analysis showed that all treatments were profitable and economically viable. Feed cost constituted the highest in total variable cost followed by seed cost. Although total variable cost was higher in tilapia monoculture (3340.4±45.6 NRs/100 m^2) than in rest treatments, it had a good gross margin. Despite lower gross return, T1 and T3 had similar gross margin which might be due to lower total variable costs in T1. Tilapia fingerling price was higher (5 NRs./fish) than carp therefore, total variable costs was higher in T3.

CONCLUSION

Most of the aquaculture production comes from Terai region in Nepal where drought is common in dry season. The water level drops during this period and fish growth and survival decreases. It affects year round production, supply and availability of fish. Selection of appropriate fish species is important for dry period in dry prone areas. Nile tilapia farming seemed appropriate for dry period because it survives well and grows better in low water level and suboptimal water conditions.

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REFERENCES

Adhikari, S. (2018). Drought Impact and Adaptation Strategies in the Mid-Hill Farming System of Western Nepal. *Environments*, 5(9), 101; https://doi.org/10.3390/environments5090101.

APHA. (2012). Standard methods for examination of water and waste water (22nd ed.), American Public Health Association; Washington DC, USA. 1360 pp.

Al-Humairi, K. O., Al-Tameemi, R. A., & Al-Noor, S. S. (2020). Growth Performance and Feed Efficiency Assessment of Two Groups of Common Carp (*Cyprinus carpio* L.) Cultivated in Iraq. *Basrah Journal of Agricultural Sciences*, *33*(1), 189-199.

Bhandari, B. (1992). The current status of wetlands in Nepal. In *Asian Wetland Symposium organized by Ramsar Centre Japan, Otsu-Kushiro, Japan* (Vol. 1420).

CFPCC (2019) Fisheries National Data Base. Central Fisheries Promotion and Conservation Centre (CFPCC), Department of Livestock Services, Kathmandu, Nepal, 138 p.

Das, S., Hossain, M. A., Rahman, M. M., Imteazzaman, A. M., & Mofasshalin, M. S. (2017). Fish culture in ponds under drought prone Barind area of Bangladesh.

El-Shebly, A. A., & Hossain, M. Y. (2007). A preliminary observation on the pond culture of European eel, Anguilla anguilla (Linnaeus, 1758) in Egypt: recommendations for future studies. *Pakistan journal of biological sciences: PJBS*, *10*(7), 1050-1055.

Goolish, E. M., & Adelman, I. R. (1984). Effects of ration size and temperature on the growth of juvenile common carp (Cyprinus carpio L.). *Aquaculture*, *36*(1-2), 27-35.

Hosen, M.H.A., Sarker, K., Chhanda, M.S., & Gupta, N. 2019. Effects of Water Depth on Growth Performance of Indian Major Carps at a Poly Culture System in Bangladesh. *International Journal of Sciences: Basic and Applied Research*, *48*(3), 9-23.

Hossain, M. A., Mondal, R. C., Biswas, N. R., & Rabbani, M. G. (2010). Production and economics of fish farming in irrigated rice field ecosystem in drought prone barind area of Rajshahi, Bangladesh. *Bangladesh Journal of Progressive Science and Technology*, *8*(2), 239-242.

Jha, S., Rai, S., Shrestha, M., Diana, J. S., Mandal, R. B., & Egna, H. (2018). Production of periphyton to enhance yield in polyculture ponds with carps and small indigenous species. *Aquaculture Reports*, *9*, 74-81.

Jhingran, V. G. (1991). Fish and Fisheries of India, Hindustan Pub. *Co., New Delhi*, *727*.

Kausar, R., & Salim, M. (2006). Effect of water temperature on the growth performance and feed conversion ratio of Labeo rohita. *Pakistan Veterinary Journal*, *26*(3), 105-108.

Kundzewicz, Z. W. (1997). Water resources for sustainable development. *Hydrological Sciences Journal*, *42*(4), 467-480.

Laudari, S., Yadav, C. N. R., Singh, A. K., & Mishra, R. (2015). Assessment of optimum feeding rate on growth and production of carp polyculture in Nepal. *Technical Publication Thesis Grants*.

MoALD (2021) Statistical Information on Nepalese Agriculture. Ministry of Agriculture and Livestock Development (MoALD), Government of Nepal, Kathmandu, Nepal.

Mandal, R. B., Rai, S., Shrestha, M. K., Jha, D. K., & Pandit, N. P. (2018). Effect of red algal bloom on growth and production of carps. *Our Nature*, *16*(1), 48-54.

Miyan, M. A. (2015). Droughts in Asian least developed countries: vulnerability and sustainability. *Weather and Climate Extremes*, *7*, 8-23.

Sharma, S., Hamal, K., Khadka, N., Shrestha, D., Aryal, D., & Thakuri, S. (2021). Drought characteristics over Nepal Himalaya and their relationship with climatic indices. *Meteorological Applications*, *28*(2), e1988.

Shrestha, T. K. (2019) Ichthyology of Nepal. B. J Shrestha Publisher, Kathmandu, Nepal. p. 509 + 72 plates.

UNDP (2009). In Symposium on Utilization of Animal Resources of Orissa.