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Comparative study on growth and survival of Genetically Improved Farmed Tilapia (*Oreochromis nitoticus*) fry reared under two different culture systems

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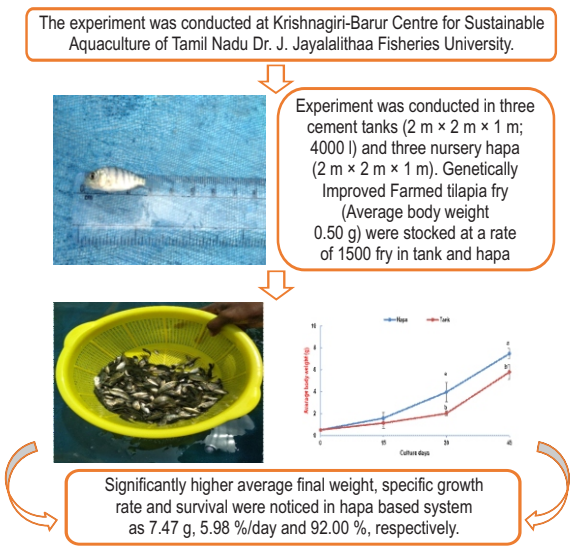
Abstract

Aim: The aim of the present study was to analyze two different culture systems for their suitability in rearing the Genetically Improved Farmed Tilapia fry.

Methodology: Genetically Improved Farmed Tilapia fry (Average body weight 0.50 g) were stocked, at a rate of 1500 fry,in tank and hapa.Three cement tanks (2 m × 2 m × 1 m; 4000 l) and three nursery hapa (2 m × 2 m × 1 m) were used for this experiment following completely randomized design. Fry were fed using prepared diet (crude protein 32%) at a feeding rate of 8-10 % of their body weight for 45 days. Fortnightly, feeding rate was adjusted based on the sampling.

Results: After 45 days of rearing, tilapia fry attained a body weight of 5.44 g and 7.47±0.00 g in cement tanks and hapa based production systems, respectively. The specific growth rate significantly differed and it was higher (5.98 %/day) in hapa based system. Similarly, survival was significantly higher (92.00 %) in hapa based system. In contrast, increased feed conversion ratio was noticed in tank-based culture system (2.06) than the hapa based system (1.69). The protein efficiency ratio was significantly higher (1.97) in hapa based system.The recorded water quality parameters were within the optimal range for rearing of Genetically Improved Farmed Tilapia fry.

Interpretation: Overall, the results of this study demonstrated that rearing of Genetically Improved Farmed tilapia fry in hapa, installed in earthen pond, would lead to better growth, feed utilization and survival. This method can be disseminated to farmers for better profitability in seed production of Genetically Improved Farmed Tilapia.



Key words: Genetically improved farmedtilapia, Growth performance, Hapa, Nursery rearing, *Oreochromis nitoticus*

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Introduction

Aquaculture, the cheapest protein producing sector, is fulfilling half of the global protein needs and contributes to about 50% of the overall fish production. According to FAO (2020), the present global fish production is 179 million tonnes. However on the other side, the demand for fish is increasing day by day, at global level, which can be met only through culture based fisheries, in future, due to over-exploitation of commercial stocks from natural ecosystems. Among various freshwater fish produced in the world, tilapia is the second largest produced fish, after carps, and it is presently cultured in more than 140 countries (Zhang *et al.,* 2020). Global tilapia production is expected to double from 4.3 million tons to 7.3 million tons between 2010 and 2030 (Kobayashi *et al.,* 2015). The lower production cost and affordability of tilapia continue to play an important role in boosting the tilapia production which in turn supplies nutritious food to human. In addition to this, tilapia has many attractive facts which makes tilapia as an important future food fish, throughout the world. Even though tilapia is promoted as a major candidate species for aquaculture, size variation and stunted growth in culture systems, due to their unconditional propagation, are severely hindering the expansion of tilapia culture (Shubha and Reddy, 2011).

In general, male Nile tilapia grows faster than female therefore, today "monosex tilapia farming" has been widely promoted among tilapia farmers (Alice, 2015).Among the various strains of tilapia cultured, the Genetically Improved Farmed Tilapia, a hybrid strain of *Niloticus* species of tilapia, is the emerging cultivable species in freshwater fish culture practices. In a short span of time, Genetically Improved Farmed Tilapia, developed by the World Fish Centre, Malaysia has attained economical importance in the developed countries (NFDB, 2015). The other commercially important species are *Oreochromis niloticus, Tilapia zillii, T. melanopleura* and *Sarotherodon galililae* (Lawson and Anetekhai, 2011).To improve the growth trait in tilapia, the Genetically Improved Farmed Tilapia was developed, following selective breeding, using the traits of farmed and wild collected tilapia strains from tropical countries (Eknath *et al.,* 2007). In India, tilapia, the most commonly seen exotic fish, was introduced in 1952 from South Africa (NFDB, 2015). Among various tilapia strains introduced to India, the Genetically Improved Farmed Tilapia is provides an income and sustainable source of food and nutrition to farmers. However, the non-availability of quality seed of Genetically Improved Farmed Tilapia is significantly hampering further expansion of tilapia culture in India.

Generally, tilapia fry are reared, in nursery phase, using tanks, hapa, cages and ponds systems. However, the choice of nursery rearing facility adopted by farmers is influenced by operational cost, demand for seed in the market and availability of late fry (Debnath *et al.,* 2019). A significant variation observed in the growth and survival of fry, in different rearing systems, is limiting the adoption of single nursery rearing system by the farmers. Romana-Eguia *et al.* (2010) reported higher growth and survival of Nile tilapia and red tilapia strains in cages-based culture system than tanks-based system. In contrast, best growth performance of Zeway and Awassa strains were found in the concrete tank based rearing system (Workagegn and Gjoen, 2012). The comparative study by Kunda *et al.* (2014) found that Genetically Improved Farmed Tilapia has significantly higher growth and survival than the existing Nile tilapia (*Oreochromis niloticus*) strain in hapa based rearing system. Further, the study found that tilapia fry (*Oreochromis niloticus*) displays better survival in a stocking density of 900/m^2 under hapa based system. In contrast, another study by Asase *et al.,* (2016) using hapa system found better growth rate, survival and profitability in a stocking density of 800 fish m^{-3}. The Genetically Improved Farmed Tilapia strain, *O. niloticus*, reared in a synthetic hapa, installed in a pond, displayed better growth and survival (Hossain *et al.,* 2017). The inconsistent results of previous reports on better rearing system for tilapia nursery rearing is limiting the adoption of single nursery rearing system. Therefore, to identify the best rearing system, the present comparative study was conducted which evaluated the growth performance of Genetically Improved Farmed Tilapia fry under two different rearing systems.

Materials and Methods

Rearing of fish: The experiment was conducted at Krishnagiri-Barur Centre for Sustainable Aquaculture of Tamil Nadu Dr. J. Jayalalithaa Fisheries University. Experiment was carried out in cement tanks (2 m × 2 m × 1 m; 4000 l) and nursery hapa following completely randomized design and each system were triplicated. Genetically Improved Farmed Tilapiafry (Average body weight 0.50 g), collected from the University farm where the research was carried out, were stocked randomly at a rate of 1500 fry per tank and hapa. The stocked fry were fed using prepared diet (crude protein 32%), at a feeding rate of 8-10% of body weight, and reared for a period of 45 days.

Water quality monitoring: The physico-chemical parameters of water samples were collected between 08:00 and 9:00 hours periodically for analysis of various water quality parameters *viz.* temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness of water samples following standard methods (APHA, 2005).

Growth parameters: Growth performance of stocked fry was assessed, fortnightly, using a weighing balance with 0.01 g accuracy to record the weight of fish. In each sampling, 20 numbers of fry from each tank and hapa (n=60/treatment) were collected and used for sampling. At the end of Experiment, growth parameters like weight gain, specific growth rate, survival, feed conversion ratio, feed efficiency ratio and protein efficiency ratio were calculated (Sarker *et al.,* 2016).

Statistical analyses: Data were expressed as mean ± SE values of three replicates. Data recorded during the experiment for growth parameters were analysed using independent t-test in the statistical program SPSS version

28.0. Significant difference of the test was set as P<0.05 while comparing the treatments mean values.

Results and Discussion

In the present study, pH, dissolved oxygen, ammonia, total hardness, and water temperature were ranged 7.60±0.27-7.80±0.27,4.25±0.25-4.60±0.21mg l^{-1},0.20±0.04-0.25±0.04 mg l^{-1}, 65.0±0.82-70.00±0.55 mg l^{-1} and 27.20±0.01-30.05±0.05°C, respectively, in both the systems and did not vary significantly between the two systems (Table 1). The observed water quality parameters were within the optimal range which ideally supported the growth of Genetically Improved Farmed Tilapia (Mensah *et al.,* 2014). Being a hardy species by nature, Genetically Improved Farmed Tilapia can tolerate and grow well in wide range of environmental conditions. The growth performance of Genetically Improved Farmed tilapia fry reared in two different culture systems is presented in Table 2.

The study found significant difference in the final weight, weight gain, specific growth rate, survival, feed conversion ratio, feed efficiency ratio and protein efficiency ratio between two different rearing systems. At the end of experiment, fish reached a final weight of 5.44 g and 7.47 gin tank and hapa based systems, respectively. Similar range of body weight gain was reported in Genetically Improved Farmed Tilapia reared under pond based aerobic microbial floc system (Yuvarajan *et al.,* 2018). The present study found better growth performance in hapa based system than the tank based system. Similar kind of growth pattern in Genetically Improved Farmed Tilapia was noticed under hapa based rearing system by Sultana *et al.* (1987). Significantly higher specific growth rate (5.98 % day^{-1}) and survival (92.00 %) were recorded in hapa based rearing system. The availability of natural food, inside the hapa installed in the pond ecosystem, could be the reason for better survival of tilapia fry in the hapa based system. Similarly, *O. niloticus* fry reared in hapa, installed at the pond, resulted in relatively higher growth rate and survival (Mensah *et al.,* 2014). Keremah and Esquire (2014) reported a higher survival of *Clarias gariepinus* fingerling in a pond based system than tank based system. In red tilapia, another hybrid strain of tilapia, hapa based culture system resulted in better growth, survival and body color of fish as compared with aquarium tanks (Debbarma *et al.,* 2019). On the other side, poor feed efficiency ratio (0.48) and protein efficiency ratio (1.61) were recorded in tank based rearing system. The study found significantly lower feed conversion ratio (1.69) in hapa culture system.

The availability of additional dietary protein, from the available natural food, inside the hapa could be the reason for better growth performance of fry reared under hapa based system (Keremah and Esquire, 2014) which in turn improved the feed conversion ratio. In the tank-based system, the stocked fry have to completely rely on supplementary feed, to satisfy their nutritional requirements, and the absence of natural food in the tank system elevated their feed conversion ratio and protein

Table 1: Water quality parameters of Genetically Improved Farmed Tilapia fry reared in tank and hapa based cultured systems during 45 days

Water quality parameter	Tanks	Hapa
pH	7.60±0.27	7.80±0.27.
Dissolved oxygen (mg l^{-1})	4.60±0.21	4.25±0.25
Ammonia(mg l^{-1})	0.20±0.04	0.25±0.04
Hardness(mg l^{-1})	70.00±0.55	65.00±0.82
Temperature (°C)	27.20±0.01	30.05±0.05
Nitrite (mg l^{-1})	0.003±0.05	0.002±0.005
Nitrate (mg l^{-1})	0.16±0.006	0.02±0.01
Phosphate (mg l^{-1})	0.01±0.002	0.02±0.01

Table 2: Growth performance of Genetically Improved Farmed Tilapia fry reared in tank and hapa based cultured systems during 45 days experiment

Growth parameters	Tanks	Hapa
Average Initial weight (g)	0.56±0.00	0.54±0.00
Average weight (g)	$5.94±0.01^{b}$	$7.47±0.00^{a}$
Weight gain %	$1059.17±15.23^{b}$	$1376.53±18.67^{a}$
Specific growth rate (% day^{-1})	$5.44±0.02^{b}$	$5.98±0.03^{a}$
Survival (%)	$86.50±2.50^{b}$	$92.00±2.00^{a}$
FCR	$2.06±0.14^{a}$	$1.69±0.08^{b}$
FER	$0.48±0.01^{b}$	$0.59±0.03^{a}$
PER	$1.61±0.09^{b}$	$1.97±0.11^{a}$

*In each row, mean values (n=60 fish per treatment) with different superscript differ significantly at p<0.05.

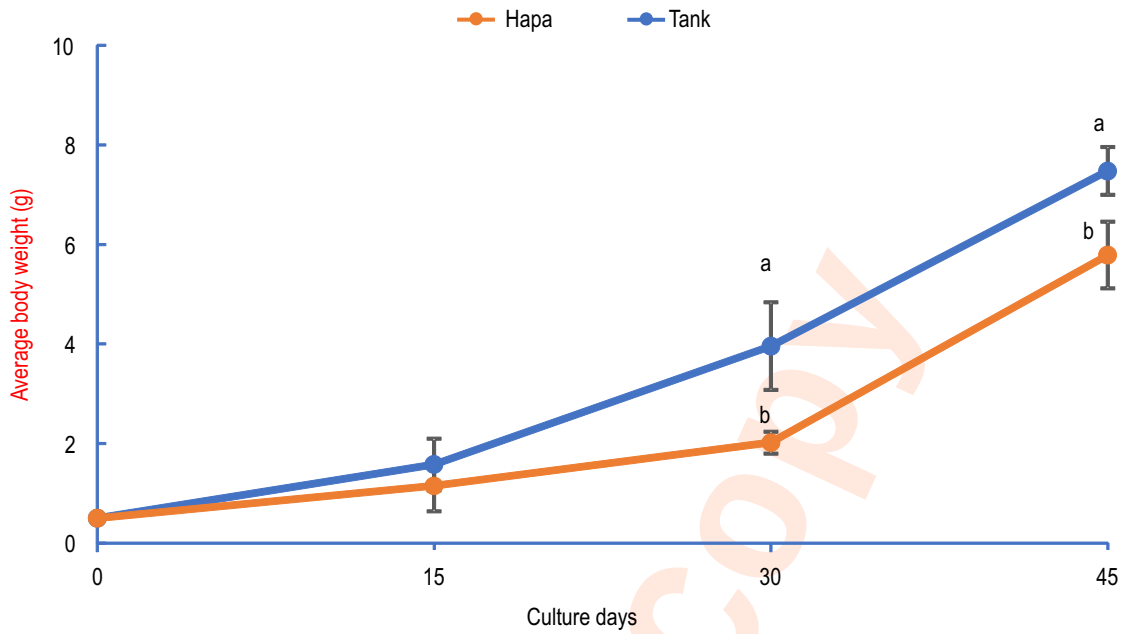

Fig. 1: Growth performance of Genetically Improved Farmed Tilapia fry reared in tank and hapa based cultured systems at 15 days intervals.

conversion ratio. Besides natural food availability, monitoring of seed health conditions, feeding, and harvesting are much easier in hapa based system. Moreover, hapa based system, installed in the earthen ponds, is more cost effective for fingerling production, as hapa, manufactured with nylon net, can be conveniently reused several times. (Escover *et al.,* 1987; Little and Hulata, 2000; Bhujel *et al.,* 2007). Similarly, *T. rendalli* reared in two different culture systems, hapa and tank, displayed similar results, where fry reared under hapa based system produced better weight gain, specific growth rate and biomass than their counterpart tank system (Zidana *et al.,* 2015).

An another study in Nile tilapia fingerling at nursery phase found faster growth rate, high profit index and survival using hapa based system (Asase *et al.,* 2016). Besides better growth performance, rearing of tilapia fry in a hapa-based culture offers easy handling, flexibility, high production per unit area and lower mortality. Additionally, hapas can be installed in ponds, stocked with fish, which ensures maximum utilization of ponds for fish production (Towers, 2015). On the other side, the tank-based culture system has its own drawbacks, since the lack of natural food in tank demands completely balanced diet, containing essential nutrients, vitamins and minerals for fry. Moreover, regular water exchange and supply of oxygen (through aeration system) make the tank based rearing system as a much costlier production system (Rakocy, 2005).

The increased demand for quality fish fingerling, to stock in rearing ponds, is making the production systems to utilize the open water bodies for nursery rearing. In this context, it has been suggested that hapa based culture system as a most viable and favorable choice of rearing system for both the open and closed water bodies (Kunda *et al.,* 2014). Additionally, cheaper construction cost of hapa and their more convenient management practices (can be shifted or moved from one pond to another pond, if the culture system encounters any water quality or disease issues in fish) are making the hapa based system as highly suitable production system for nursery rearing of Genetically Improved Farmed Tilapia. Overall, the results of the present study suggest that rearing of Genetically Improved Farmed Tilapia seed using hapa based system, for fingerling production, enhances the survival and growth performance of fish which would help to increase the profit and production.

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Add-on Information

Authors' contribution: R.V. Bhosle: Researcher, conducted the experiment and write original draft; **J.S. Sampathkumar:** Research concept development and overall guidance; **C. Antony:** Experimental designing and data verification; **S. Aanand:** Statistical analysis of data; **V. Senthilkumar:** Data analysis and tabulation; **C.J. Betsy:** Manuscript correction and revision; **R.S.S. Lingam:** Experiment supervision and providing support facilities.

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