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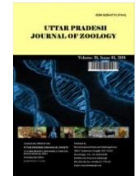

MONOSEX TILAPIA (*O. niloticus*) PRODUCTION UNDER TANK CULTURE: AN ALTERNATIVE FOR RURAL DEVELOPMENT IN PURBA MEDINIPUR DISTRICT, INDIA

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AUTHOR'S CONTRIBUTION

The sole author designed, analysed, interpreted and prepared the manuscript.

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Case Study

ABSTRACT

Monosex tilapia tank culture has taken a vital role in the fish farming business for great demand and value of this species in the local and international market. Intensive tank culture system reduces the limitations of pond culture and it is continuously aerated and does not dependent on phytoplankton for O_2 production. Therefore, intensive tank culture can produce very high yields, year round, on small parcels of land. High fish density in tanks disrupts breeding behavior and allows male tilapia to be grown to marketable size. The study was conducted at Kelomal village of Purba Medinipur district from August, 2016 to March, 2017 following standard protocol. The result revealed that if a person invests total cost of Rs.2879/ during 3 months in tank farming (length, width & depth ratio is 30:3:1) then the net profit is Rs.3025/ excluding all expenses. So, it is easily told that how much it is profitable (nearly 50%). The study is confined to only *Tilapia nilotica* (*Oreochromis niloticus*) other than two strains because its high growth rate under tropical region, strength, diseases less and production for twice-thrice a year. Naturally male tilapia grows rapidly than female. The main objectives of this study were to establish a sustainable aquaculture method for the production of a major animal protein source by comparing the growth pattern of monosex tilapia under tank culture systems. Therefore, commercial monosex tilapia farming can play an important role for making the people sustainable development and fulfilling the protein and nutritional demand.

Keywords: Growth rate; high yield; monosex; Nile tilapia; sustainable development; tank culture.

1. INTRODUCTION

The Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is one of the leading species of fish in tropical and sub-tropical aquaculture [1]. It provides one of the major sources of animal protein and income throughout the world [2,3]. It is currently ranked second only to carps in global production and

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is likely to be the most important cultured fish in the 21st century [4]. Tilapias belong to the cichlid family and the order under perciformes [5].

Tilapia fish can usually survive our environment in 12° to 40°c temperature [6] and grow well in 16° to 35°c temperature. Naturally male tilapia grows rapidly than female. The popularity of live tilapia in the market has persistent a great deal of improvement of the tank-based industry in the United States [6]. Monosex tilapia has significant demand and value in the local and international market. It can be an excellent substitute to pond or cage culture if sufficient water or land is not available and the economics are constructive. This hybrid tilapia (*Oreochromis niloticus* x *O. aureus*) was cautiously chosen because of its hardiness, plasticity to overpopulation and low dissolved oxygen demand [7] and availability from government fish seed multiplication centers at moderate costs. Moreover, sex-specific variances in growth were substantial in *Oreochromis niloticus* where males grow prompt expressively, larger and more identical in size than females [8].

The most common species of tilapia used for tank culture in the West Bengal are *Tilapia nilotica*, *Tilapia aurea*, *Tilapia mossambica* and hybrids between these species or strains. But the study is confined to only *Tilapia nilotica* or nile tilapia (*Oreochromis niloticus*) because of its highest growth rate and strong under tropical region, diseases are minus and produce for twice a year. Intensive tank culture offers some advantages over the use of ponds. Dennis et al. [6] found that high fish concentration in tanks disrupts breeding behavior and permit male tilapia to be grown to marketable size. The tank is always bubbling and does not dependent on phytoplankton for O_2 production. While in ponds, mixed-sex populations breed so effectively that parents and offspring compete for food, individual fish growth is abridged, and therefore population becomes arrested. Tilapia can be fully fledged on diets that are high in vegetable, such as soya protein, which is a more renewable and sustainable element than fish meal derived from wild fish catches [9]. Tilapia can also be cultured in waste water treatment such as RAS (recirculating aquaculture system), Biofloc and Aquaponic technologies [10].

Tanks allow the fish farmers to easily handle stocks and to apply a relatively high degree of environmental control over different parameters such as, water, temperature, DO, pH and waste that can be accustomed for maximum production [11]. Thus, androgen hormone treated (sex-inversion is the oral administration) in monosex tilapia culture in tank as a substitute of earthen ponds can be regarded as one of the advance method for eco-socio-economic condition increased fish production in West Bengal. Tilapia has been extensively introduced in the shallow and seasonal ponds of eastern region of India. But, its performance in open water ponds of the country has been discouraging over the years [12]. The significance of monosex tilapias has been recognized in many commercial backgrounds but there are relatively few published studies comparing the growth performance of androgen treated monosex nile tilapia with mixed-sex tilapia, under tank culture, especially from the Indian perspective [13,14,15]. Therefore, the main objectives of this study were to establish an eco-socio-economic condition for the production of a major animal protein source by comparing the growth pattern of monosex tilapia under tank culture systems.

2. MATERIAL AND METHODS

The study was conducted at Kelomal village (C.A.D.C Tamluk project) of Purba Medinipur district of West Bengal from August, 2016 to March, 2017 for 240 days and complete only two production cycle and the method was followed standard protocol [16]. The site of the study is located at 22.3097°N and87.8773°E as shown in Fig. 1.

2.1 Selection of Culture Tank

Tanks come in a variety of shapes, but the most common forms are circular and rectangular. Circular tanks are very famous because they are to be self-cleaning. Few of the incoming water may flow directly to the drain, while the other areas of the tank may become stagnant, which all permissible waste to accumulate and lowers oxygen levels.

Circular tanks run better conditions than rectangular tanks for tilapia culture and it may be as large as 100ft in diameter, but common sizes range from 13-28ft in diameter and from 3-5ft in depth. To study used to a circular tank of which surface area was 96sq. ft., depth was 3ft., width was 7ft. and diameter was 34ft.

2.2 Culture Systems

The tank culture system was consisted of circular concrete tank; the flow-through tank systems hinge on constant or periodic water exchange to flush out fish waste products. The flow through tank was identical to the ordinary tank with the added systems of continuous water flow at a constant rate. For commercial operations, the expense of supplemental oxygen can often be offset by the significant increase in maximum biomass density. Throughout the entire

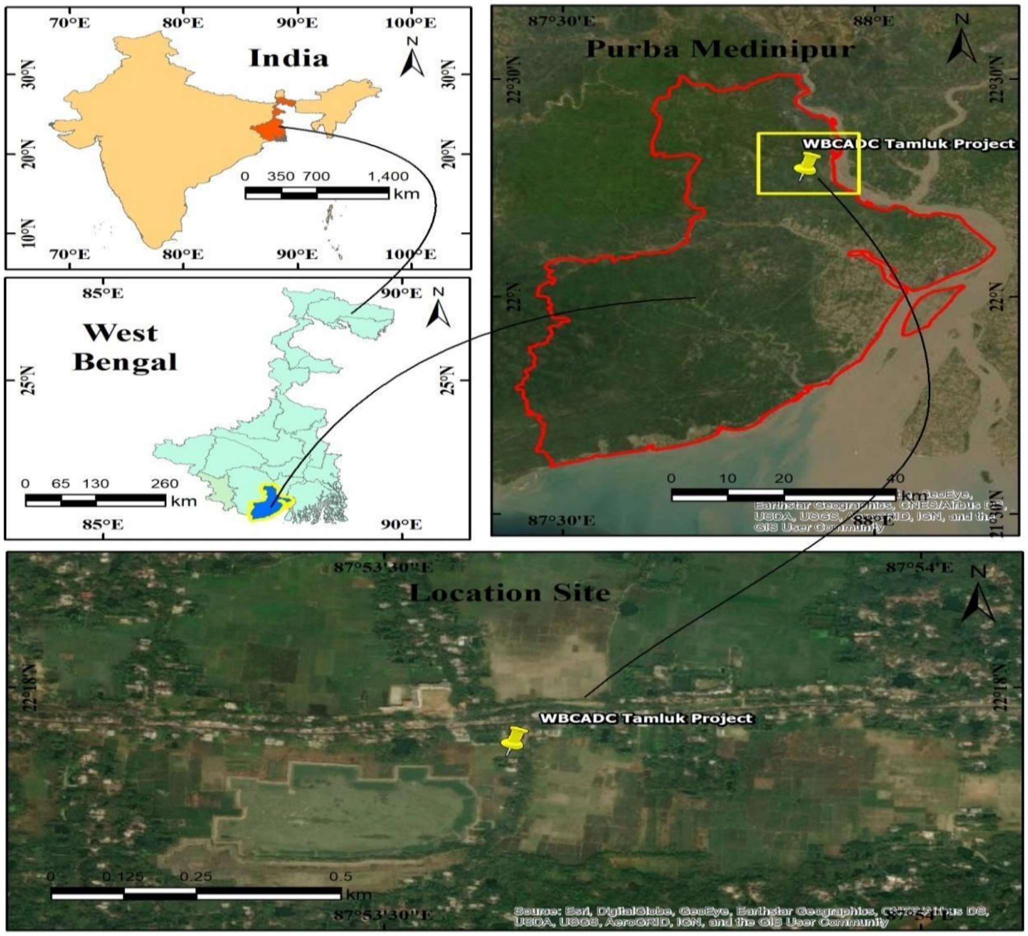

Fig. 1. Map showing the location of study site of Purba Medinipur district of West Bengal, India

culture period, different water quality parameters like temperature, DO_2 and free CO_2, pH, total alkalinity and turbidity were regularly monitored using the standard procedures of American Public Health Association [17].

2.3 Monosex Tilapia Production

Two-four days old mixed sex juveniles of nile monosex tilapia (mean weight 0.021±0.007 g; mean length 1.22±0.14 cm) were collected from the Fish Hatchery at Naihati, West Bengal. Due to small size and shallow of concrete tanks, the carrying capacity is very low and as a result monosex (hybridised) tilapia fingerlings (<46 g) were stocked at 6-8 fish/m^2 into the concrete tanks, and were cultured for 240 days (two cycle of production). In this field hormone mixed diet was prepared by the alcohol evaporation technique (Shelton et al., 1978). Water in all tank were replaced weekly and the fish were retained under similar photoperiod (14 L: 10 D), temperature (T=30±2°C) and density (6000-10000 fish /m^3). For better result poultry wastes (30-50% manure, the rest waste feed), applied at 800 kg/ha/wk by spreading on the water surface worked as organic fertilizer as well as indirect fish feed. Soybean cake was also applied as complementary feed and fed once daily at 4% of the total fish body weight by broadcasting at selected feeding spots within the tanks. Water temperature and pH in the concrete tanks were monitored before 9am bi-weekly throughout the culture period.

2.4 Growth Performance Analysis

At the end of culture period all fish were harvested, counted, and measured individually for weight and length. Growth parameters such as specific growth rate (SGR), daily weight gain (DWG), food conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein utilization (ANPU), net production and survival rate were calculated accordingly [18]:

SGR (% day^{-1}) = 100 (Ln final weight - Ln initial weight)/ days

DWG (g/fish) = mean final body weight - mean initial body weight
FCR = total dry feed fed (g)/total wet weight gain (g)
PER = total wet weight gain (g)/ total dry protein fed (g)
ANPU = (total final body protein – total initial body protein) / protein consumed
Survival rate (%) = (final number of fish / initial number of fish) X 100
Net production = final biomass - initial biomass (kg/tank)

Moisture content was calculated by drying a sample at 105°C in an oven for 24 hours and total ash content was assessed by burning the sample at 550°C overnight in a muffle furnace. Crude protein and crude lipid were decided using the Kjeltec system 1026 distilling unit and Soxtec system HT 1043 (Tecator, Hognas, Sweden) respectively. To estimate these body composites by wet mass, the proportion of dry tissue unruffled of protein, fat and ash was multiplied by percent solids from the original sample. The percent solid was calculated as the proportion of dry mass to wet mass.

3. RESULTS

The study shows that for proper growth of monosex tilapia, food should be provided with a daily quantity equivalent to 5% of fish biomass in each tank during the first 12 weeks, then gradually reduced to 2% during the second 12 weeks and then reduced to 1.5%. We measured growth rate of monosex tilapia fish in every one week gap and then prepared a growth curve for better understanding as shown in fig. 2. Changes in average body length (cm /fish) of monosex tilapia cultivated in concrete tanks for 08-16 weeks at different stocking density. It is experimentally prove that the lowest stocking density grows faster and had 10.5 folds more than the highest stocking density.

This growth curve shows sigmoid type where see that up to eight weeks the curves almost steady state and then it shows luxury growth upto16-18 weeks and therefore it is said that it is profitable for marginal farmers.

Data on Monosex tilapia growth, survival and yield, and water quality obtained in this study are presented in Table 1. To study the tank surface area is 24 m^2. Number of tilapia culture is used per stocking tank per production cycle is 144 and finally harvest is 125.

From the Table 1 also shows that the mean tilapia weight initially per production cycle is 49.6g but finally its gain in average weight is 186g.

Hybrid tilapia used in this study are fast growing and with their omnivorous feeding habit, attained market size of > 180g after each production cycle lasting 120 days. The feed conversion ratio (FCR) varied from 2.80-2.81 for the three production cycles.

Table 1. Production cycles and culture parameter of monosex tilapia in concrete tanks.

Sl. no	Culture parameters	Production cycles		
		1	**2**	**3**
1	Tank surface area / tanks/household (m2)	24	24	24
2	Number of tilapia (fish/ tanks) - at stocking- at harvest	144 125	144 131	144 130
3	Mean tilapia weight (g) – initial- final	49.5 185.5	49.7 185.9	49.7 185.9
4	Survival (%)	87.5	87.5	87.5
5	Mean daily growth (g/fish/day)	1.12	1.14	1.14
6	Feed conversion ratio	2.80	2.80	2.81
7	Total harvest weight (kg/tank) - adult tilapia - juvenile tilapia	23.12 2.16	23.22 2.18	23.22 2.18
8	Water quality in tanks - pH range - average temperature (°C)	7-8 27.0	7-9 27.0	7-8 27.2

3.1 Basic Norms for Computing Costs and Returns

- One homestead concrete tanks were used for the study.
- The projected amount of sales is not more than85- 90% of the production for the study period.
- Fish mortality and loss of fish were put at 10-15% of stock.
- Market-size of adult monosex tilapia was estimated to be 150-200 g.
- Output was estimated based on final crops of tilapia per production cycle in a year.
- Approximate weight of fish is acquired by average weight x total number of fish production.
- Cost price of fingerlings was calculated at current market prices.
- Poultry waste product was obtained free, only transportation cost was computed.
- Increase in cost of soybean meal (feed) will take care of inflation and price changes.
- Personnel cost price was not included, as household labour was readily available at no cost.

Experiment result shows from Table 2 that total production was 59.04 Kg/ sq. ft per culture tank. The initial fish weight is 5 g and the fish reached a larger size 125 g because larger fingerlings were stoked. Therefore initial growth rates were higher.

From the Table 3, it shows that total production cost of this culture is Rs. 2879.00, where the price of the fry was Rs. 369.00, the cost of the feed is Rs 450.00, the price of the fertilizer was Rs 60.00 and Cost of the human labour was Rs. 2000.00 and therefore, the net profit after 4-6 months it is Rs. 3025.00. So, from this point of view it is told that it is absolutely profitable business for those marginal farmers of our society. The cost and return of tilapia production per tank culture is calculation by Benefit /cost ratio (BCR) from the table3. Here BCR is(3025/2879)1.05.

3.2 Water Quality

Strictly maintain of water quality parameters are needed for monosex tilapia tank culture. Throughout the study the different water quality parameters are regularly monitored time to time using water analyzer kit (Elico- Microprocessor based) model no(PE-138) test kit and these parameters were recorded as Table 4: water temperature, 30.0-31.5°C; pH;7.2- 8.4; turbidity,27.6-41.6 cm; alkalinity, 122.2-144.6 mgL^{-1}; dissolved oxygen, 4.6–6.6 mgL^{-1}; free co_2, 2.6-7.8 mgL^{-1} respectively.

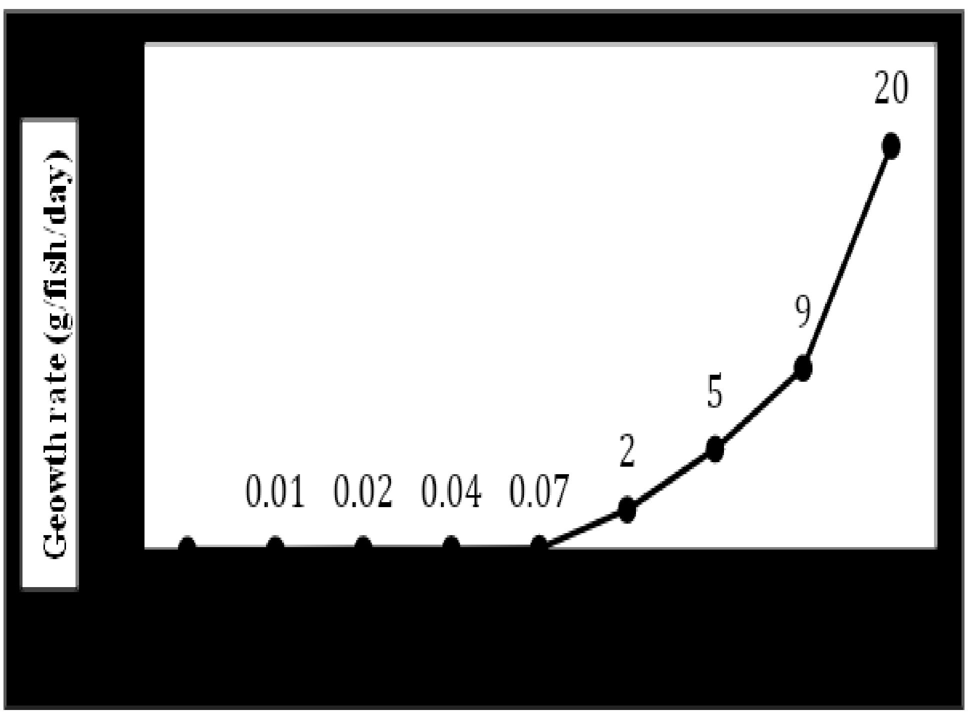

Fig. 2. Monosex tilapia growth rates over 12 weeks in flow through tank system

Table 2. Production of Nile Tilapia

No. of stock fish	Initial Weight(g)	Final Weight(g)	No. of fish recovered	Survival (%)	Production(kg)		Production (%)
616	5g	125(g)	492	79.87	59040g	59.04kg	72.68

Table 3. Cost and Return of Tilapia Fish Production per tank culture

Item	Amount (Rs.)
Cost price of fry	369.00
Cost of feed	450.00
Fertilizer	60.00
Labour cost	2000.00
Total production cost (A)	= 2879.00
Depreciation (B)	= 0.00
Gross Benefit (C)	59.04kg@100.00=5904.00
Net Benefit (D)=C-A	= 3025.00

4. DISCUSSION

Aquaculture has become the world's fastest growing food producing sector, with a growth rate of 10% annually since 1984 and its production more than doubled between 1990 and 1999 from 16.8 million t in 1990 to 42.8 million t in 1999 [19]. Commercially monosex tilapia farming can play a vigorous role for building the people economically stout and fulfilling the protein and nutritional demand. From Table 1 it is observed that the mortality rate of tilapia in tank culture system is so high i.e., 89%. Post-stocking mortality is low and ranged from 9.2% to 12.6%. Siddiqui & Adam [20] is reported similar mortality values (6%-10.4% for nile tilapia, *Oreochromis niloticus*) in tanks, while Balarin & Haller [21] was observed far lower mortality (2.4%) during the growing phase of 25- 50g to 250g monosex tilapia. The values of mean daily growth of nile tilapia fish per culture tank is obtained from this study is 1.12-1.14g/fish/day (Table 1) were lower than values of 1.71-1.81 g/fish/day reported by Siddiqui et al. [22]. Bhujel [23] told that for tilapia culture in Thailand, the cheapest feeds and feed by-products accessible are used to minimize production costs, thereby maximizing profits. Elsewhere, attractiveness of monosex tilapia farming business is increasing rapidly in our country because they are very fast growing, stout and disease less. So, if you are thinking about glowering fish farming business then you can start monosex tilapia farming. The feed conversion ratio (FCR) varied from 2.80-2.81 for the three production cycles when soybean cake or other commercial feed was used as supplementary feed. Allison et al. [24] reported that FCR of 0.92-1.56 for Blue tilapia (*Oreochromis aureus*) fed 25% protein-rich pelleted feed in concrete tanks.

According to study from Table 3, it is experimentally prove that if a farmer invests initially Rs. 2879.00 for tilapia tank culture then his net profit is Rs. 3025.00 (Table 3) excluding in all expenses. The calculation of benefit/cost ratio is presented in table 3 is 1.05. This result of the BCR (Benefit/ Cost ratio) is >1, which indicates that tilapia culture is profitable and hence it is accepted [25]. Therefore, it is nearly 50% profitable which support directly or indirectly to their family as well as society which change their livelihood development. The study has revealed that monosex tilapia could be successfully cultured in peri-urban homestead concrete tanks. Tilapia has worthy potential for the improvement of production in the fishery sector of India but extensive research is required to adopt different techniques of tilapia culture that are practiced in other countries. This practice will significantly enhance the current low per-capita fish protein intake, and when it is widely accepted and extensively practiced it will probably reduce the existing deficit between fish supply and demand in Nigeria [25]. There is must to introduce and boost the practice nation-wide and it should be supported with adequate extension service and advertising with the aim of creating awareness.

In the study optimum growth for tilapia temperature is achieved at 30 to 31.5 °C. The study by Odinga et al. [26] also showed that 60 mg MT/kg feed for 28 days at 30^0C are the optimal conditions for growth of *Oreochromis niloticus* fry grown by hatchery farmers in western Kenya. Water pH and temperature were in optimum ranges for tilapia growth [21]. But they reported acceptance growth rates are at 77 to 90 °F (25 to 32°C). Temperatures in the extreme upper range make it more difficult to maintain the dissolved oxygen concentration. These results are in accordance with the outcomes of WHO reported that in the Indian subcontinent, most of the water bodies had their temperature lying between 7.8^0C and 38.5°C [27]. From the study pH ranged between 7.2to 8.4and the average mean 7.7±0.20 are recorded. Monosex tilapia

Table 4. Range and average values (±Standard error) of selected water quality parameters during experimental period

Treatment	Temperatu re (°C)	pH	Turbidity (cm)	Alkalinity (mgL^{-1})	Do (mgL^{-1})	Free CO_2 (mgL^{-1})
Mono- sex Tilapia	30.0 -31.5 (30.5±0.3)	7.2- 8.4 (7.7±0.20)	27.6-41.6 (33.2±18.7)	122.2-44.6 (131.9±3.8)	4.6 – 6.6 (5.5±0.34)	2.6-7.8 (5.5±0.9)

can survive a wide range of pH, from 5 to 10, but it said to grow best at pH 6 to 9. The dissolved oxygen is ranged between 4.6 to 6.6 mg per liter. Operating levels of DO between 5.0 and 7.5 milligrams per liter (mg/L) are suggested by Singh et al. [28]. Growth and feed conversion will be affected by chronically low DO concentrations below 3.5 mg/L. In tank systems, dissolved free carbon dioxide causes pH to decline because of the formation of carbonic acid (H2CO3) in solution. It is recorded from study is 2.6- 7.8 mg per liter. Maintain at less than 40 mg/L-1 elevated carbon dioxide levels cause slow feeding response in fish. While Nile tilapia can tolerate a wide range of pH dissolved carbon dioxide gas stripping is required in water reuse Systems to keep pH above 6.8.Alkalinity should be maintained at 100to 250 mg/L-1 by accumulation a soluble Sodium bicarbonate is commonly used because it is easily available, highly soluble and safe to handle. So, higher alkalinities need to be maintained if CO_2 stripping is poor. In tilapia tank culture here alkalinity reported is 122.2-144.6 mg/lit which is favorable for culture.

The study has revealed that tilapia can be successfully cultivated in village homestead concrete tanks. Successes and failures have extra to our knowledge of system design, species selection, stock management and nutrition. The practice can be both economically and technically viable, as revealed by the results of the NPU (Net protein utilization) and BCR calculations on the study. The study has also revealed that the culture of hybrid monosex tilapia in outdoor concrete tanks is possible without affecting growth and water quality. There are a number of recurring short courses, workshops and conferences where approaching tank aqua-culturists can learn to plan, design, build and operate facilities with confidence. Formerly putting significant money at risk, it is to your advantage to use these resources, along with resources obtainable on the Web and from your state Cooperative Extension Service.

5. CONCLUSION

The tank culture of nearly all-male populations (monosex) is being conducted with good success. Tilapia culture in India is mainly proficient in small scales by rural people who do not have the infrastructure facilities required for cistern or flowthrough culture systems. Thus, under the eco-socio-economic condition of India, where a large number of freshwater impoundments are obtainable for aquaculture, rearing of androgen treated monosex tilapia in earthen ponds or homestead concrete tanks may be considered as the ideal method of choice for a viable fish production. Before dropping remarkable capital at danger, so it is to our great opportunity to use these resources.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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