



Impact of Stocking Density as the Growth and Biomass Production of Hybrid Tilapia (Red Strain) in Cages

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to evaluate the effect of stocking density influencing the growth of Hybrid Tilapia (Red strain) in cages for culture period of 120 days. The experiment is conducted in Thanjavur Center for sustainable Aquaculture, Sorrokottai, Tamil Nadu, India. Hybrid Tilapia fingerling ABW of (3.3±0.01 g) were stocked at 20/m³ (T₁), 30/m³ (T₂) and 40/m³ (T₃) and fed 3 times daily (9:00, 12:00 and 17:00 H) with a commercial food 40% protein gradually reduce to 35 to 30% protein and stock was sampled fortnight. Among three stocking densities, 20 fish/m³ was found to be the best for the growth in cages, while the FCR and net biomass production were found higher in high stocking densities fishes (30, 40 fish/m³). The best FCR was 1.08 ±0.06 from T₁ (20 fish/m³) with 92.5±0.04% of FCE. The highest net biomass production was 19 kg (3.16 kg/m³) from T₂ (30 fish/m³). Present study reveal that stocking density has negative effect on bio-growth parameters but biomass production has positive effect with stocking density.

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1. INTRODUCTION

Tilapia is the second most cultivated fish in world. Tilapia have been considered as an appropriate animal categories for cage culture by numerous laborers [1-4]. In India Tilapia has been generally presented in the shallow and regular lakes. This fish can shape a promptly accessible wellspring of creature protein in the eating regimens of provincial and urban inhabitants having a place with the lower financial strata. The notoriety of Tilapia is additionally because of its market worthiness and for generally resilience to a wide scope of water temperature, broke up oxygen (DO), saltiness, pH, light power and photo periods. In any case, the assurance of stocking thickness for developing Tilapia is fundamental for the expansion of its generation, productivity and manageability. This is on the grounds that stocking density is viewed as one of the significant elements that an impacts fish development, feed use and the gross yield of fish [5] in many developed fish species, development is conversely identified with stocking density and this is predominantly credited to social associations. In Tilapia, probes the impact of stocking density have been led on various fish sizes including broil and adolescents [6], sub-grown-ups [7] and huge Tilapia [8]. Studies were additionally led utilizing diverseculture frameworks suchas tanks [9], lakes [10] and netenclosures [11,12]. Every one of these investigations demonstrated the immediate connection of stocking density and development execution. At crossroads further examinations are expected to confirm the impacts of stocking thickness and stocking size on the development execution of mixture Tilapia in escalated enclosure cultivating practice. Mossambique Tilapia (*Oreochromis mossambicus*) was the primary Tilapia presented in India during 1952 and because of the productive rearing immediately picked up the notoriety of being an irritation. The red half breed Tilapia (*Oreochromis mossambicu x O. niloticus*) is picking up prevalence among neighbourhood customers because of its good qualities, for example, simple to culture and the executives and furthermore wide agreeableness as a protein source. Thus the prominence of Tilapia is additionally because of its market adequacy and for moderately resistance to a wide scope of water temperature, broke up oxygen (DO), saltiness, pH, light power and photoperiods. Worldwide Tilapia aquaculture

production in 2018 was 5,977 mt and 2017 was 5,798 mt where the India positioned 13 in worldwide Tilapia production. In 2017 the production of Tilapia in India was 18000 mt. FAO reports demonstrate that the Global Tilapia production is relied upon to achieve 7.3 million tons by 2030.

Tilapia cultivating in cage shows better outcomes as far as development than others cultivating framework. To expand Tilapia creation, the escalated cultivating assume a significant job mostly because of utilization of less cultivable zone with higher stocking density and higher yield in brief time frame and furthermore required less serious work. In enclosure cultivating the stocking density greatly affects development, survival, well being, nature of fish seeds, meat, sizes, water quality, creation cost and financial return. In this manner, for better survival rate, greatest fish generation, most noteworthy productivity and manageability in confine culture framework, it is basic to decide its ideal stocking density. Since the stocking density is viewed as one of the significant factor that impacts fish development, feed use and the gross yield of fish . In many developed fish species, development is contrarily identified with stocking density and this is for the most part credited to social associations. In Tilapia, investigates the impact of stocking density have been directed on various fish. Studies were likewise led utilizing distinctive culture frameworks. Every one of these examinations found the immediate connection of stocking density and development execution. It is apparent, consequently, that further investigations are expected to confirm the impacts of stocking density on the development execution of Tilapia in escalated confine cultivating framework.

2. MATERIALS AND METHODS

2.1 Experimental fish (Hybrid Tilapia - Red strain)

The seeds of hybrid tilapia (Red strain) were procured from "Krishnagiri Barur, Center for Sustainable Aquaculture" Tamil Nadu, India. All the fish seeds were properly acclimatized and were nursed for 21 days in hapa. The seeds were graded after 21 days according to their body weight and length. Uniform size seeds were taken for the experiment. The average body weight of the seeds stocked was 3 ± 0.14 grams.

These seeds were stocked in the cages as per the stocking density selected for the study.

2.2 Study Location and Period

The experiment was conducted at “Thanjavur, Centre for Sustainable Aquaculture, Tamil Nadu, India. The experiment was carried for a period of 120 days. The experiment was conducted by using 6 numbers of floating cages of uniform size, each cage measuring 2m L + 2m B+ 1.5m D. The confines were put in a vast water body (1 Ha) situated inside the grounds premises. There were efficient bay and outlet frameworks to keep up appropriate water level in the framework.

2.3 Experimental Design

Uniform size cages with uniform highlights were utilized for this investigation. The cages were given an external net of 1.0 cm work size and internal net of 0.7 cm work estimate with top end shut for biosecurity. The investigation was led to see the impact of various stocking densities (20, 30, 40 fish/m³) with same stocking size (2 inch TL) on development and survival of red tilapia.

2.4 Pre Stocking Preparation

Before beginning the examination the accompanying advances were considered as pre stocking arrangement:-

- a) The site for the settlement of cages were chosen and cleaned up all harmful vegetations of the pond by rehashed manual expulsion framework.
- b) Undesirable, ruthless species which may aggravate little fries were expelled by rehashed drag netting.

- c) Liming is finished by the degree of PH of the lake at 200 kg/ha.
- d) After 15 days of liming, the preparation was finished with just natural compost (Cow dung 10,000 kg/ha).
- e) The gliding cages were arranged and fixed to the shafts with the goal that it can't move away by the water momentum. The confines were additionally tied down with the solid grapple square to forestall their floating. Inward and external net were additionally balanced for each confine. Each confine was checked and levelled obviously to perceive the stock.
- f) The oar Wheel aerators were fixed on the opposite side of the lake to quicken breaks down oxygen content on the pond.
- g) The water parameters were tested for ideal quality checking.
- h) Hybrid tilapia seeds of 2 inches (TL) were sort out as per their size (Total length). The Total Length and weight of the chosen fishes has been recorded before stocking. For Each treatment, a replication group also given to reduce the sampling error. (i.e: T₁ R₁; T₂ R₂; T₃ R₃).
- i) The fishes were discharged in the cages at stocking density of 20 fish/m³ in T₁ R₁; 30 fish/m³ in T₂ R₂; 40 fish/m³ in T₃ R₃.

2.5 Food and Feeding

The exploratory fishes were sustained with 30-40% Crud Protein content business disintegrate encourages (M/s "Growell") accessible in market with various breadths (i.e: 0.6mm, 0.7mm, 1.2 mm, 1.7 mm). Choice of various sizes of feed were finished by the mouth size of the fishes. The proximate arrangements of "M/s growell" are given in Table 2.

Table 1. Experimental design of different stocking density treatment

SL. NO	Stocking density(fish/m ³)	Stocking size (Inch)	Stocking Numbers per cage	Experimental code (T=Treatment) (R=Replica)
1	20	2	120	T ₁ R ₁
2	30	2	180	T ₂ R ₂
3	40	2	240	T ₃ R ₃

Table 2. Proximate composition of commercial crumble feed (Growell feed)

Feed size	Crude protein % Min	Crude Fat % Min	Crude Fiber % Max	Moisture % Max
0.6 mm	40	0.6	3	11.5
0.6 mm	40	0.6	3	11.5
1.2 mm	35	0.6	3	11.5
1.7 mm	30	0.5	5.5	11.5

Table 3. Feeding strategy during the period of 120 days

Culture period (days)	Size of feed (diameter)	Feeding frequency	Feeding rate (% ABW)
0-30	0.6 mm	5 times	4-5%
30-60	0.7 mm	3 times	4-5%
60-90	1.2 mm	3 times	2-3%
90-120	1.7 mm	3 times	2-3%

The feeds were given to the fishes according to the prescribed portion coordinated by the feed maker. The underlying encouraging recurrence was five (5) times each day at 4-5% of the normal body weight. After continuously it has been diminished to three (3) times each day at 2-3% of the normal body weight of the fishes. The bolstering techniques are appeared in Table 3.

2.6 Post Stocking

In the wake of stocking of the seeds in the cages, the accompanying advances have been done consistently.

- Regular cleaning of inward nets to stay away from the overabundance algal arrangement inside the confines.
- Regular cleaning and checking of external nets to avert spillages or some other damages.
- Application of quick lime encompassing the cages to keep away from sullyng of the unsafe pathogens, parasite and so on.
- Daily checking of water temperature and water level and other water parameters and watch their diurnal variations etc.
- Recording the amount of feed given and motility rely on everyday schedule.
- Proper documentation and record keeping and the executives.

2.7 Sampling of Fishes

The mean weight of hybrid tilapia (red strain) under various stocking densities were recorded once in 15 days interim during 120 days study period. The length and weight of fishes were recorded by using scale and convenient portable weighing balance. The fish were outwardly analyzed to decide the well being condition.

2.8 Estimation of Bio Growth Parameters

Following parameters were calculated based on the formula of Pechsiri and Yakupitiyage (2005)

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

Average daily weight gain(ADG) = Final weight – Initial weight / days of culture

Specific growth rate (SGR) = (Ln final weight – Ln initial weight) x 100/ Days of culture)

Food conversion ratio (FCR) = Total feed (g) / Weight gain (g)

Food Conversion Efficiency (FCE) = (Net Biomass / Total feed x100)

Survival rate (SR) = Number of fishes survived / Number of fishes stocked x 100

Production (Biomass) = Number. of fish harvested × Average final weight of fish

2.9 Harvesting

Harvesting was done in the early morning in all cages. The fishes were caught by just lifting the internal nets from the cages. The total biomass of fish were recorded and measured the final weight of the fishes.

2.10 Statistical Data Analysis

The data obtained during the experiment was statistically analyzed by the IBM-SPSS.25. version. The descriptive statistics was used to outline the basic features of the data by simply summarizing the means and standard deviation of weight and other physico chemical parameters. One way analysis of variance (ANOVA) was used to test the study hypothesis followed by the Tukey's HSD used for multiple comparisons.

3. RESULTS

The Bio-growth parameters, Biomass production (Kg/m³/120 days) and Feed conversion parameters details of Hybrid Tilapia (red strain)

under different stocking densities were calculated and presented in Tables 4 and 5. The treatment T₁ (20/m³) shows higher growth rate followed by the treatment T₂ (30/m³) and T₃ (40/m³) respectively shown in Fig. 1. The final mean weights of these three treatments are found to be 220±5.65^a g; 160 ± 5.06^a g and 120 ± 1.41^a g in different stocking densities whereas the initial weights of the fishes were almost similar (3.4 g). One way ANOVA was tested and also compare among the stocking groups shown in the Tables 6, 7. The mean weight gain and daily weight gain are found to be higher in T₁ compare to other treatments that is 216.6±5.37^a and 1.8±0.042 .45±0.01%; 3.17±0.02%; 2.95±0.2% per day for T₁, T₂, T₃(Table 4).

The final biomass found after final harvesting was calculated as 18.9±0.4^a kg in T₁; 19.6±0.6^a kg in T₂; 0.7±0.14^a in T₃. Net biomass production was also calculated by deducting the initial biomass from the final biomass. The Net biomass production was observed highest in T₂ (20/m³) which was 19±2.56 kg (3.16 kg/m³/cage)

and the lowest was 17.7±2.31 kg (1.3 kg/m³/cage) in T₃(40 fish/m³). There is no significant difference among the Net biomass production in three treatments at 5% level of significance (Table 5). The other important parameters which effects directly or indirectly to the growth of the fishes such as survival rate, feed conversion ratio (FCR), Feed conversion efficiency (FCE) also taken into account. The highest FCR was found 1.41±0^a in T₃ and the lowest 1.08±0.062^a in T₁ whereas the FCE value was found to be higher in T₁ (92.5±0.047^a) followed by the T₂ (82.6±0.029^a) and T₃ (70.8±0.03^a) respectively. There is found significant (p<0.01) different of FCR & FCE percentage among three stocking groups. The better survival rate was observed in T₁ (71%) where less fishes were stocked at 20 fry/m³ and the lowest survival rate was found in T₃ (63.5%) where fishes were stocked comparatively in higher stocking density at 40 fish/m³ (Table 5). The survival rates are significantly (p<0.01) different between the stocking groups.

Table 4. Comparison of growth parameters at three (3) different stocking densities

Treatments	Parameters (Mean ± SD)					
	Stocking Number/m ³	Initial weight (g)	Final weight (g)	Weight gain (g)	Daily weight Gain (g)	Specific growth Rate(%/day)
T ₁	20	3.4±0.27	220±5.65 ^a	216.6±5.37 ^a	1.8±0.042 ^a	3.45±0.01
T ₂	30	3.4±0.14	160.5±0.6 ^a	157.1±0.56 ^a	1.305±0.007 ^a	3.17±0.02
T ₃	40	3.3±0.14	120±1.41 ^a	116.2±1.31 ^a	0.965±0.014 ^a	2.95±0.2

*Values having superscript ^a indicates significantly different at (*p<0.05) level of significance.

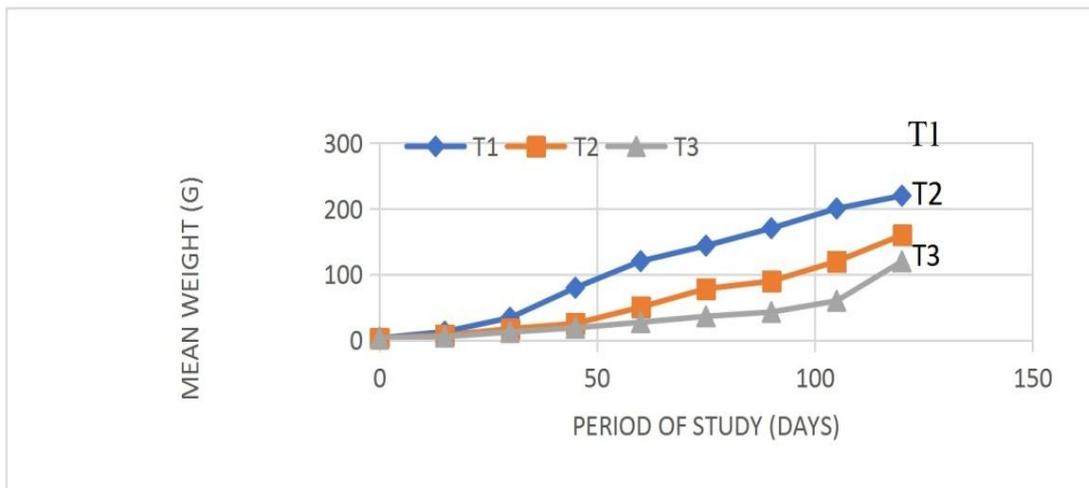


Fig. 1. Growth trends of Hybrid Tilapia grown in cage at different stocking densities

Table 5. Biomass production and feed conversation parameters of Hybrid Tilapia at different stocking densities

Treatments	Parameters (Mean \pm SD)							
	Stocking Number (No/m ³)	Initial Biomass (Kg)	Final Biomass (Kg)	Net Biomass Production gain (Kg/120 days)	Total Feed Given (kg)	Feed conversation ratio (FCR)	Feed conversation Efficiency (FCE %)	Survival Rate (SR%)
T ₁	20	0.4 \pm 0.28 ^a	18.9 \pm 0.4 ^a	18.5 \pm 5.99	20 \pm 0 ^a	1.08 \pm 0.062 ^b	92.5 \pm 0.047 ^b	71 \pm 1 ^b
T ₂	30	0.6 \pm 0.14 ^a	19.6 \pm 0.6 ^a	19 \pm 2.56	23 \pm 0 ^a	1.21 \pm 0.02 ^b	82.6 \pm 0.029 ^b	67.5 \pm 1.5 ^b
T ₃	40	0.7 \pm 0.14 ^a	18.4 \pm 1.41 ^a	17.7 \pm 2.31	25 \pm 0 ^a	1.41 \pm 0 ^b	70.8 \pm 0.03 ^b	63.5 \pm 0.7 ^b

*Values having superscript 'b' indicates significantly different at (*p<0.01) level of significance

Table 6. ANOVA table for mean weight of Hybrid Tilapia

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26545.001	2	13272.501	3.501	.046
Within Groups	90995.199	24	3791.467		
Total	117540.200	26			

Table 7. HSD test for multiple comparisons between different stocking density experiment fishes

Stocking density	Stocking density	Mean Difference	Sig.
20	30	50.31667	.214
	40	75.41111	.040
30	20	-50.31667	.214
	40	25.09444	.667
40	20	-75.41111	.040
	300	-25.09444	.667

4. DISCUSSION

In the present study, it has been observed that the growth performance of Red tilapia is better in lower stocking density groups at 20 fish/m³ than that of fish reared at 30 fish/m³ and 40 fish/m³ stocking groups respectively. And also showed there is highly significant ($p < 0.05$) between the stocking groups. That means there is effect of stocking density on the growth rate of Red tilapia in cage culture system.

This findings also shows similar results found by the Haque et al. [13] who has achieved best growth at lower stocking densities. The mean weights of the two former groups (T₁ & T₂) was significantly higher than the latter (T₃). Based on the summary of studies, this also showed agreement with the majority findings, where found that greater mean final weight corresponded to the low density when studied with different densities. It may be due to less number of fish of similar size in a pond could get more space, food, less competition and dissolved oxygen are reported by various authors (Wiener and Hameman, Ahmed, Benetti et al., Narejo et al., Hanibal et al.) [14,15,16,17,18]. The lower stocking density reduces competition among the fishes which influenced them to take feed properly and it might be absent in the treatments with higher stocking densities.

This finding also similar to the findings of Diana et al. [19], who has suggested that Tilapia stocked at a low density showed better growth than at a higher density. The lower growth performance of Tilapia at higher stocking density could have been caused by voluntary appetite

dominance, more expenditure of energy because of intense aggressive developmental contact, competition for food and living space.

Survival rate is the most important factor for a successful cage aquaculture because they determine the production performance and profit of the system. In the present study the percentage of survival as recorded was 71%, 67% and 63% for T₁, T₂ and T₃ respectively, these results show similar with the findings of Sayeed et al. [20]. Who reported that the Survival was found to be negatively influenced by stocking densities. Fish survival was reasonably good at both low and high stocking densities in both experiments. The findings may indicate that stocking density might have a limited effect on fish survival. The results are more or less similar to those reported by Dambo & Rana [21] reported that the survival of Nile tilapia fry was between 94.5% and 100% at stocking densities ranging from 2 to 20 fry/L.

In addition, El-sayed [22] also found that the survival rate of Nile tilapia ranged from 90 to 100% stocked at different rates ranging from 3 fry/ L to 15 fry/ L. It might be due to the high competition and space among the fishes. Lower density gave larger size and higher survival rate in *Clarias macrocephalus* reported by Mollah [23]. The highest weight gain and survival rate of *Heteropneustes fossilis* in lower stocking density reported by Narejo et al. [24].

Feeds and feeding are the most important criteria in terms of cost of production in cage culture system. In the present study, the FCR values of T₁ were significantly lower followed by T₂, and T₃.

This indicates probably low density stocked fishes might have high efficiency to convert given feed to flesh than fish stocked with high density in terms of growth. It can be explained that Food conversion ratio increased with increasing stocking density thus as stocking densities increased the fry became less efficient for converting given feed, hence the growth may hamper. This is also attributed to increased stress due to decreasing water quality as stocking density is increased far beyond the carrying capacity.

This is in agreement Guimareaes et al. [25] who found out that efficient utilization of diets may vary within a single species because of not only the particular strain of fish but also environmental factors.

The daily weight gain and specific growth rate generally decreased with increasing stocking density in the experiment indicating the decreasing feed utilization ability as increasing density as explained above. But anomaly at 20 fry/m³ is attributed to the very high survival rate. This affected growth negatively thus lowering both the specific growth rate and daily weight gain. Higher SGR, ADG and WG in reared fish imply fast growth as compared to lower values observed indicated slow growth. This result is in agreement with the findings of Gibtan et al. [26] who studied the effects of stocking density (50/m³, 100/m³, 150/m³ and 200/m³) on the same species under cage culture and found that the highest weight (219.71g) of *O. niloticus* was attained at a density of 50 fish/m³ followed by average weight of 197.48 g, 169.120 g and 147.76 g respectively.

There was an increasing trend of gross and net fish yield with increasing stocking density (Fig. 1). The final harvest and production values were directly related to stocking density and there must be a limit where mortality will be severe and growth and production will be reduced [27]. In contrast, Ridha, M. T. [28] better growth and production performance in mixed sex GIFT tilapia at T₁ 25 than the present study.

5. CONCLUSION

The experiment was conducted to study the effect of stocking density on growth, biomass production and survival rate of Hybrid Tilapia (Red strain) in six floating cages with three treatments (T₁, T₂ and T₃) each having one replication which were selected randomly. The experiment was done in 120 days. Hybrid tilapia

fingerling after rearing in hapa for 30 days were stocked in cages at stocking densities of 20 fish/m³(T₁), 30 fish/m³ (T₂) and 40 fish/m³ (T₃). They were culture for 120 days with regular feeding (M/s Gro-well feed) and monitoring water quality parameters such as TDS, DO, pH, temperature, alkalinity, ammonia, nitrite & nitrate at laboratory.

20 fish/m³ was found to be the best stocking density for Hybrid Tilapia in intensive cage culture system. The mean weight gain was found to be 216.6±5.37 g for the T₁ (20 fish/m³) and the survival was 71.1±1%. The best FCR was 1.08±0.06 with FCE 92.5% in T₁ (20 fish/m³).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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