Indian J. Fish., 68(2): 70-75, 2021
DOI: 10.21077/ijf.2021.68.2.99722-09

Impact of inclusion of hybrid red tilapia (*Oreochromis mossambicus* × *O. niloticus*), on total production in farm pond aquaculture

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ABSTRACT

The present study was conducted to evaluate the impact of inclusion of hybrid red tilapia (*Oreochromis mossambicus* × *O. niloticus*) on productivity in carp based pond aquaculture. An experiment for a period of 270 days was conducted in two sets of earthen ponds (each of 0.132 ha size with 1.5 m depth). In Set I, five species *viz. Catla catla*, *Labeo rohita*, *Cirrhinus mrigala, Ctenopharyngodon idella* and *Cyprinus carpio*) were stocked (@13636 ha^{-1}) in a respective ratio of 1:1:1:1:2. In Set II, hybrid red tilapia was included as additional species to other five carp species and stocked @ 13636 ha^{-1} in equal numbers. The seeds stocked (initial size 5-6 cm) were fed on commercial pellet feed having 20% protein, by broadcasting over the pond surface. The water quality parameters *viz*., temperature, pH, dissolved oxygen, alkalinity, nitrogen, phosphate and potassium remained more or less same in both the sets of experimental ponds. However fish growth parameters significantly differed in both the sets of experiments. Highest production of 2575.79±107.08 kg ha^{-1} was recorded in Set II followed by Set I with a production of 1894.32±428.44 kg ha^{-1}. Tilapia stocked as an additional species provided a net estimated additional yield of 680.64 kg ha^{-1}, which was 36.47% higher than that of Set I. The results of this study have proved significant impact of hybrid red tilapia inclusion on enhancing the net productivity.

Keywords: Additional species, Farm ponds, Productivity, Red tilapia, Stocking density, Yield enhancement

Introduction

The growth in the fish farming sector mainly comes from the freshwater aquaculture sector, as marine finfish culture is hardly practiced on a large scale. About 12.8% of total animal protein consumed in India comes from freshwater fish. Historically, the Indian freshwater fish farming was based on a multi-species system. Natural fish food organisms were generated by adding organic and inorganic fertilisers to water and the different species cultured utilise this food based on the trophic system in the pond.

A combination of Indian major carps (IMCs) comprising catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) were used as the main target species for culture, along with Chinese carp species like silver carp (*Hypophthalmichtys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) (Bias, 2018). The technology developed for induced breeding of carps and the abundance of agri-byproducts used as supplemental feed led to the rapid development of freshwater aquaculture in the country.

The three IMCs, contribute to the bulk of production to the extent of 70 to 75% of the total freshwater fish production (Jayasankar, 2018), followed by silver carp, grass carp, common carp and catfishes forming a second important group contributing to the balance of 25 to 30% (FAO, 2017).

FAO (2016) suggested hybrid tilapia (*Oreochromis mossambicus* × *O. niloticus*) as an additional fish species for inclusion to enhance the pond productivity. This species grows well with the IMCs. For the same reason, the majority of tilapia production systems are pond-based polyculture with IMCs (Menaga and Fitzsimmons, 2017). According to Fitzsimmons and Watanabe (2010), tilapias have become the second most important farmed fish globally after carps. James and Andrew (1989) have recommended the culture of tilapia with other species to take advantage of many natural foods available in ponds.

The significant role of tilapia inclusion in pond aquaculture farming system has been well established elsewhere. However, the scientific data generated elsewhere for aquaculture cannot be adopted as such without refinement at regional level. Though a number of farmers are also culturing red tilapia with carp species in pond culture systems, scientific data especially from Tamil Nadu State in South India, are not available. In view of this, the present study was conducted in earthen ponds to evaluate the impact of inclusion of hybrid red tilapia on total production in farm pond aquaculture.

Materials and methods

This experiment was carried out from 5 December 2018 (date of stocking) to 5 September 2019 (date of harvest) at the fish farm of the Directorate of Sustainable Aquaculture, Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU), Thanjavur, Tamil Nadu (lat. 10° 47' 13.1964" N; long. 79° 8' 16.1700" E). Four farm ponds of uniform size (0.132 ha), shape (rectangle 30 m x 44 m) and depth (1.5 m) were selected. These four ponds (average water depth 1.2 m) were divided into two sets *i.e.* Set I and Set II. In Set I only the three IMCs plus two exotic carps *viz*., grass carp and common carp were stocked. Whereas in Set II, hybrid red tilapia seeds procured from Krishnagiri Barur Centre for Sustainable Aquaculture, TNJFU, Tamil Nadu were also stocked as additional species to above five carp species.

Based on the pH and water quality in the ponds, dosages of lime (30 kg 0.132 ha^{-1}), kerosene (20l 0.132 ha^{-1}) and cowdung (1320 kg 0.132 ha^{-1}) were applied as per the approved protocol for pond aquaculture (Jena and Das, 2011).

Both the ponds in Set I were stocked with five species (5-6 cm sized) *viz., C. catla*, *L. rohita*, *C. mrigala, C. idella* and *C. carpio* (@13636 ha^{-1}) in a respective ratio of 1:1:1:1:2. In Set II hybrid red tilapia (5-6 cm) was included as additional species to other five carp species and stocked @ 13636 ha^{-1} in equal numbers. The fishes were fed with ABIS fish feed (IB Group, India) through broadcasting method twice a day on the pond water surface. The feeding rate was 5-6% for the 1^{st} month and 3-4% for the subsequent months.

For monitoring of water quality in farm ponds, water samples were collected before fish seed stocking and subsequently at monthly intervals. Selected water quality parameters such as water temperature, total dissolved solids (TDS), pH, alkalinity, dissolved oxygen, total nitrogen, total phosphate and gross productivity were monitored as per the standard methods of APHA (2005). Periodical sampling (fortnightly) of fishes was done by cast netting to determine the weight of fish and accordingly the amount of feed was adjusted.

At the time of harvest, the individual species mean weight and length were randomly recorded for 50 fishes along with the total weight of the harvested fishes. Since the harvested fishes were sent for live fish marketing and due to the compulsion to keep the fishes less disturbed, accurate individual numbers of each species could not be recorded. Therefore, the survival of fishes was taken as a whole mass and the individual species survival was determined with the available data that could be sampled and collected from the harvested lot.

The data recorded for water quality parameters, fish weight gain and total harvested biomass were statistically analysed using standard procedures as described by Steel and Toori (1960).

Results

The results pertaining to selected water quality parameters in experimental ponds, fish growth and production are presented in Tables 1-4 and Fig. 1-2. The water quality in both the sets of experimental ponds remained more or less same. In general, the levels of different water quality parameters indicated congenial environment for the survival and growth of freshwater fish (Table 1). In Set II ponds, the mean values of water quality parameters like temperature, TDS, pH, alkalinity and dissolved oxygen were 30.63±0.18°C, 0.32±0.05 ppt, 8.13±0.02, 128.58±16.26 mg l^{-1} and 4.055±0.02 mg l^{-1}, respectively. Whereas in Set I the respective values of temperature, TDS, pH, alkalinity and dissolved oxygen were 31.5±0.00°C, 0.355±0.01 ppt, 7.94±0.04 mg l^{-1}, 105.91±2.99 mg l^{-1} and 4.115±0.01 mg l^{-1} (Table 1). The mean values of pond water fertility factors like nitrogen, phosphorus, potassium and GPP (gross primary productivity) were 1.79±0.15 mg l^{-1}, 0.35±0.08 mg l^{-1}, 1.29±0.05 mg l^{-1} and 0.54±0.08 gC m^{-3} h^{-1}, respectively for Set II, while in Set I, these were 1.29±0.06 mg l^{-1}, 0.26±0.03 mg l^{-1}, 1.39±0.38 mg l^{-1} and 0.58±0.22 gC m^{-3} h^{-1} (Table 1).

Fish growth and production parameters from experimental ponds are presented in Tables 2, 3 and 4. It could be observed that the initial mean biomass in both the treatments were approximately similar, 4.04 and 3.93 kg in Set II and Set I respectively (Table 2). After a rearing period of 270 days, there was a significant difference in biomass between both the sets of treatments. As such the highest (335.98 kg 0.132 ha^{-1}) and lowest (246.12 kg 0.132 ha^{-1}) biomass was recorded in Set II and Set I respectively (Table 2). From these production figures it is obvious that an additional production of 89.96 kg was contributed by Set II, where hybrid red tilapia was included in culture system.

Table 1. Physico-chemical parameters and fertility factors of water in the experimental farm ponds

Experimental set	Physico-chemical parameters					Fertility factors			
	Temperature (^{0}C)	TDS (ppt)	pH	Alkalinity (mg l^{-1})	DO (mg l^{-1})	Total nitrogen (mg l^{-1})	Total P (mg l^{-1})	Total potassium (mg l^{-1})	Gross primary productivity (gC m^{-3} h^{-1})
Set-I	31.5±0.00	0.355±0.01	7.94±0.04	105.91±2.99	4.12±0.01	1.29±0.06	0.26±0.03	1.39±0.38	0.58±0.22
Set-II	30.63±0.18	0.32±0.05	8.13±0.02	128.58±16.26	4.06±0.02	1.79±0.15	0.35±0.08	1.29±0.05	0.54±0.08

Table 2. Biomass production parameters of fishes in the farm ponds

Species	Initial biomass (kg)		Final biomass (kg) Mean±SD		% in total Final Biomass		Net biomass produced (kg) Mean ± SD		% in total Net Biomass	
	Set-I	Set-II	Set-I	Set-II	Set-I	Set-II	Set-I	Set-II	Set-I	Set-II
L. rohita	0.681	0.681	44.63±8.01	61.39±2.17	17.85	18.05	43.94±8.01	60.70±2.17	17.85	18.06
C. catla	0.741	0.741	45.07±19.78	66.88±8.67	18.02	19.67	44.33±19.78	66.14 ±8.67	18.01	19.69
C. mrigala	0.735	0.735	61.06±25.27	90.23±14.59	24.42	26.54	60.33±25.27	89.50±14.59	24.51	26.64
C. idella	0.627	0.627	35.22±8.82	43.19±1.15	14.09	12.70	34.59±8.82	42.56±1.15	14.05	12.67
C. carpio	1.146	0.573	64.08 ±12.31	61.88±18.76	25.62	18.20	62.93±12.31	61.30±18.76	25.57	18.25
Oreochromis spp.	-	0.683	-	16.44±0.27	-	4.84	-	15.76±0.27	-	4.69
Total	3.93^b	4.04^a	250.05± 56.55^d	340.01±14.13^c	100	100	246.12±56.55^f	335.98±14.14^e	100	100

Values bearing different superscripts are significantly differ at 5% probability level

Table 3. Species-wise growth and biomass harvested from farm ponds

Species	Experimental Set-I		Experimental Set-II	
	Mean final weight of individual (kg) (Mean ± SD)	Total harvested weight (kg) (Mean ± SD)	Mean final weight of individual (kg) (Mean ± SD)	Total harvested weight (kg) (Mean ± SD)
L. rohita	0.45±0.18	44.63±8.01	0.48±0.01	61.39±2.17
C. catla	0.45±0.26	45.07±19.78	0.53±0.06	66.88±8.67
C.mrigala	0.62±0.37	61.06±25.27	0.70±0.13	90.23±14.59
C. idella	0.34±0	35.22±8.82	0.34±0.02	43.19±1.15
C. carpio	0.62±0.24	64.08±12.31	0.48±0.12	61.88±18.76
Oreochromis spp.	-	-	0.13±0.001	16.44±0.27
Total	2.47±1.05	250.05±56.55	2.66±0.04	340.01±14.13
Overall mean	0.41±0.18	41.56±9.26^b	0.45±0.01	56.41±2.37^a

Values bearing different superscripts significantly differ at 5% probability level

The growth of IMCs was found higher in treatment Set II as compared to Set I. As in net biomass, the contribution was found 0.21% higher for rohu, 1.68% higher for catla and 2.13% higher for mrigal (Table 2). Among the stocked species, highest growth was observed for *C. mrigala* in both the treatments and it contributed to a level of 6.64% of total production in Set II, while 24.51% in Set I (Table 2). In net biomass, *C. carpio* contributed 18.25% in Set II, while it was 25.57% in Set I.

Among the stocked carps, the maximum average weight was gained by *C. mrigala* (0.70 ±0.13 kg in Set II and 0.62±0.37 kg in Set I). Similarly, the total biomass production of *C. mrigala* was 29.17 kg higher in Set II than that of experimental Set I, Further, among the stocked carps, minimum average weight was gained by *C. idella* that was 0.34±0.02 kg in both Set I and II (Table 3). At the end of the production cycle (*i.e.*, 270 days), the estimated gross biomass production was 681.47 kg ha^{-1} higher in Set II than that of Set I. The net production level was estimated to be 36.47% higher in Set II than that of Set I (Table 4). The mean contribution (%) of individual species in the net biomass production is depicted in Fig. 1. The difference in the estimated net biomass production between the treatments is given in Fig. 2.

In the case of production parameters, no significant difference was found between mean initial body weight of individual fish and mean initial biomass of the fishes. However, mean final body weight of individual fish at harvest, average weight of fishes of individual species at harvest and average growth rate of the individual fish were significantly different ($p<0.05$).

Discussion

The impact of hybrid red tilapia inclusion in carp pond culture system was evaluated with special reference to its contribution to total production in farm pond

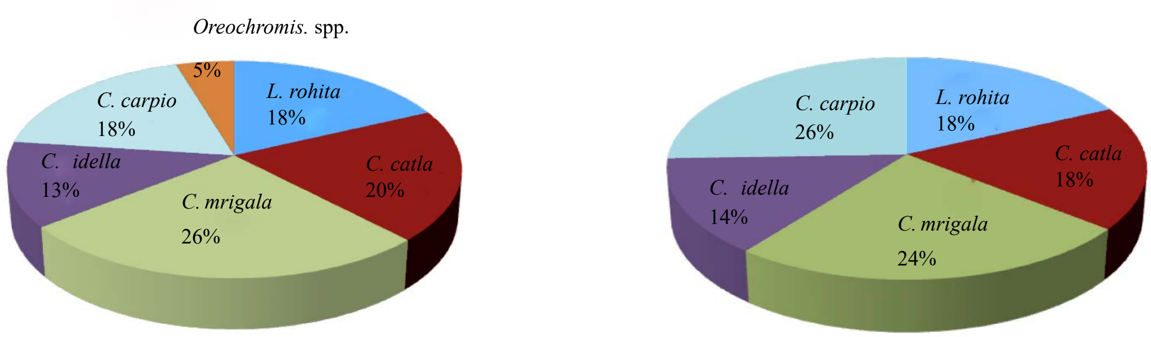

Fig. 1. Mean contribution (%) of individual species in net biomass production in the ponds

Table 4. Estimated production parameters in the farm ponds

Experimental set	Mean survival rate (%)	Gross production per ha	Net biomass production in the pond (kg)	Net biomass production per ha (kg)	Average daily growth rate (kg ha^{-1} day^{-1})	Difference in net biomass production among treatments	
						kg ha^{-1}	%
Set-I	35.29 ±7.39[b]	1894.32±428.44[b]	246.12±56.55[b]	1864.53±428.43[b]	6.91±1.59[b]	680.64	36.47
Set-II	42.71 ±1.23[a]	2575.79±107.08[a]	335.97±14.14[a]	2545.17±107.08[a]	9.43±0.396[a]		

Values bearing different superscripts (column-wise) are significantly different at 5% probability level

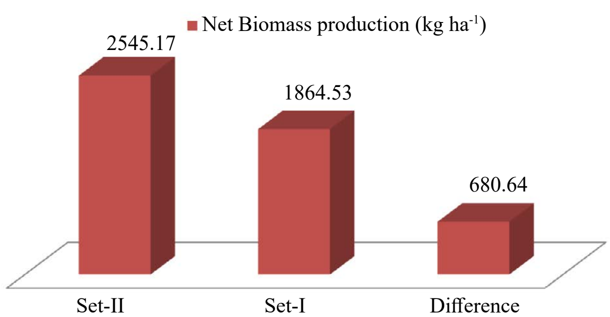

Fig. 2. Estimated net biomass production in different treatment ponds

aquaculture. The findings of the present study in which hybrid red tilapia was included in addition to carps in pond aquaculture systems have proved its significant impact on production. As such, an additional production of 680.64 kg ha^{-1} (36.47%) in ponds with hybrid tilapia than the ponds without inclusion of hybrid red tilapia was achieved. The experiment of Shahin *et al.* (2011) also supplements the present findings; they suggested that the inclusion of tilapia in carp-prawn-polyculture system led to higher total yields. Haque *et al.* (2016) have stocked prawn with sex-reversed male tilapia of GIFT strain and demonstrated better net benefit. The findings of James and Andrew (1989) on enhanced production due to red tilapia inclusion in polyculture system (silver carp, grass carp and channel catfish) further supports the results of the present study.

During the present study, the total production of farm ponds stocked with hybrid tilapia was 2545.17±107.08 kg ha^{-1} $crop^{-1}$ (Table 4). However, a slightly higher production (3600-4000 kg ha y^{-1}) was reported in earlier studies where hybrid tilapia was raised as one of the species in a polyculture trial with common carp and grass carp (Sin, 1980; Jhingran and Sharma, 1986).

The stocking density used in this experiment (13636 ha^{-1}) was found to be safe as it did not create any negative impact on the production. de Oliveira *et al.* (2012) opined that selection of proper stocking density is important since fish survival, growth rate, feeding behaviour, health, water quality and total production are directly influenced by the stocking density. Generally in farm pond aquaculture, the stocking density recommended by Jena and Das (2011) is followed with 5000-10000 fingerlings of 100 mm size per hectare. But in the present trial, the stocking density was elevated to 13636 ha^{-1}. According to Rahman and Marimuthu (2010), stocking density influenced growth both positively or negatively depending on number per ha and the pattern of this interaction was very specific to the selection of species. Based on the findings, it could be said that the present combination of species tried with the stocking ratio adopted, the stocking density (13636 ha^{-1}) used might be supportive for production. Further research in altered species combination and species ratio is required for other species in culture under similar conditions.

The effect of stocking density on the growth was examined with different fish sizes including fry and juveniles (El-Sayed, 2002), sub-adults (D'Silva and

Maughan, 1995) and large tilapia (Yi *et al.,* 1996). Studies were conducted under different culture systems such as tanks (Bailey *et al.,* 2000), ponds (Diana *et al.,* 2004) and net cages (Cruz and Ridha, 1991; Yi *et al.,* 1996). All these studies showed the direct relation of stocking density with growth performance. James and Andrew (1989) have suggested that, tilapia can be cultured with channel catfish with only a minor reduction in catfish yields. They reported that male tilapia stocked at a rate of 800 per acre yield nearly 770 pounds per acre when channel catfish were stocked at 3,000 per acre. At this stocking rate, net production of catfish declines by roughly 170 pounds per acre, but for every reduction of 1 pound in catfish production, 4.5 pounds of tilapia are produced. Catfish production does not decline when cultured in combination with tilapia, silver carp (*H. molitrix*) and grass carp (*C. idella*) at densities of 800; 1,000 and 20 per acre, respectively. In the present study also, the lesser stocking of hybrid tilapia could have positively impacted the production of carps.

In the present study, we did not observe a major impact of stocking tilapia on the water quality parameters tested. The mean survival rate of fishes was higher in the ponds stocked with hybrid tilapia than the ponds without additional species. This is in line with the findings of James and Andrew (1989), who observed good water quality and better survival in the ponds where hybrid tilapia were stocked in a polyculture system.

Higher survival was recorded in Set II which further confirms the compatibility and supporting nature of hybrid tilapia in carp production pond. Haque *et al.* (2016), have also noticed significantly ($p<0.05$) higher survival rate for GIFT tilapia strain in polyculture systems. They have also reported improved individual harvesting weight, individual weight gain, specific growth rate (SGR %), gross and net yields in ponds stocked with tilapia as additional species. Results of the present study on fish growth and production data are more or less same as earlier reported by Haque *et al.* (2016).

Among the IMCs, *C. mrigala* was found to achieve the highest growth (0.70±0.13 kg) (Table 3) and production (90.23±14.59 kg per 0.132 ha). In a semi-intensive carp culture system, Verma (2018) has also recorded the highest growth for *C. mrigala* (172.42 %) compared to other carp species used in this experiment. Although no specific reasons could be attributed for the higher growth of *C. mrigala*, the poor growth of *C. idella* could be attributed to the scarcity of grass and aquatic vegetation in the ponds.

The observed water quality parameters in both the sets of experimental tanks showed a fair similarity. However, the variations in pH and alkalinity (Table 1) observed were also statistically significant ($p<0.05$). On the other hand, no statistical significance could be seen for total nitrogen, potassium and GPP ($p>0.05$). There might be more than one factor that would intervene and impact the soil water interaction. However, it could be concluded that the addition of hybrid tilapia did not create any negative situation in the ponds; rather it supported the system with higher fertility and conducive environment for the fishes. This could have been a hidden or indirect reason for higher survival and production which needs to be be further investigated.

The results of the present investigation clearly evidenced that the inclusion of hybrid red tilapia in carp polyculture system has positive impact on production. On the other hand, no significant difference in water quality was observed between ponds stocked with or without tilapia. The inclusion of hybrid red tilapia could help to produce 680 kg more fish from a hectare water area. On the basis of the results of the present study it is recommended that hybrid tilapia can be included in farm pond aquaculture as an additional species and the stocking density can be used up to the level of 14,000 nos. per hectare. However, further trials with different stocking densities and stocking ratios at different geographic locations can be conducted to generate more information.

Acknowledgements

The authors are grateful to the farmers of Vellamperambur Village, Tamil Nadu for providing their farm ponds for conducting the experiments. We are thankful to Mr. Chinnakuppan, Assistant Director of Fisheries, Thanjavur, Mr. Durairaj, Inspector of Fisheries and other supporting staff for their support in different ways for the successful conduct of the experiment. We also thank Prof. Dr. S. Felix, Former Vice Chancellor, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Tamil Nadu, for providing all the laboratory facilities and technical support during the research. A special thanks to TN-IAMP (Tamil Nadu- Irrigated Agricultural Modernisation Project), a World Bank financed project, for the Systematic Research Fund.

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Date of Receipt : 02.04.2020
Date of Acceptance : 10.05.2021