

EFFECTS OF STOCKING DENSITY AND PROTEIN LEVEL IN DIET ON GROWTH PERFORMANCE, SURVIVAL RATE AND FEED EFFICIENCY OF NILE TILAPIA (*OREOCHROMIS NILOTICUS* L.) FRY MONOSEX DURING THE NURSERY PERIOD.

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ABSTRACT

The effects of stocking density and dietary protein levels on growth performance, larval survival and feed utilization efficiency of Nile tilapia (*O. niloticus* L.) fry monosex (0.014 g average initial body weight) were investigated in a single-stage nursery-rearing system using 1389 and 2778 hatchlings/ m³ as stocking densities within each density 29.71, 34.43 and 39.11% dietary protein levels. Twelve fiberglass tanks (180 liter volume for each) on a flow- through system (100%/day) were used to represent the two stocking densities and the three protein levels in replicates. The dietary treatments were fed 7 days/week (twice daily) at a rate of 15% of the total biomass during the 1st 45-days then reduced to 10% of total biomass from days 46 to 75, after that it was reduced to 5% of total biomass till the end of the experiment (105 days).

The results revealed that there was significant increase ($P < 0.01$) in growth rate with decreasing stocking density and increasing dietary protein level during all experimental periods. The same trend was also observed for mean body weight (g), specific growth rate (SGR%/day), condition factor (k) and survival rate (SR %). The best final mean body weight (g), SGR, K and (SR %) were recorded in groups of fish stocked in 1389 hatchlings /m³ and fed on the diet containing 39.11% CP (T₃SR₁).

Feed conversion ratio (FCR) was significantly ($P < 0.01$) decreased (improved) in T₃SR₁ (Lower stocking density with higher dietary protein level) group compared to the other groups. Improvement in FCR was achieved when dietary protein increased, while increasing stocking density increased (not improved) FCR ($P < 0.01$). On the contrary, protein

efficiency ratio (PER) was negatively correlated with dietary protein level and stocking density.

The highest net return was achieved with T₃SR₁ (lower stocking density with higher dietary protein) followed in a descending order by fish of T₂SR₂ (higher stocking density with medium dietary protein) and T₃SR₂ (higher stocking density with higher dietary protein). The lowest net return was recorded by fish of T₁SR₂ (higher stocking density with lowers dietary protein).

Results of this study revealed that fish reared at low stocking density (1389 hatchlings/m³) and fed high dietary protein level (39.11%) T₃SR₁ group may be advisable in a single- stage nursing for production of adequate quality seeds of Nile tilapia monosex in short time with lowest mortality in order to be available as healthy fry at the beginning of the culture season for fish farmers.

INTRODUCTION

Tilapia is the second most important farmed fish in the world, after carps. Great attention has been paid to tilapia culture in recent years. Despite the great potential of tilapia culture, shortage of fry production to meet the increased global demands remains one of the main obstacles limiting the expansion of intensive culture of these fishes. Information regarding larval culture, especially the effects of stocking density and dietary protein levels on fish fry management is limited, inconsistent and sometimes controversial. For example, Dambo & Rana (1992) found that the growth rates of Nile tilapia (*O. niloticus* L.) fry were negatively correlated with stocking density, ranging from 2 to 20 fry/ liter. They suggested 5-10 fry/liter as optimal stocking density. Similarly, El- Sayed (2002) considered 5 fry/ liter as optimal stocking density of *O. niloticus* L. On the contrary, Gall & Bakar (1999) reported that body size of tilapia fry was not affected by stocking densities ranging from 10 to 200 fry/L, when water flow was uniform. Furthermore, El- Sayed (2002) found that the relationship between the survival of Nile tilapia fry and stocking density was negatively correlated.

The protein requirements of fish are ranging from 30% to 55% according to fish species, fish size, dietary protein sources and environmental conditions (NRC, 1993). Dietary protein level for high growth performance of Nile tilapia was found to be 32% for fingerlings (Lovell, 1989), extraprotein in relation to energy in diet cause the use of protein as an energy source, which increases ammonia secretion and

deteriorate water quality (Prather & Lovell 1973; Shyong, *et al.*, 1998 ; Hatlen *et al.* 2005).

Growth, survival, production and feed efficiency of fry and fingerlings in a single- stage nursery – rearing system depends mainly on stocking density and dietary protein level. Therefore, the present study was undertaken to investigate the effects of stocking density and protein level on growth performance, survival rate and feed efficiency of Nile tilapia (*O. niloticus* L.) fry monosex reared in circular fiberglass tanks during a single-stage nursery- rearing system.

MATERIALS AND METHODS

Study site and experimental design:

The present study was carried out at the fish hatchery of Arab Fisheries Company at Abbassa village, Abu- Hammad, Sharkia Governorate, Egypt. Twelve circular fiberglass tanks each of 180 liter volume were used in this study. The twelve tanks represent two stocking densities (250 and 500 hatchlings in 180 liter fiberglass tank) and within each stocking density studied three dietary protein levels (29.71, 34.43 and 39.11%) were tested. Six treatments were applied in the experimental fiberglass tanks. These were (T1SR1) stocked with 250 hatchlings / 180 liter and fed with 29.71% protein, (T1SR2) stocked with 500 hatchlings / 180 liter and fed with 29.71% protein, (T2SR1) stocked with 250 hatchlings / 180 liter and fed 34.43% protein, (T2SR2) stocked with 500 hatchlings / 180 liter and fed with 34.43% protein, (T3SR1) stocked with 250 hatchlings / 180 liter and fed 39.11% protein and (T3SR2) stocked with 500 hatchlings / 180 liter and fed 39.11% protein. Each treatment was performed in duplicate. The water tanks were on a flow- through system at 100%/ day to avoid any harmful effect of water quality parameters that were within the acceptable limits for fish growth and health (Table 1).

Fish and culture facilities:

Nile tilapia fry were produced from tilapia broodstock kept in the hatchery. Fertilized eggs were removed from the mother's mouths and stocked in hatching jars provided with upward aeration to keep stirring them. After two days from hatching (complete absorption of yolk-sac.), the fry were stocked into 180- liter circular fiberglass tanks. They were then fed on the tested diets mixed with 17 α methyl testosterone (sex controlling) at a dose of 60 mg/kg diet (1g 17 α methyl testosterone was dissolved in 1 liter ethyl alcohol, then 60 cm³ of this solution were

sprayed on 1kg diet). Three test diets were formulated to contain three levels of protein (29.71, 34.43 and 39.11%). Ingredients and proximate composition of the experimental diets are presented in Table (2).

Nile tilapia (*O. niloticus* L.) fry (0.014g average weight) were given the mash prepared experimental diets at a daily rate of 15% of total biomass during (1st 45-days) then reduced to 10% of total biomass from days 46 to 75 after that reduced to 5% of total biomass till end of the experiment (105-days), while the fish were fed 7 days/week (twice daily at 9.00 am and 3.00pm). The amount of feed was bi-weekly adjusted according to the changes in body weight throughout the experimental period (105-days).

At the post-larvae stages, hatchlings were much sensitive and very small in size. So, subsampling techniques for avoiding the great loss and harmful stress on hatchings should be used. The weight per fish were calculated by dividing the subsamples weight on the total number of hatchlings per sample to produce the average weight per hatchling. While the total length of hatchlings were measured individually to the nearest millimeter by using the millimetric petry dishes.

Growth performance parameters were measured by using the following equations.

$$\text{Specific growth rate (SGR)} = \frac{\text{Ln}W_2 - \text{Ln} W_1}{t} \times 100$$

Where: Ln = the natural log, W_1 = initial weight (g)

W_2 = the final fish weight in "grams" and t = period in days.

$$\text{Relative growth rate (RGR)} = \left[\frac{W_2 - W_1}{W_1} \right]$$

Where: W_1 = initial weight and W_2 = final weight in "grams"

Mass weight gain (WG) (net increment) = final weight (g) - initial weight (g)

Condition factor (K) = weight / (L)³ × 100

Feed conversion ratio (FCR) = feed ingested (g) / weight gain (g)

Protein efficiency ratio (PER) = weight gain (g) / protein ingested (g)

Statistical analysis:

The statistical analysis of data was carried out by applying the computer program, SAS (2000) by adopting the following model.

$$Y_{ijk} = \mu + R_i + \alpha_j + E_{ijk}$$

Where, Y_{ijk} = the observation on the ijk^{th} fish reared in the j^{th} treatment for the i^{th} replicate; μ = overall mean, R_i = the effect of i^{th} replicate; α_j = the effect of j^{th} treatment and E_{ijk} = random error.

Differences among means were tested for significance according to Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

Growth performance:

At stocking, all hatchlings were of the same age group with a mean length and weight of 0.9 ± 0.003 cm and 0.014 ± 0.001 g, respectively. Results of body weight (BW) as affected by stocking density (1389 and 2778 hatchling/m³) and dietary protein levels (29.71, 34.43 and 39.11% CP) tested are illustrated in Table (3). As described in this table, average BW at all experimental periods (0-105-day) decreased significantly ($P < 0.01$) as the fish stocking density increased from 1389 to 2778 hatchling/m³ within each dietary protein level tested, while the reverse was true with increasing the dietary protein level from 29.71 to 39.11% CP in the diets. These results are in agreement with those reported by Abdel- Hakim *et al.* (2001) who found that BW of Nile tilapia (27.11 – 29.02g) increased significantly with increasing the dietary protein level and decreasing the stocking density. Also, Al- Azab (2001) came to the conclusion that higher tilapia stocking densities released negative effects on its body weight and length, where body weight and body length decreased as the stocking density increased.

Results in Table (3), showed that averages of specific growth rate (SGR) of monosex Nile tilapia fry during the whole experimental period (0-105-day) were 4.78, 4.25, 4.94, 4.73, 5.36 and 4.88 for T_1SR_1 , T_1SR_2 , T_2SR_1 , T_2SR_2 , T_3SR_1 and T_3SR_2 , respectively and the differences between these values were significant ($P < 0.01$). These results indicate that within each protein level fed decreasing the stocking density improved SGR records and the improvement was more pronounced at higher protein levels. These findings may be due to competition for food and habitat due to higher density of fish (Islam *et al.*, 2002; Rahman and Rahman, 2003). These results are in accordance with the findings of El- Sayed (2002), who reported that SGR of Nile tilapia (with average initial weight 0.016g)

reared in fiberglass tanks, in a closed, recirculating indoor system for 40 days, were negatively correlated with stocking density and this may be due to social stress causing chronic stress response. In agreement with the present findings, Barcellos *et al.* (1999) reported that the resting plasma cortisol concentration of Nile tilapia fingerlings increased with increasing density of fish, indicating a chronic stress response, attributable to social stress. Furthermore, King *et al.* (2000) cleared that stress due to space availability was the primary factor inhibiting the growth of summer flounder (*Paralichthys dentatus* L.) larvae stocked at high densities. Results of Rahman *et al.* (2005), indicated that SGR of fingerlings of *Tor putitora* (0.012g) was also negatively correlated with stocking density.

As shown in Table (3), average SGR values of monosex Nile tilapia were 4.25 and 4.88 for T₁SR₂ and T₃SR₂, respectively, with significant ($P \leq 0.01$) differences between these values. These results indicate that fish fed higher protein level and stocked at higher densities (T₃SR₂) grow better than those fed lower portion level and also stocked at higher densities (T₁SR₂). They are in agreement with Abdel- Hakim and Moustafa (2000) who indicated that SGR of Nile tilapia reared in cages was improved almost significantly with each increase in the dietary protein level fed from 20 to 32% protein. Also, the same trend was observed for the relative growth rate (RGR) and the averages of daily gain in weight (DWG) during the whole experimental period. Similar findings were reported by Rahman *et al.* (2005) who noticed that growth in terms of length, weight, weight gain and SGR of fingerlings of *Tor Putitora* reared in nursery ponds were significantly higher in ponds stocked with 0.6 million hatchling/ha than those from the ponds stocked with 0.8 and 1.0 million hatchlings/ha respectively.

Values of condition factor (K) ranged from 1.42 to 1.9 at the end of the experimental period, with significant ($P < 0.01$) differences between the different treatments (Table 3). The best K value was recorded with T₃SR₁ where fish reared at the lowest density (1389 hatchlings/m³) and fed the highest dietary protein level (39.11%CP). On the other hand, fish kept in the highest density (2778 hatchlings/ m³) and fed the lowest dietary protein level (29.11%CP) showed the worst K records. These results indicate that the condition factor improved with the decrease in stocking density and increase in the dietary protein level. These findings may be attributed to the availability of adequate food and space for fry reared.

Results presented in table (3) revealed significant ($P < 0.05$) effects of stocking density and dietary protein levels on larval survival and growth performance. Fish survival improved almost significantly ($P < 0.05$) with each decrease in the stocking density and increasing the dietary protein levels tested. The highest value of survival (96.5%) was obtained with T_3SR_1 , while the lowest (88%) was observed for T_1SR_2 . Although the survival rate (SR) of T_1SR_2 was numerically lower than that of T_3SR_1 with significant difference ($P < 0.05$), there were insignificant differences ($P > 0.05$) between SR of T_1SR_1 and T_1SR_2 , between SR of T_1SR_2 and T_2SR_2 , between SR of T_3SR_1 and T_3SR_2 and between SR of T_2SR_1 and T_3SR_2 . These results are in accordance with those reported by El- Sayed (2002) who found that survival rate of Nile tilapia (0.016g) were negatively correlated with stocking density. On the other hand, Abdel-Hakim *et al.* (2001) and Al- Azab (2001) reported that both protein level fed and stocking density had no remarkable effects on tilapia survival.

The relative increase in mortality at 2778 hatchlings/m³ (higher stocking density) and 29.71%CP (lowest dietary protein) (12.0 % mortality, $P < 0.05$) was most likely due to cannibalism (not stocking density) as has been reported with other tilapia species, including *O. mossambicus* (Macintosh & De Silva, 1984). *O. niloticus* (Dambo and Rana, 1992) and tilapia hybrids (Macintosh & De Silva, 1984). These results demonstrated that cannibalism could be a main cause of tilapia fry mortality.

Food utilization:

Results in Table (4) show average feed conversion ratio (FCR) values during the whole experimental period (0-105-days) of fish stocked at high- densities were significantly ($P < 0.01$) higher (not improved) than those of fish stocked at lower- densities at 29.71, 34.43 and 39.11%CP. This indicates that decreasing the stocking density will provide a more efficient utilization of dietary protein for the growth of fish. Improvement of FCR at decreasing stocking density had been observed in other studies (Abdel- Hakim and Moustafa 2000; Abdel- Hakim *et al.* 2001 ; Al- Azab 2001). In this connection, the results of Rahman, *et al.* (2005) are in agreement with the present findings. They reported that FCR values of *T. putitora* fingerlings reared in nursery ponds improved significantly at lower stocking density.

As illustrated in Table (4), the average of FCR of fish fed the high- dietary protein level were significantly lower (better) than those of fish fed the low- dietary protein level at both stocking densities (1389 and

2778 hatchlings/m³). This indicates that, the FCR improved with the increase in dietary protein level fed. These results are in accordance with those reported by Abdel- Hakim and Moustafa (2000) and Abdel- Hakim *et al.* (2001) who reported that FCR values of Nile tilapia reared in cages improved significantly with increasing the protein level fed from 20 to 32% and the improvements in FCR were more pronounced at lower stocking densities (80 and 100 fish/m³) compared to higher ones (120 or 140 fish/m³). Hammer *et al.* (2006) and Wange *et al.* (2006) also showed a similar trend. On the other hand, Watanabe *et al.* (1990) showed that FCR of monosex Florida red tilapia held in cages did not differ at densities that ranged from 100 to 300 fish/m³.

Averages of protein efficiency ratio (PER) of fish tended to increase at low dietary protein level at all stocking densities tested. Also there was significant differences ($P < 0.01$) among the same protein level, except at T₂SR₁, T₂SR₂ (34.43% CP), which showed no significant differences ($P > 0.05$) as shown in Table (4). This indicates that PER values were negatively correlated with dietary protein level and stocking density. Similar results were obtained by Abdel- Hakim *et al.* (2001) who reported that, the average PER records of Nile tilapia (27.11 – 29.02g) stocked in fiberglass tanks at densities of 50 and 100 fish/m³ decreased from 1.60 to 1.09, respectively. Also, Kim and Lee (2005) confirmed that PER and protein retention of fish decreased with increasing dietary protein level. They found that PER decreased from 3.56, 3.43, 2.75 and 2.59 as dietary protein level increased from 22, 32, 42 and 52% in fish diet. In accordance with the present results, El- Dahhar *et al.* (1999) reported a significant decrease in PER as dietary protein level increased. They found that PER decreased from 3.56 to 1.34 as dietary protein level increased from 14 to 38% in Nile Tilapia diets.

Economic efficiency:

From the economical point of view, results in Table (5) show that the percentages of net returns relative to total costs for different treatments were 305.88, 284.73; and 288.55. 333.08, 339.24 and 321.97% for T₁SR₁, T₁SR₂, T₂SR₁, T₂SR₂, T₃SR₁ and T₃SR₂, respectively. These results indicated that the highest benefits were obtained by fish of T₃SR₁ (lower stocking density with higher dietary protein) followed in a descending order by those of T₂SR₂ (higher stocking density with medium dietary protein) and T₃SR₂ (higher density with higher dietary protein). The lowest net returns relative to total costs was recorded by fish of T₁SR₂ (higher stocking density with lower dietary protein). These

results are in accordance with those of Rahman *et al.* (2005) working with mahseer (*Tor putitora*) fingerlings reared in ponds for 8 weeks. They found that higher growth, survival and benefits of fingerling were obtained at a density of 0.6 million hatchlings/ha than those from 0.8 and 1.0 million hatchlings/ha.

In the present study, a significantly higher number of fry were produced in tanks stocked with 2778 hatchlings/m³ than those from the tanks stocked with 1389 hatchlings/m³, at each dietary protein level tested. Despite this, consistent higher net returns to total costs were obtained with fish of T₃SR₁ than those of T₂SR₂ and T₃SR₂. The higher market price of the relatively larger fry (suitable for stocking grow-out ponds) were produced in T₃ SR₁, substantially increased the net return relative to total costs compared to relatively smaller fry that produced in other groups with higher stocking densities.

Recommendation:

Finally, it can be concluded that growth, survival and feed utilization of Nile tilapia fry were inversely related to the stocking density of hatchlings. In all respects, 1389 hatchlings/m³ with 39.11% protein in the diet (T₃SR₁) showed highest values of growth parameters, survival and income compared to higher stocking rates at each dietary protein level. Stocking density of 1389 hatchlings/m³ with 39.11 CP may be advisable for rearing of Nile tilapia fry for 15 weeks in a single-stage nursing system, for production of adequate quality seeds of Nile tilapia in shorter time with lower mortality rates in order to be available as healthy fry at the beginning of the culture season for fish farmers.

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**EFFECTS OF STOCKING DENSITY AND PROTEIN LEVEL 81
IN DIET ON NILE TILAPIA FRY DURING THE NURSERY PERIOD**

Table (1): Effects of stocking density and dietary protein level on averages water quality parameters (mean±SE) of monosex Nile tilapia fry over the rearing period.

Parameters	Treatments					
	T ₁ SR ₁	T ₁ SR ₂	T ₂ SR ₁	T ₂ SR ₂	T ₃ SR ₁	T ₃ SR ₂
Water temperature (°C)	28.1 ±2.65 ^a	28.41 ±2.64 ^a	28.3 ±2.71 ^a	28.53 ±2.73 ^a	28.35 ±2.71 ^a	28.69 ±2.51 ^a
Dissolved oxygen (mg/L)	6.2 ±0.51 ^a	5.31 ±0.49 ^{ab}	6.01 ±0.50 ^a	5.11 ±0.48 ^{ab}	5.01 ±0.51 ^{ab}	4.83 ±0.43 ^b
PH	7.71 ±0.18 ^a	7.52 ±0.18 ^a	7.61 ±0.19 ^a	7.41 ±0.17 ^a	7.31 ±0.18 ^a	7.21 ±0.19 ^a
Total alkalinity (mg/L)	610.0 ±45.0 ^a	613.0 ±36.0 ^a	630.0 ±47.0 ^a	615.0 ±36.0 ^a	610.0 ±46.0 ^a	635.0 ±39.0 ^a
Total hardness	260.0 ±15.0 ^a	240.0 ±15.0 ^{ab}	245.0 ±13.0 ^{ab}	215.0 ±13.0 ^b	220.0 ±15.0 ^b	230.0 ±16.0 ^b

a, b means in the same row having the same superscript are not significantly different (P > 0.05)

Table (2): Composition and proximate analysis of experimental diets containing different levels of protein .

Feed ingredients %	Experimental diets		
	Diet 1 29.71%	Diet 2 34.43%	Diet 3 39.11%
Fish meal	20.0	23.5	33.5
Soybean meal	31.0	39.0	37.0
Wheat bran	10.5	14.0	9
Yellow corn	31.5	16.5	13.5
Starch	2	2	2
Vegetable oil	2	2	2
Vit. & Min. mixture ¹	3	3	3
Total	100	100	100
Chemical composition (on DM basis%)			
Dry matter (DM)	92.70	93.01	92.95
Crude protein (CP)	29.71	34.43	39.11
Ether extract (EE)	8.9	6.3	9.2
Crude fiber (CF)	9.2	5.5	4.3
Ash	7.31	7.13	7.03
NFE ²	44.88	46.64	40.36
Gross energy K cal / kg diet ³	4682.9	4626.3	4865.5

¹ Vitamin & mineral mixture/ kg premix : Vitamin D₃, 0.8 million IU; A, 4.8 million IU; E, 4g; K, 0.8g; BI, 0.4g; Riboflavin, 1.6g; B₆, 0.6g, B₁₂, 4mg; Pantothenic acid, 4g; Nicotinic acid, 8g; Folic acid, 0.4g Biotin, 20 mg, Mn, 22g; Zn, 22g; Fe, 12g; Cu, 4g; I, 0.4g; Selenium, 0.4 g and Co, 4.8 mg.

² NFE= nitrogen free extract (calculated by difference) .

³ According to Jobling (1983) as 5.65, 9.45 and 4.11 K cal / g for protein lipid and carbohydrate, respectively. P/E ratios (mg CP / K cal GE) were 63.44, 74.42 and 80.38, respectively.

Table (3): Effects of stocking density and dietary protein level on the performance (mean \pm SE) of monosex Nile tilapia (*O. niloticus* L.) fry during the rearing period.

Stages	Treatments						Test of significance
	T ₁ SR ₁	T ₁ SR ₂	T ₂ SR ₁	T ₂ SR ₂	T ₃ SR ₁	T ₃ SR ₂	
Initial body weight/fish (g)	0.014 ± 0.001	0.014 ± 0.001	0.014 ± 0.001	0.014 ± 0.001	0.014 ± 0.001	0.014 ± 0.001	N.S
Initial body length /fish(cm)	0.9 ± 0.003	0.9 ± 0.003	0.9 ± 0.003	0.9 ± 0.003	0.9 ± 0.003	0.9 ± 0.003	N.S
15- day post stocking	0.03 $\pm 0.001^a$	0.023 $\pm 0.001^b$	0.035 $\pm 0.001^a$	0.03 $\pm 0.001^a$	0.031 $\pm 0.001^a$	0.026 $\pm 0.001^b$	*
30- day post stocking	0.15 $\pm 0.003^a$	0.086 $\pm 0.003^c$	0.15 $\pm 0.006^a$	0.12 $\pm 0.004^b$	0.156 $\pm 0.006^a$	0.127 $\pm 0.005^b$	**
45- day post stocking	0.27 $\pm 0.007^b$	0.158 $\pm 0.007^c$	0.30 $\pm 0.016^{ab}$	0.255 $\pm 0.018^b$	0.384 $\pm 0.02^a$	0.33 $\pm 0.02^a$	**
60- day post stocking	0.62 $\pm 0.02^b$	0.38 $\pm 0.02^c$	0.73 $\pm 0.03^{ab}$	0.59 $\pm 0.022^{bc}$	0.83 $\pm 0.04^a$	0.76 $\pm 0.045^a$	**
75- day post stocking	0.91 $\pm 0.038^c$	0.625 $\pm 0.037^d$	1.16 $\pm 0.053^b$	1.03 $\pm 0.06^b$	1.42 $\pm 0.07^a$	1.13 $\pm 0.054^b$	**
90- day post stocking	1.37 $\pm 0.053^a$	0.89 $\pm 0.055^d$	1.58 $\pm 0.073^b$	1.28 $\pm 0.08^c$	2.4 $\pm 0.051^a$	1.62 $\pm 0.08^b$	**
105- day post stocking	2.11 $\pm 0.042^c$	1.22 $\pm 0.061^d$	2.5 $\pm 0.072^b$	2.01 $\pm 0.053^c$	3.91 $\pm 0.05^a$	2.35 $\pm 0.032^b$	**
Final body length /fish (cm)	5.0 $\pm 0.63^b$	4.41 $\pm 0.61^c$	5.4 $\pm 0.81^{ab}$	5.0 $\pm 1.15^{ab}$	5.9 $\pm 1.25^a$	5.31 $\pm 0.81^{ab}$	**
Daily weight gain (g/day/fish)	0.02 $\pm 0.001^c$	0.011 $\pm 0.001^d$	0.024 $\pm 0.001^b$	0.02 $\pm 0.001^c$	0.037 $\pm 0.001^a$	0.022 $\pm 0.001^b$	**
Net increment	2.10 $\pm 0.08^d$	1.21 $\pm 0.091^c$	2.49 $\pm 0.09^b$	2.00 $\pm 0.073^d$	3.90 $\pm 0.091^a$	2.34 $\pm 0.051^c$	**
Specific growth rate (SGR)	4.78 $\pm 0.13^c$	4.25 $\pm 0.13^d$	4.94 $\pm 0.13^b$	4.73 $\pm 0.13^c$	5.36 $\pm 0.13^a$	4.88 $\pm 0.13^b$	**
Relative growth rate (RGR)	149.71 $\pm 0.19^c$	86.14 $\pm 0.19^d$	177.57 $\pm 0.19^b$	142.57 $\pm 0.19^c$	278.29 $\pm 0.19^a$	166.86 $\pm 0.19^b$	**
Initial condition factor	1.92 ± 0.001	1.92 ± 0.001	1.92 ± 0.001	1.92 ± 0.001	1.92 ± 0.001	1.92 ± 0.001	N.S
Final condition factor	1.68 $\pm 0.07^b$	1.42 $\pm 0.06^d$	1.58 $\pm 0.07^{cd}$	1.61 $\pm 0.08^c$	1.9 $\pm 0.07^a$	1.57 $\pm 0.08^{cd}$	**
Survival rate %	90.0 $\pm 0.11^c$	88.0 $\pm 0.11^{cb}$	92.5 $\pm 0.11^b$	88.5 $\pm 0.11^c$	96.5 $\pm 0.11^a$	94.5 $\pm 0.11^{ab}$	*

a, b, c, d means within each row having different letters are significantly different at ($P < 0.05$) otherwise they are not. NS= non significance * = $P < 0.05$ ** = $P < 0.01$

**EFFECTS OF STOCKING DENSITY AND PROTEIN LEVEL 83
IN DIET ON NILE TILAPIA FRY DURING THE NURSERY PERIOD**

Table (4): Effects of stocking density and dietary protein levels on feed efficiency (mean \pm SE) of monosex Nile tilapia fry during the rearing period.

Traits	Treatments						Test of significance
	T ₁ SR ₁	T ₁ SR ₂	T ₂ SR ₁	T ₂ SR ₂	T ₃ SR ₁	T ₃ SR ₂	
Feed intake g/fish	3.46 $\pm 0.051^c$	2.2 $\pm 0.031^d$	4.05 $\pm 0.05^b$	3.36 $\pm 0.031^c$	5.04 $\pm 0.021^a$	4.08 $\pm 0.023^b$	**
Protein intake g/fish	1.03 $\pm 0.05^d$	0.65 $\pm 0.05^c$	1.39 $\pm 0.031^c$	1.15 $\pm 0.033^d$	1.97 $\pm 0.061^a$	1.59 $\pm 0.015^b$	**
FCR	1.65 $\pm 0.01^c$	1.83 $\pm 0.01^a$	1.63 $\pm 0.01^c$	1.68 $\pm 0.01^c$	1.29 $\pm 0.01^d$	1.75 $\pm 0.01^b$	**
PER	2.03 $\pm 0.05^a$	1.85 $\pm 0.05^b$	1.78 $\pm 0.05^b$	1.73 $\pm 0.05^{bc}$	1.97 $\pm 0.05^a$	1.47 $\pm 0.05^c$	**

a, b, c, d means within each row having different letters were significantly different at ($P < 0.01$).

Table (5): Economical evaluation of the experimental treatments.

Factor	Treatments					
	T ₁ SR ₁	T ₁ SR ₂	T ₂ SR ₁	T ₂ SR ₂	T ₃ SR ₁	T ₃ SR ₂
Stocking rate (No/m ³)	1389	2778	1389	2778	1389	2778
Average size at stocking (g)	0.014	0.014	0.014	0.014	0.014	0.014
Average size at harvest (g)	2.11	1.22	-2.5	2.01	3.91	2.35
Total weight gain (g/fish)	2.10	1.21	2.49	2.00	3.90	2.34
Survival rate (%)	90.0	88.0	92.5	88.5	96.5	94.5
Total No. at harvest/ m ³	1250.1	2444.64	1284.8	2458.5	1340.4	2625.2
A- operating costs						
Fish fry 20 LE/ 1000 fry	27.78	55.56	27.78	55.56	27.78	55.56
Costs of one ton feed (L.E)	1750	1750	2100	2100	2450	2450
Relative to control (%)	100	100	120	120	140	140
Increase in feed cost (L.E/ton%)	0.00	0.00	20.00	20.00	40.00	40.00
Feed intake (g feed/fish)	3.46	2.2	4.05	3.36	5.04	4.08
Total food (kg/m ³)	4.81	6.11	5.63	9.33	7.00	11.33
Cost of food/m ³ (L.E)	8.42	10.69	11.82	19.59	17.15	27.76
Screen, pump and labor L.E. /m ³	10.0	10.0	10.0	10.0	10.0	10.0
Total costs/m ³ (L.E)	46.2	76.25	49.6	85.15	54.93	93.32
Feed conversion ratio (FCR)	1.65	1.83	1.63	1.68	1.29	1.75
Feed cost to produce 1kg fish (L.E)*	2.89	3.20	3.42	3.53	3.16	4.29
Relative to control (%)	100	100	118.34	110.31	109.34	134.06
B- Total returns/m³ (L.E.)	187.52	293.36	192.72	368.77	241.27	393.78
Net returns/ m ³	141.32	217.11	143.12	283.62	186.34	300.46
C- Net returns to operating cost	305.88	284.73	288.55	333.08	339.24	321.97

Local market price of feed and fingerlings when the experiment was done

One ton feed 29.7% C.P. 1750 L.E.

34.3% 2100 L.E.

39.1% 2450 L.E.

Fingerling by weight of 1-2g 120 L.E.

2-3 g 150 L.E.

3-4 g 180 L.E.

* Feed cost to produce 1 kg fish = Feed price × FCR.