Journal of Fisheries International 8 (2): 25-30, 2013
ISSN: 1817-3381

Growth and Economic Performance of Nile Tilapia (*Oreochromis niloticus*) Fed Two Feed Type at Different Stocking Densities in Semi Flow Through Culture System

A.F. Yakubu, O.O. Ajiboye, N.A. Nwogu, E.D. Olaji and T.E. Adams
Nigerian Institute for Oceanography and Marine Research,
P.M.B. 4015, Sapele, Delta State, Nigeria

Abstract: The growth and economic performance of Nile tilapia (*Oreochromis niloticus*) in relation to stocking density was evaluated in a semi flow through culture system. Fingerlings weighing 6-8 g were held in densities of 158, 237 and 316 m^{-3} in 12 circular fibre glass tanks each containing 1.9 m^{-3} of water. The experimental animals were fed 2 types of feed: MULTI feed (foreign) and NIOMR feed (local) of 32 and 44% Crude Protein (CP), respectively for over 24 weeks. The overall growth rates showed significantly ($p<0.05$) highest growth, feed conversion and survival rate in treatment II (MULTI feed at 158 fish m^{-3}) while significantly lowest growth rate and feed conversion was recorded in treatment V (NIOMR feed at 158 fish m^{-3}). In terms of gross profit, treatments 2, 4 and 5 seemed more profitable with values of 801.50, 59.78 and 153.43 Naira, respectively. The profit index, also showed that treatments 3 and 5 had better profit index of 26.01 and 28.09, respectively than other treatments. In addition, treatments I recorded the best incidence of cost with a value of 5.69 followed by treatment 3 with value of 5.79. Treatments 2, 4 and 5 recorded values of 1.22, 1.01 and 1.02, respectively indicating that those treatments were profitable unlike the other treatments. The results of the study indicate that fish fed with MULTI feed and stocked at 158 fish m^{-3} in treatment 2 had the best FCR of 6.52. In addition, all water qsuality parameters are within the acceptable and suitable range for proper growth of *O. niloticus*. Based on the growth performance (final mean weight, survival rate, feed conversion ratio) size of fish at harvest and benefit cost ratio, treatment 2 (stocking density of 158 fish m^{-3}) fed multi feed is recommended.

Key words: Growth, yield, economic performance, Nile tilapia, flow-through culture system

INTRODUCTION

Fish accounts for about a 5th of world total supply of animal protein and this has risen 5 folds over the last 40 years from 20-98 million metric ton in 1993 and projected to exceed 150 million metric ton by the year 2010 (Olagunju *et al*., 2007). According to the FAO (2006) aquaculture has grown into a multi-billion dollar industry. Rapid growth in the aquaculture industry has helped to alleviate some of the human dependence on depleted natural fish stocks. The Nile tilapia, *Oreochromis niloticus* is a member of the Cichlid family native to Africa (FAO, 2001) that has been widely cultured due to its culture potentials (for example, wide tolerance for poor environment, prolific breeder and completes its life cycle in captivity) (El-Sayed, 1999; Tahoun *et al*., 2008).

The importance of financial analysis and information for fish farming cannot be over emphasized. To compare economic returns from a production venture, budgets for expenditure and returns for each feed/stocking density combination must be prepared (McCay and Boutwell, 1977). Surprisingly, the benefits of fish farming in monitory terms have not been fully documented. However, information on yield is available. Information on yield without corresponding information on cost of production cannot give accurate information on economic returns. Meade (1989) and Pfeiffer and Jordan (1986), reported that profit or loss can be measured from expenditure and income record of the farm.

Fish culture activities in many other parts of the world create the need to have adequate knowledge of good stocking to obtain better and healthier yields. Stocking density is an important indicator that determines the economic viability of the production system (Ako *et al*., 2005; Aksungur *et al*., 2007). Knowing the best densities for a species is a critical factor for good husbandry practices and creating efficient culture systems. On the other hand, intensive water flow through system using fibre glass tanks offers several advantages over pond culture. For instance, high fish density in fibre

Corresponding Author: Olufemi Oluseun Ajiboye, Nigerian Institute for Oceanography and Marine Research, P.M.B. 4015, Sapele, Delta State, Nigeria

glass tank disrupts breeding behavior and allows male and female tilapia to be grown together to marketable size. The objectives of the present study, therefore was to investigate the effects of stocking densities and two feed type (MULTI feed (foreign) and NIOMR feed (local)) on growth and economic performance of *O. niloticus* reared in a semi flow through culture system.

MATERIALS AND METHODS

Growth and economic performance of mixed-sex population of Nile tilapia (*Oreochromis niloticus*) fingerlings of average weight of 6-8 g were analyzed in 12 circular fibre glass tanks each with a capacity of 3.08 m^{-3} of water. The experiment was conducted at the Nigerian Institute for Oceanography and Marine Research, Sapele out-station (N05°54'03.5"E05°39'56.4") in 2 phases in succession and cultured for a period of 24 weeks in each phase. Different stocking densities of 158, 237 and 316 m^{-3} were used and the trial was repeated twice. The tanks were mounted indoor in a flow through and arranged in a row.

Throughout the study, experimental fish were fed commercial diets (NIOMR feed) containing 44% crude protein and (MULTI feed) containing 32% crude protein twice daily 6 experimental treatments were used. Each combination was replicated twice in 2 phases. The experimental design was 2 feed type ×3 stocking densities replicated twice. A total of 12 culture units were used in the 2 phases as earlier stated.

During the 24 weeks culture period, random samples of 100 fish were measured and weighed bi-weekly from each tank. Fish were weighed in grams using mettler PC 180 weighing balance. Different growth parameters and economic parameters of feed calculated as described by Ahmad (2000).

Proximate analysis of the experimental diets was carried out. Sampling of the cultured fish was carried out bi-weekly for a period of 24 weeks for the collection of data to determine the variation among the treatments. Throughout the entire culture period, different water quality parameters like temperature, dissolved oxygen, pH, nitrate, nitrite and total ammonia were regularly monitored. Data collected were subjected to statistical test using Analysis of Variance (ANOVA). Mean separation was done using Duncan multiple range test and least significant difference. All tests were carried out at 5% probability level ($p<0.05$). The genstat statistical package (version 8.1) was used for te analysis.

RESULTS AND DISCUSSION

The growth parameters of *O. niloticus* in different treatments in terms of mean weight gain, final mean weight, Specific Growth Rate (SGR) survival (%) FCR and fish biomass were calculated and are shown in Table 1. Apart from the sampling at week 2, the general trend for bi-weekly growth pattern for all treatments showed a step-wise pattern with the 2 feed types at the stocking density of 158 fish m^{-3} being the highest while that of 316 fish m^{-3} was consistently the lowest (Fig. 1).

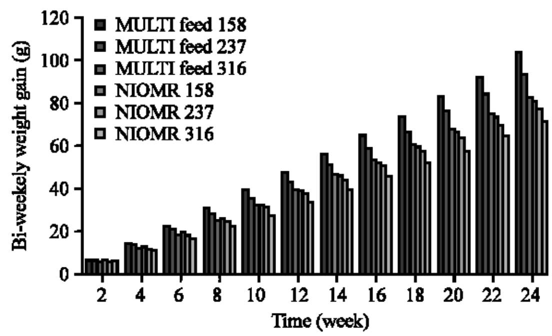

Fig. 1: Bi-weekly weight gain of *O. niloticus* stocked at different densities and fed 2 types of feed

Table 1: Growth parameters of *O. nilotiocus* with different stocking densities reared in fibre glass tanks fed NIOMR feed and MULTI feed in a semi flow through culture system

	Treatments					
Parameters	1	2	3	4	5	6
Initial mean weight (g)	6.92^{a}	6.65^{a}	5.78^{c}	6.85^{a}	6.14^{b}	5.83^{c}
Mean weight gain (g)	73.93^{d}	97.03^{a}	71.72^{e}	79.96^{b}	59.20^{f}	71.16^{c}
Final mean weight (g)	80.85^{d}	103.68^{a}	77.50^{e}	86.81^{b}	65.34^{f}	76.99^{c}
Specific growth rate (% day^{-1})	1.46^{a}	1.64^{a}	1.55^{a}	1.56^{a}	1.46^{a}	1.58^{a}
Survival rate (%)	96.33^{b}	98.00^{a}	96.96^{b}	97.00^{b}	96.98^{b}	94.02^{c}
Feed intake (g/feed/fish)	510.39^{f}	633.01^{e}	749.98^{d}	865.44^{c}	887.97^{b}	1034.88^{a}
Mean size at harvest (g)	80.85^{c}	103.68^{a}	77.50^{d}	86.81^{b}	65.34^{f}	76.99^{e}
Mean biomass at harvest (kg)	23.92^{f}	30.80^{e}	34.48^{d}	40.00^{b}	37.21^{c}	43.73^{a}
Feed conversion ratio	6.90^{c}	6.52^{c}	10.46^{b}	9.97^{b}	13.59^{a}	13.44^{a}

Means with different superscripts in the same row are significantly different ($p<0.05$); 1 = NIOMR feed at 158 fish m^{-3}, 2 = MULTI feed at 158 fish m^{-3}; 3 = NIOMR feed at 237 fish m^{-3}; 4 = MULTI feed at 237 fish m^{-3}; 5 = NIOMR feed at 316 fish m^{-3}; 6 = MULTI feed at 316 fish m^{-3}

The result of proximate analysis of the feed were with 44% crude protein, 5.23% ether extract, 5.60% crude fiber, 4.33% ash, 11.60% moisture and 1.20% calcium for NIOMR diet while 32% crude protein, 4.0% ether extract, 5.0% crude fiber, 8.0% ash and 1.20% phosphorous for MULTI feed.

There was no significant difference in mean biomass among the treatments ($p>0.05$). Mean biomass generally increased with stocking density and within the same stocking density. Treatments that received multi feed recorded higher mean biomass than treatments that received NIOMR diet (Table 1). The highest mean size of harvested fish (103.68 g) was recorded in treatment 2 stocked at a lower density 128 fish m^{-3} but lower yield (30.80 kg) (Table 1). Treatment 4 (MULTI feed at 316 fish m^{-3}) recorded a greater yield (43.73 kg) and greater mean size of fish (76.99 g).

The results of the study on the effects of stocking densities and feed type on growth and economic performance of Nile tilapia (*O. niloticus*) in semi flow-through culture system are presented.

Stocking density and growth: The growth parameters were significantly affected by stocking density ($p<0.05$). In this present study, fish fed at low (158 fish m^{-3}) and intermediate stocking density (237 fish m^{-3}) generally have higher growth rate than the high density treatment (316 fish m^{-3}). The results of the study also showed a significant difference ($p<0.05$) between the 2 different types of diet even at similar densities. The fish growth rate proceeded in a linear fashion throughout the treatment as shown in Fig. 1.

Mean Weight Gain (MWG): As shown in Table 1 and Fig. 1, stocking density has significant effects on the mean weight gain. The highest mean weight gain of 97.03 g was recorded in treatment 2 (MULTI feed at 158 fish m^{-3}) which was significantly different from all the other treatments (Table 1). The least mean weight gain of 59.20 g was observed in treatment 5 (NIOMR feed at 316 fish m^{-3}).

Specific Growth Rate (SGR): The average values of SGR ranged between 1.46 in treatment 1 and 5-1.64 in treatment 2 (Table 1). No significant differences were observed in SGR between the treatments ($p>0.05$).

Final mean weight: Table 1 show that there were significant differences in final mean weight between the 2 feed types and among the three stocking densities. The highest final mean weight of 103.68 g was recorded in

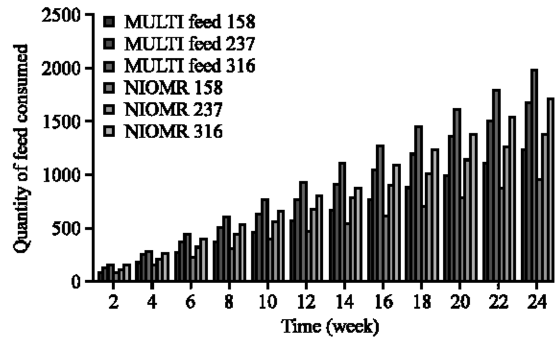

Fig. 2: Quantity of 2 feed types consumed during experimental period

treatment 2 (MULTI feed at 158 fish m^{-3}) while the least final mean weight of 65.34 g was observed in treatment 5 (NIOMR feed at 316 fish m^{-3}). In general, final mean weight increased with decreasing stocking density and treatments that were fed with multi feed performed better than those fed with NIOMR diet at equivalent stocking densities. This stepwise pattern of growth was illustrated in Fig. 1.

Survival: In terms of survival rate, there were significant differences among treatments ($p<0.05$). However, survival rate exceeded 90% in all treatments (Table 1). The survival rate was found highest (98.0%) in treatment 2 (MULTI feed at 158 fish m^{-3}) while significantly ($p<0.05$) lowest survival rate was recorded (94.02%) in treatment 4 (MULTI feed at 316 fish m^{-3}).

Feed intake: As shown in Table 1 and Fig. 2, there was a significant difference in the feed intake among the treatments ($p<0.05$). The highest feed intake (1034.88 g) was recorded in treatment 4 (MULTI feed at 316 fish m^{-3}) while significantly ($p<0.05$) lowest feed intake (510.39 g) was recorded in treatment 1 (NIOMR feed at 158 fish m^{-3}). Furthermore, the data indicate that at a similar stocking density fish fed with NIOMR diet consumed significantly less feed than those fed with MULTI feed diet.

Feed Conversion Ratio (FCR): Feed conversion ratio varied significantly among the treatments (Table 1). Treatments 1 and 2, recorded the lowest FCR which were not significantly different from each other. In a similar manner, treatments 3 and 4 performed equally and recorded intermediate FCR while treatments 5 and 6, stocked at the same rate but received 2 different feed types had the highest FCR and were not significantly different from each other. Thus, the FCR increased with increasing stocking density for the 2 feed types and better at lower stocking densities.

Water quality analysis: The results show that the highest temperature of 25.80°C was recorded for treatment 5 while the least temperature of 25.50°C was observed in treatment 3. The highest pH of 7.00°C was recorded for treatment 3 while the least pH of 6.98°C was recorded in treatments 5 and 2.

The highest Dissolved Oxygen (DO) of 11.05 mg L^{-1} was recorded for treatments 3 while the least DO of 10.93 mg L^{-1} was recorded in treatment 4.

The highest ammonia nitrogen (NH_3N) of 3.00 mg L^{-1} was recorded for treatment 6 while the least ammonia nitrogen (NH_3N) of 2.43 mg L^{-1} was recorded in treatment 2.

The highest unionized ammonia (NH_3) of 0.02 mg L^{-1} was recorded for treatments 6 while the least unionized ammonia (NH_3) of 0.01 mg L^{-1} was recorded in treatments 2. In general, there was no significant difference in the water quality parameters recorded among the treatments. All water quality parameter are within the acceptable and suitable range for proper growth of *O. niloticus*.

Benefits and returns: Treatments 2, 4 and 5 recorded positive gross profit while treatments 1, 3 and 6 showed negative values (Table 2). The highest gross profit of ₦801.50 was recorded in treatment 2 (MULTI feed at 158 fish m^{-3}). This was followed by treatments 5 and 4 that recorded ₦153.43 and 59.78, respectively. This suggests that unlike treatments 1, 3 and 6 that recorded negative gross profit, *O. niloticus* can be produced at a profit using this system.

All the treatments showed positive profit index (Table 2). The highest profit index of ₦28.09 was observed in treatment 5 (NIOMR feed at 316 fish m^{-3}) while treatment 6 (MULTI feed at 316 fish m^{-3}) recorded the lowest profit index of ₦18.41.

Incidence of cost: In terms of incidence of cost, treatment 6 ((MULTI feed at 316 fish m^{-3}) recorded the highest value of ₦6.77 while treatment 1 recorded the least value of ₦5.69 (Table 2).

Benefit/cost ratio: The benefit/cost ratio is shown in Table 2. Treatments 2, 4 and 5 recorded values of 1.22, 1.01 and 1.02, respectively indicating that those treatments were profitable. Treatments 1, 3 and 6 showed values of 0.92, 0.85 and 0.80, respectively indicating a loss.

Growth performance: In this study, there was significant reduction in growth ($p<0.05$) with increasing stocking density in all the treatments. This result is in agreement with Huang and Chiu (1997) who studied the effects of stocking density (0.1, 0.2, 0.4, 1.6 and 3.2 fry L^{-1}) for fry Nile tilapia and found that the fish size and production were found to be significantly affected by stocking density. Also Canario *et al.* (1998), studied the effect of stocking density (0.35, 1.3 and 3.2 kg m^{-3}) on the growth of gilthead sea-bream, *Sparus aurata* and found that fish in the highest density group grew 25% slower than fish in the lowest density group. The explanations for the effects of stocking density on fish growth are very complex, as many interdependent factors are concerned (Abou *et al.*, 2007). However, stocking density is already cited as an inhibitory factor for fish growth (Helser and Almeida, 1997; Irwin *et al.*, 1999; Islam, 2002), space limitation (Ewing *et al.*, 1998) and low DO (Yi *et al.*, 1996).

Based on the overall growth performance of *O. niloticus* in a semi-flow through culture system as observed in this study, final mean weight and mean weight gain increased with decreasing stocking density and treatments that were fed MULTI feed performed with

Table 2: Cost benefit analysis of *O. niloticus* cultured at different stocking densities in a flow through culture system

	Quantity		Unit cost (₦)		Total cost (₦)		Depre-ciation	NIOMR feed			MULTI feed		
Items	NIOMR	MULTI	NIOMR	MULTI	NIOMR	MULTI	(%)	1	3	5	2	4	6
Fixed costs													
Fibre glass tank	6	6	12500	12500	150000	150000	20	20	20	20	20	20	20
Variable cost													
Fingerlings	2850	2850	10	10	13500	13500		3000	4500	6000	3000	4500	6000
Feed (15 kg bag^{-1})	2.16	2.53	4000	4300	576	725.27		136.07	199.65	239.94	181.46	247.90	296.41
Labour (₦)	1	1	1500	1500	1500	1500		500	500	500	500	500	500
Total variable cost								3636.07	5199.95	6739.94	3681.46	5247.68	6796.41
Revenue													
Tilapia sales (₦)	95.61	114.53	200	200	19122	22906		3344	4437	6893.37	4482.96	5307.68	5456.24
Profitability													
Gross profit (₦)								-292.07	-762.95	153.43	801.50	59.78	-1339.87
Profit index (₦)								24.58	26.01	28.09	24.71	21.41	18.41
Incidence of cost (₦)								5.69	5.79	6.45	5.89	6.19	6.77
Variability													
Benefit/cost ratio								0.92	0.85	1.02	1.22	1.01	0.80

1 = NIOMR feed at 158 fish m^{-3}; 2 = MULTI feed at 158 fish m^{-3}; 3 = NIOMR feed at 237 fish m^{-3}; 4 = MULTI feed at 237 fish m^{-3}; 5 = NIOMR feed at 316 fish m^{-3}; 6 = MULTI feed at 316 fish m^{-3}

better than, those fed with NIOMR diet at equivalent stocking densities (Fig. 1). Similarly Silva *et al.* (2000), also studied the effect of stocking density (2, 3 and 4 kg m^{-3}) on the growth of tetra-hybrid red tilapia and found that final body weight gain was significantly higher at density of 2 and 3 kg m^{-3} while the biggest biomass and feed consumption were observed at density of 4 kg m^{-3}.

The values for crude protein, ether extract and crude fibre were higher in NIOMR diet then in MULTI feed while ash content was the reverse. The research findings in this study also show that FCR is density dependent, i.e., higher fish density resulted in higher FCR. Similar observations have been made in caged farming by Cruz and Ridha (1989) and Watanabe *et al.* (1990) with *O. niloticus* and Florida Red Tilapia, respectively, as well as with the catfish *Pangacius sutchi* (Almazan-Rueda, 2004).

The most rapid growth and highest survival occurred in treatment 2. The application of feed remains an important tool because even at 316 fish m^{-3} and intensive feeding, water quality remained within the acceptable limit. Because concentrations of DO and other water quality variables never fall below the minimum acceptable levels it would have been expected that a higher stocking rate would likely have resulted in greater production and profit. The semi water flow-through system used in this experiment appeared to be a successful way to control nutrient addition, as there were no differences in most chemical and biological variables among the treatments. This was in agreement with Diana *et al.* (1991) who conducted a similar experiment on effects of stocking density and supplemental feeding in Nile tilapia and similar results were reported. Considering that the critical water quality variables that were monitored were all within acceptable levels, it is surprising that higher stocking and feeding did not result in greater production and possible profit.

Economic performance: Treatments 2, 4 and 5 showed positive gross profit which increased from ₦59.78 for treatment 4 to ₦153.43 for treatment 5. In contrast, treatments 1, 3 and 6 recorded negative profit indices indicating less desirability. Two of the three treatments (2, 4) that showed positive profit index received MULTI feed at the low and intermediate stocking densities while the 3rd treatment (5) received NIOMR feed at the high stocking density. Treatments showing negative profit index included treatments 1 and 3 that received NIOMR feed at the low and high stocking densities and treatment 6 that received multi feed at the high stocking density. It could be concluded that multi feed gives positive profit index when fed to *O. niloticus* stocked at the low and intermediate stocking densities whereas NIOMR feed performed better than the multi feed only at the high stocking density. It appears that multi feed (32% crude protein) that costs ₦4,300.00 bag^{-1} gives more efficient growth performance at low and intermediate stocking densities whereas NIOMR feed (44.38% crude protein) and cheaper showed better growth performance only at the high stocking density.

The profit index showed that it was more beneficial in terms of feed input to invest on treatments 3 and 5 with a profit index of ₦26.01 and ₦28.09, respectively. This result was at variance with the pattern in the total net production and feed intake. The fish fed MULTI feed in treatment 4 and 6 had better net production. This could be attributed to large number of individuals and consequently higher weigh at harvest. The incidence of cost for *O. niloticus* culture in semi water flow-through system at different stocking densities showed values for treatments, 1, 3 and 5 to be 5.69, 5.79 and 6.45, respectively while treatments 2, 4 and 6 had values 5.89, 6.19 and 6.77, respectively.

The benefit/cost ratio showed that only treatment 2, 4 and 5 were viable with values above 1. Utomakili and Aganmwonyi stated that benefit/cost ratio that is >1 is viable. Thus, 2 stocking densities (2 and 4) fed with MULTI feed are economically viable while one stocking density (treatment 5) fed with NIOMR feed is also economically viable. The viability of MULTI feed at treatment 2 and 4 can be attributed to better growth performance and returns. In all the stocking densities NIOMR fed fish at treatments 1 and 3 that received NIOMR feed and treatment 6 that received MULTI feed had benefit/cost ratio of <1, thus making them not viable. Although, treatment 6 recorded the highest mean biomass (yield) of 43.73 kg, its benefit/cost ratio showed that it is not profitable. This is in agreement with other studies that have shown that highest yields per unit of area are not the most economical in culture systems that receive feed and/or fertilizers. Therefore, it is more economically viable to invest on culture of *O. niloticus* usinsg water flow through system at stocking densities of treatments 2 and 4 using MULTI feed, since it gives good return.

CONCLUSION

Based on the overall growth performance (mean weight gain, final mean weight, survival rate and feed conversion ratio) size of fish at harvest and benefit/cost ratio, treatment 2 (stocking density of 158 fish m^{-3}) and feeding with multi feed appears preferable to feeding with

NIOMR feed. Further studies, especially in the areas of protein quality and protein-energy ratio are suggested in the formulation of NIOMR feed.

REFERENCES

Abou, Y., E.D. Fiogbe and J.C. Micha, 2007. Effects of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed Azolla diet, in earthen ponds. Aquacult. Res., 38: 595-604.

Ahmad, M.H., 2000. Improve productive performance in fish. Ph.D. Thesis, Department of Animal Production, Faculty of Agriculture, Zagazig University.

Ako, H., E. Shimizu, K. de Lemos, L. Asano and C. Tamaru, 2005. Behavioral limitations of high density fish grow-out. World Aquacult., 36: 25-29.

Aksungur, N., M. Aksungur, B. Akbulut and I. Kutlu, 2007. Effects of stocking density on growth performance, survival and food conversion ratio of Turbot (*Psetta maxima*) in the net cages on the southeastern coast of the Black Sea. Turkish J. Fish. Aquat. Sci., 7: 147-152.

Almazan-Rueda, P., 2004. Towards assessment of welfare in African catfish, *Clarias gariepinus*: The first step. Ph.D. Thesis, Wageningen University, The Netherlands.

Canario, A.V.M., J. Condeca, D.M. Power and P.M. Ingleton, 1998. The effect of stocking density on growth in gilthead sea-bream, *Sparus aurata* (L.). Aquac. Res., 29: 177-181.

Cruz, E.M. and M. Ridha, 1989. Preliminary study on the production of tilapia, *Oreochromis spilurus* (Gunther), cultured in seawater cages. Aquacult. Fish. Manage., 20: 381-388.

Diana, J.S., C.K. Lin and P.J. Schneeberger, 1991. Relationship among nutrient inputs, water nutrient concentrations, primary production and yield of *Oreochromis niloticus* in ponds. Aquaculture, 92: 323-341.

El-Sayed, A.F.M., 1999. Alternative dietary protein sources for farmed, *Oreochromis* sp. Aquaculture, 179: 149-168.

Ewing, R.D., J.E. Sheahan, M.A. Lewis and A.N. Palmisano, 1998. Effects of rearing density and raceway conformation on growth, food conversion and survival of juvenile spring chinook salmon. The Progres. Fish-Cult., 60: 167-178.

FAO, 2001. Summary tables of fishery statistics: World aquaculture production by principal species. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2006. The state of the world fisheries and aquaculture. FAO, Rome, Italy.

Helser, T.E. and F.P. Almeida, 1997. Density-dependent growth and sexual maturity of silver hake in the Northwest Atlantic. J. Fish Biol., 51: 607-623.

Huang, WB. and T.S. Chiu, 1997. Effects of stocking density on survival, growth, size variation and production of *Tilapia* fry. Aquac. Res., 28: 165-173.

Irwin, S., J. O'Halloran and R.D. FitzGerald, 1999. Stocking density, growth and growth variation in juvenile turbot, *Scophthalmus maximus* (Rafinesque). Aquaculture, 178: 77-88.

Islam, M.S., 2002. Evaluation of supplementary feeds for semi-intensive pond culture of mahseer, *Tor putitora* (Hamilton). Aquaculture, 212: 263-276.

McCay, E.W. and J.L. Boutwell, 1977. Preparation of Financial Budget for Fish Production, Catfish Production in Areas with Level Land and Adequate Ground Water. Agricultural Experiment Station, Auburn University, Auburn, Alabama, Pages: 48..

Meade, J.W., 1989. Aquaculture Management. Van Nostrand Reinhold Publishers, New York, USA., ISBN: 9780442205706, Pages: 175.

Olagunju, F.I., I.O. Adesiyan and A.A. Ezekiel, 2007. Economic viability of catfish production in Oyo state, Nigeria. J. Hum. Ecol., 21: 121-124.

Pfeiffer, W.C. and H. Jordan, 1986. Investment analysis of commercial aquaculture in central Canada. Canada Industry Report of Fisheries and Aquatic Science, No. 160, University of Gueiph, Ontario, Canada, May 1986, pp: 60-70.

Silva, P.C., V.L. Souza, D.M.C. Padua, P.C. Dalacorte and D.C. Goncalves, 2000. Effect of Stocking Density on Growth and Fillet Composition of Tetra Hybrid Red Tilapia, Israeli Strain. In: Tilapia Aquaculture in the 21st Century: Proceedings from the 5th International Symposium on Tilapia Aquaculture, Volume 2, September 3-7, 2000, Fitzsimmons, K. and J.C. Filho (Eds.). Ministry of Agriculture, Rio de Janeiro, Brazil, pp: 341-345.

Tahoun, A.M., M. Ibrahim, Y.F. Hammouda, M.S. Eid, E. Zaki, M.M.A. Din and F.I. Magouz, 2008. Effects of age and stocking density on spawning performance of Nile tilpia, *Oreochromis niloticus* (L.) broodstock reared in hapas. Proceedings of the 8th International Symposium on Tilapia in Aquaculture, October 12-14, 2008, Cairo, Egypt -.

Watanabe, W.O., J.H. Clark, J.B. Dunham, R.I. Wicklund and B.L. Olla, 1990. Culture of Florida red tilapia in marine cages: The effects of stocking and dietary protein on growth. Aquaculture, 90: 123-134.

Yi, Y., C.K. Lin and J.S. Diana, 1996. Effects of stocking densities on growth of caged Nile tilapia (*Oreochromis niloticus*) and on yield of small tilapia in open pond water in earthen ponds. Aquaculture, 146: 205-215.