EFFECTS OF THE CROWDING ON GROWTH PERFORMANCE AND TOTAL YIELD OF NILE TILAPIA (OREOCHROMIS NILOTICUS) REARED IN SEMI-INTENSIVE EARTHEN PONDS BY USING UNDER GROUND WATER

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Abstract

Effects of high stocking density on growth performance, survival, total yield, food conversion and economic efficiency of *Oreochromis niloticus* (Linnaeus) were evaluated. Fries of tilapia (average weight 0.8 g) were stocked in nine 350 m^2 earthen ponds at stocking rate of 8, 12 and 16 fish /m^2 (in triplicate) and reared at semi-intensive culture for 154 days. Ponds were provided with under ground water and aerated through water spraying system. Organic (in sacks) and chemical fertilizers were used for all experimental ponds to enhance phytoplankton and zooplankton growth. Fish were offered a 25 % crude protein diet in pellets, at feeding rate of 3% of the total fish biomass. The growth rate was inversely related to stocking density with final mean weights of 186.6, 162.2 and 117.8 g per fish at the low, medium and high densities respectively.($p<0.05$). The respective food conversion ratios (FCR) were 1.63; 1.73 and 2.00 while the survival rates were 92, 87 and 79 % at low, medium and high densities respectively. The total average values of condition factor (K), specific growth rate (% SGR), and daily weight gain (DWG) were negatively correlated with stocking density increasing. At harvest, standing crop biomass averaged 480.7, 606.3 and 514.6 Kg per pond for the three densities respectively, indicating that increasing stocking density of Nile tilapia increased the total fish production, however from the economical point of view, medium stocking density (12 fish/ m^2) of Nile tilapia showed the best in terms of net return and the best percent of returns relative to total costs compared to other densities under the study conditions.

Key words: Nile tilapia, *Oreochromis niloticus*, crowding, stocking density, organic and chemical fertilizers, spraying aeration system, earthen ponds, semi-intensive culture, and under ground water.

INTRODUCTION

Tilapia, are considered as the best species for culture because of their high tolerance to adverse environmental conditions, ease of reproduction, their fast growth and potential for domestication (El-Sayed,1999).

In fish culture ponds, many factor affect on tilapia growth performance. The effect of most of these factors on tilapia in different culture systems have been extensively studded (Kirk, 1972; Chervinski, 1982; Philippart and Ruwet, 1982). Stocking density is a major factor affects fish growth under farmed conditions (Jobling, 1995; Yi *et al.* 1996; Hengsawat *et al.*; 1997 and Maragoudaki *et al.*, 1999).

Moav *et al.* (1977) and Balarin (1979) showed that growth depression of fish stocked at higher rates may attribute to crowding, social interactions and aggression. Macintosh and De Silva (1984) reported that increasing stocking density of (*Oreochromis mosambicus*) fry might have lead to diminishing social dominance, leading to higher survival but lower individual growth rates. Increasing stocking density may also cause deterioration in water quality, leading to stressful conditions (Barton & Iwama 1991; Pankhurst & Van der Kraak 1997).

Abdel-Hakim *et al* (1995) showed that the relationship between stocking rate of Nile tilapia and production can be represented by a parabolic curve. Silva, *et al.* (2000) found that the growth of tetra hybrid red tilapia decreased with increasing stocking density. Also, Abdel- Hakim and Moustafa (2000) reported that within each protein level tested (20; 24; 28 and 32%), increasing stocking rate of Nile tilapia in cage culture from 80 to 100; 120 and 140 fish/m^3 decreased body weight and length. In another study, Abdel-Hakim, *et al.* (2001) reported that increasing tilapia stocking density from 50 to 100 or 150 fish/m^3 of tank water decreased significantly the final body weight and length of fish.

Ashagrie Gibtan, *et al.* (2008) revealed that the holding of Nile tilapia fingerlings in cages with lower density were heavier than the ones held at higher densities, and showed higher weight gain and daily weight gain .

In general, Fish held at high stocking densities are generally exposed to chronic stress situations that impose severe energy demands and may predispose the fish to infection ((Benjamin Costas, *et al.* 2008).

This study was conducted to investigate the effect of high stocking density (crowding) of mono-sex Nile tilapia (*Oreochromis niloticus*) fries cultured in semi-intensive earthen pond on their growth performance, total yield and the economic efficiency.

MATERIAL AND METHODS

This study was carried out at a private fish farm located near Al-Hamraa region in Wadi Al-Notroun, Egypt, during one culture season from 1st of June to 2nd of November.

Experimental ponds: A total of nine earthen ponds, each of 350 m^2 total area with 1.5 m deep were used in this study. Every three ponds as a group represented one stocking density in triplicate. The first group of ponds were stocked with Nile tilapia fries at the rate of 8 fish /m^2 (T_1), the second density was 12 fish /m^2 (T_2) and the third density was 16 fish /m^2 (T_3). Earlier to experimental start, ponds were dried and exposed to sunrays. After that all experimental ponds were filled with under ground water.

Experimental fish: Nile tilapia (*Oreochromis niloticus*) mono sex fries produced by hormone treatment were purchased from a privet tilapia hatchery, located at Abbasa village, Sharkiya Governorate. Fish were transported from the hatchery to the experimental ponds at the early morning, in plastic bags filled with water and supplied with oxygen. The experimental fish was exposed to an adaptation period for 20 minutes, to be adapted to a new water temperature. At the start of the experiment, weight of fish (gram) and length (cm) were estimated from 100 fish of each treatment. The initial body weight of fries was 0.8 g. / fish and initial body length was 2.5 cm / fish. At every 2 weeks intervals, the weights and lengths were recorded in a sample of 30 fish from each pond. At experimental termination, the fish of the ponds were harvested by seining and weighted then total yield were recorded.

Fish feeding: Fish were fed on a floating diet containing 25% protein and 3750 kcal/kg gross energy. It was purchased from fish feed manufacture company. Experimental fish were fed at a daily rate of 3% of the total pond biomass divided in tow portions during the day. The diet was offered 7 days a week in wooden plats (2 feeders for each pond).

Water quality: Temperature; secchi disk reading (transparency); pH; dissolved oxygen were measured weekly, the pH values were determined by digital pH meter model 68 engineered systems. The water temperature and oxygen saturation were measured at 9:00 a.m. by an oxygen meter, WPA 20 Scientific Instrument. The levels of salinity; total hardness; total alkalinity; nitrite; nitrate and ammonia were measured biweekly in pond water sample. Average water quality parameters are illustrated in Table (1). Analytical methods were done according to the American Public Health Association (APHA, 1985).

Fertilization: Organic and chemical fertilizers were used biweekly in all experimental ponds at the rate of 5.0 kg super phosphate Ca (H_2Po_4) and 1.25 kg urea (46%N), plus 15 kg dry chicken manure per pond (350 m^2). Chicken manure was put in 3 sacks of coarse cloth and tied by a rope to dike of the pond to control the plankton growth. Every two weeks, the sacks were been changed. Fertilization was started ten days before Nile tilapia fries stocking.

Pond aeration: An aeration spraying system was designed and used to aerate the water surface of the ponds. The system consisted of a mechanical pump, PVC converter tubes, long plastic tube that lies along the dike of the pond and spraying valves. When the pump is turned on, the valves push the water to center of the pond in a semi-circular move.

Table 1. Average of physical and chemical properties of pond water during experimental period through intervals (2 weeks) (mean ± SE)* from 1st of June to 2nd of November (2004).

ITEMS	Units	June	July	August	September	October
Temp	(C^0)	26.3 ±0.425	28.7 ±0.473	31.45 ±0.278	30.6 ±0.176	27.35 ±.291
Secchi Disk	(cm)	47 ±0.285	35 ±.358	27 ±0.394	30 ±0.382	32 ±0.243
pH values	Unit	8.8 ±0.104	8.7 ±0.128	8.4 ±0.152	8.3 ±0.176	8.6 ±0.182
D. Oxygen	(mg/L)	9.4 ±0.221	8.1 ±0.246	6.3 ±0.264	6.6 ±0.272	8.2 ±0..325
Salinity	(g/L)	1.3 ±0.084	1.4 ±0.095	1.5 ±0.98	1.6 ±0.126	1.5 ±0.117
Alkalinity	(mg/l)	240 ±15.4	215 ±12.8	180 ±9.15	210 ±10.9	230 ±16.1
Hardness	(mg/l)	475 ±44.5	525 ±56.8	650 ±50.9	620 ±48.2	550 ±40.8
NO_3	(mg/l)	0.08 ±0.004	0.07 ±0.003	0.05 ±0.004	0.04 ±0.002	0.03 ±0.006
NH_4	(mg/l)	0.3 ±0.016	0.4 ±0.018	0.7 ±0.021	0.6 ±0.017	0.5 ±0.015
NH_3	(mg/l)	0.123 ±0.008	0.128 ±0.005	0.182 ±0.006	0.215 ±0.008	0.184 ±0.007

Growth parameters:

1- Live body weight and body length: Body weight (W) in grams and body length (L) in cm. of individual fish of each experimental unit were recorded every 2 weeks (an interval) for each experimental pond sample.

2- Daily Weight Gain:

Daily Weight gain (DWG) = (final weight (W_2) – initial weight (W_1)/ t). Where t = the time in days between W_2 and W_1.

3- Condition factor (K): The represents the relationship between W and L of fish. It was calculated as follows: $K = W/L^3 \times 100$.

Where: W= fish weight in grams. L = fish length in cm.

4-Specific Growth Rate (SGR %): Specific growth rate was calculated as follow: (% SGR) = $LnW_2 - LnW_1/t \times 100$.

Where: Ln = the natural log. W_2= Final weight of a period (g).

W_1= Initial weight of the same period (g). t = Period (in days).

5-Feed Conversion Ratio (FCR): was calculated by using the following equation: FCR= dry feed ingested/ weight gain

Statistical analysis: The statistical analysis was performed using One-way Analysis Of Variance (ANOVA), and Duncan's multiple Range Test (Duncan 1955) to determine differences between treatments (the high stocking densities as main effects), and means at significance level of 0.05, standard errors of treatment means were also estimated. All statistics were carried out using Statistical Analysis Systems (SAS) program (SAS, 2005) and Microsoft Excel program 2003.

RESULTS AND DISCUSSION

Water quality parameters:

Results of Physical and chemical water quality parameters are presented in Table (1). The water temperature ranged between (26.3 and 31.5 °C). Secchi disk reading revealed that the highest reading was 47 in June after the experimental start that reflects the insufficiency of nutrients required for plankton growth. Water pH values ranged between 8.3 and 8.8 during the experimental period. The dissolved oxygen concentration ranged from 6.3 to 9.4 mg/l. As presented in the same table. the averages of salinity, total hardness ,total alkalinity, nitrite level , ammonia , Nitrate concentration were fluctuated during the experimental period in the suitable rang which was sufficient for normal growth and development of Nile tilapia.

Growth performance:

Body weight results as presented in Table (2), showed that the average of initial body weight at the start of experiment was the same for all treatments. But, through the intervals, the average of weights among treatments became significantly differ ($p < 0.05$), figure (1).

Table 2. The effect of high stocking density (crowding) on the average of body weight (W) of *O.niloticus* during experimental period (154) days, through intervals (2 weeks) (Mean ± SE)*.

Intervals		Body Weight (W) in gr.		
Date and Number	Period in weeks	T1	T2	T3
1/06 Initial	0	0.80 a ±0.00	0.80 a ±0.00	0.80 a ±0.00
15/06 1	2	5.0 a ±0.041	4.8 a ±0.024	4.1 b ±0.032
29/06 2	4	11.5 a ±0.097	10.7 a ±0.050	8.1 b ±0.052
13/07 3	6	20.4 a ±0.138	18.7 b ±0.078	13.6 c ±0.079
27/07 4	8	31.9 a ±0.166	29.0 b ±0.209	21.1 c ±0.166
10/08 5	10	46.3 a ±0.176	42.0 b ±0.244	30.8 c ±0.221
24/08 6	12	63.7 a ±0.257	57.5 b ±0.269	42.3 c ±0.129
7 /09 7	14	84.0 a ±0.302	75.3 b ±0.037	55.4 c ±0.188
21/09 8	16	106.9 a ±0.361	95.2 b ±0.248	69.9 c ±0.197
5/10 9	18	132.0 a ± 0.558	116.7 b ± 0.285	85.4 c ±0.275
19/10 10	20	158.8 a ±0.940	139.2 b ±0.572	101.4 c ±0.399
2/11 11	22	186.6 a ±0.893	162.2 b ±0.396	117.8 c ±0.403

Values are means ± S.E of three replicates. Means in the same raw having the same superscript letter are not significantly different ($p<0.05$)

The differences of final body weights among the three treatments indicated that the highest stocking density per experimental ponds decreased the average of fish body weight significantly ($p < 0.05$). These results are in agreement with those reported by Abdel-Hakim *et al.* (1995), who studied the affect of 3 stocking densities of the growth rate of *O. niloticus* (3000, 4500 and 6000 fish/feddan). He reported that mean individual growth rate was highest for the lowest stocking density and lowest for the highest stocking density. In this connection, Pagan (1970), Suwanasart (1971) and Coche (1976) showed that growth rate of fish in general decreased with increasing stocking rate. Furthermore, Moav *et al.* (1977) and Barlin (1979) showed that body weight and growth rate of fish were depressed when the fish were stocked at higher rates and the growth depression may be attributed to crowding, social interaction and aggression.

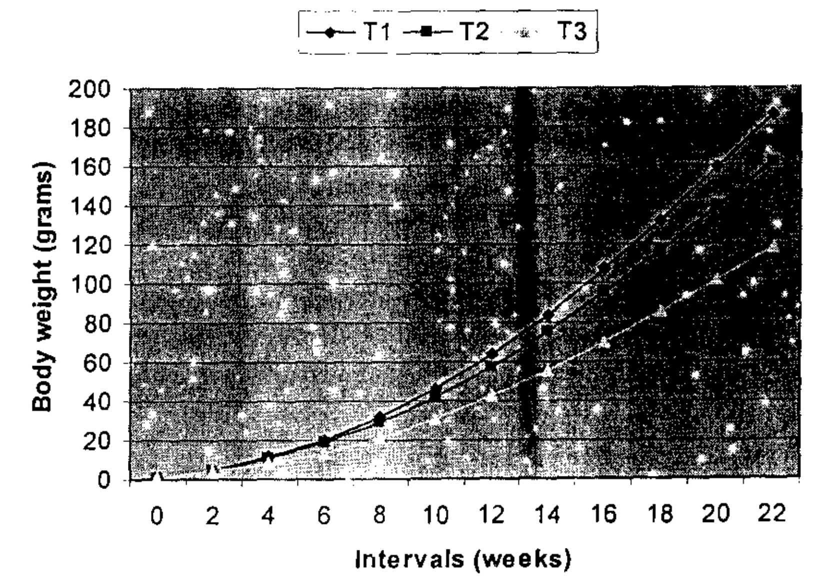

Figure 1. averag body wieght of Nile tilapia throught inretvals

Concerning to the results of daily weight gain (DWG) as shown in Table (3), They revealed that the values decreased significantly ($p < 0.05$) at the highest stocking density (16 fish /m^2) than the values at the lowest stocking density (8 fish /m^2). Results indicated that tilapia growth rate at lower stocking density had better performance compared to the higher stocking density. These results are in agreement with those of Silva, *et al.* (2000). He found that the growth of tetra hybrid red tilapia decreased with increasing stocking density.

Concerning to Condition Factor (K), results as shown in Table (3) showed that the average of K values of Nile tilapia correlated positively with increasing the stocking density ($p < 0.05$). They also, indicated that fish reared at lower densities grow more in weight than in length as similarly reported by Abdel-Hakim *et al.* (2001), who reported that increasing tilapia stocking density from 50 to 100 or 150 fish/ m^3 decreased significantly K values of tilapia.

Concerning to specific growth rate (% SGR), results were negatively correlated ($p< 0.05$) with stocking density as presented in Table (3). These results are in agreement with the findings of Eid and El-Gamal (1997), who showed that % SGR of Nile tilapia (average initial weight 30.0: 30.1 g) reared in cages at densities of 50; 75; 100; 125 and 200 fish/m^3 for 120 days decreased in a linear manner with each increase in the stocking density. Also, they are in agreement with those of Abdel-Hakim *et al* (2001), who reported that increasing tilapia stocking density reared in tanks from 50 to 100 fish/m3 decreased the % SGR values which indicating that fish at lower stocking density grow better than those stocked at higher ones.

As presented in table (3), averages of % survival rate for T_1, T_2 and T_3 were 92; 89 and 78 % respectively, indicating that the stocking density higher than 12 fish/m^2 per experimental pond decreased sharply the survival rate (T_3).

Table 3. The effect of high stocking density of *O. niloticus reared* in earthen ponds on final body weight, number of live fish, survival %, final weight gain, consumed artificial feed and total production per pond (350 m^2) during experimental period 154 days.

ITEMS		T3	T2	T1
Average area of pond	m^2	350	350	350
No. of stocked fish at start of exp.	fish/pond	2800	4200	5600
Average initial fish body weight	g/fish	0.8	0.8	0.8
Initial biomass/pond	kg/pond	2.24	3.36	4.48
Average final fish body weight	g/fish	186.6	162.2	117.8
Gain in weight/fish	g/fish	185.8	161.4	117.0
Total average of daily weight gain	DWG	1.20 a ± 0.054	1.05 b ± 0.045	0.76 c ±0.032
Total average of Condition Factor	K	2.24 c ± 0.082	2.61 b ± 0.079	2.99 a ± 0.087
Total average of Specific growth rate	SGR %	3.53 a ± 0.311	3.40 b ± 0.306	3.24 c ± 0.270
No. of survival fish/pond	fish/pond	2576	3738	4368
% of survival fish/pond	%	92	89	78
Total production/pond	Kg/pond	480.7	606.3	514.6
% of the lowest value Of total production.	%	100	126.13	107.10
Total gain in weight / pond.	Kg/pond	478.6	603.3	511.1
% of the lowest value	%	100	126.1	106.8
Total of costumed food/pond (3% of total body weight)	Kg/pond	778	1041	1018
Food conversion ratio	FCR	1.63	1.73	2.00
Total fertilizers/Pond: Super phosphate: Urea: Chicken manure:	Kg/pond	 55 14 170	 55 14 170	 55 14 170

Values are means ± S.E of two replicates

Means in the same raw having the same superscript letter are not significantly different ($p<0.05$).

The lowest survival rate of (T3) can be explained that the using of spraying aeration system was not suitable for the high stocking density of Nile tilapia over than12 fish/m^2 in earthen ponds.

Concerning to feed consumption (FC) and feed conversion ratio (FCR) as affected with high stocking density of Nile tilapia, results in Table (3) revealed that the total amounts of feed consumed during the whole experimental period for the stocking densities of 8; 12; and 16 fish/ m^2 were 778; 1041 and 1018 kg/pond, respectively. The corresponding FCR values for the same stocking densities were 1.63; 1.73 and 2.00 kg feed for each kg of gain in weight. These results were in agreement with those of El-Saidy *et al.* (2002) who reported that feed conversion ratio, feed efficiency ration and total intake were significantly ($p<0.05$) affected by stocking density and feeding levels. Also, are in agreement with the findings of Ammar *et al.* (2005), who reported that decreasing stocking density of Nile tilapia reared in earthen ponds resulted in improvement in FCR. Also, high stocking density may be attributed to crowding and reduced living space that leads to fish disturbance during feeding and normal activities (Coche, 1977), increased energy demanding activity levels connected with social interaction (Fenderson and Carpenter, 1971).

Concerning the total fish production results as illustrated in Table (3) showed that the averages of total production were correlated positively with increasing stocking density (T1 and T2), but this trend reversed in the highest stocking density (T3) which had the lowest average body weight and the highest percentage of mortality. These results indicated in general that the highest experimental pond productivity was obtained by T2, followed in a decreasing order by T3 and T1 respectively. In this connection, Van der Lingen (1959) proved that total fish yield per unit area is dependent upon stocking mass per unit area.

Economical efficiency of tilapia high stocking density

Results of costs including variable costs (LE) and fixed costs (table 4), revealed that costs of fish fry were increased as well as the stocking densities increased. The same trend was observed with the artificial fish feed, the costs of feed were very high. It represented around 70% relative to the total costs. Labor cost of (125 LE/ pond) was constant for all treatments. Total fixed costs were found to be the same per pond (110 LE) for all experimental ponds. Meanwhile, the total operating costs (variable and fixed) per/pond correlated positively with the increasing of stocking density (table, 4). The differences among treatments in total operating costs were due to the differences in fry and feed costs. However, the other costs were almost the same for all treatments.

As presented in table (4) averages of fish sales (total return) were the highest for the medium stocking density (T2), followed by lowest stocking density (T1) and the highest one. Fish of T1 and T2 were of the first grade (4-7 fish/kg), but fish of T3 was of second grade (7-10 fish/kg). So, fish sales were affected with these production grades.

Net returns calculated as returns over costs for different stocking densities (8; 12 and 16 fish /m^2). The higher net returns obtained by second stocking density, followed by the lowest one, however the highest one had negative net return. It can be explained that the biomass of second density (12 fish /m^2) under this culture condition and aeration system did not reach to the critical point of biomass. On other hand, the highest stocking density produced more fish of grade 2, which has low sell price.

Concerning the percent of returns relative to the total costs, the highest value was obtained by T_2 that had 12 fish/ m^2, followed by T_1 (8 fish/ m^2), indicating that the medium stocking density (T_2) was the most feasible and profitable for the fish farmer followed by the density of 8 fish/ m^2, while the highest density 16 fish/ m^2 seemed to be infeasible and not profitable.

Table 4. The effect of high stocking density on economical efficiency per pond (350 m^2) of Nile tilapia reared in earthen ponds under semi-intensive culture system for 154 days.

ITEMS	T1	T2	T3
1- Variable costs in LE per pond:			
a - fry/pond:	168	252	336
b - Artificial food/pond:	2179	2915	2850
c -Fertilizer:			
Super phosphate:	99	99	99
Urea:	42	42	42
Chicken manure:	180	180	180
d -Labor:	125	125	125
e -Others & fuel:	100	100	100
2-Total variable costs in LE (a+b+c+d+e):	2893	3533	3732
3- Fixed costs, LE /pond			
f-Depreciation (materials and others):			
g- Taxes:	100	100	100
	10	10	10
4- Total fixed costs in LE (f+g):	110	110	110
5-Total operating costs/pond(2+4) (variable costs + fixed costs):	3003	3643	3842
6- Interest on working capital(10 % of total operating costs x154/360):	300.3	364.3	384.2
7- Total costs in LE./pond (5+6):	3306.3	4007.3	4226.2
% of smallest value of the total costs:	100	121.2	127.8
% of the cost of feed relative to the total costs :	65.9	72.7	67.4
8- RETURN:			
Fish sales in LE./ pond:	3845.6	4850.4	3602.2
9- Net return/pond, LE(8-7):	539.3	843.1	(-) 624
% Net return relative to total costs:	16.3	21.0	----

The evaluation was calculated according to prices of 2008.

CONCLUSION

Based on the obtained results, it be concluded that treatment (T_2) that received Nile tilapia mono-sex fries stocking density at the rate of 12 fish/m^2, and cultured for 154 days in monoculture earthen ponds under semi-intensive system aerated by spraying aeration system revealed the best economic efficiency of total net return and the best percent of returns relative to total costs compared to other treatments.

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تأثير الإزدحام على مظاهر النمو والإنتاج الكلى لأسماك البلطى النيلى المرباه في أحواض ترابية بنظام الإستزراع نصف المكثف بإستخدام المياه الجوفية

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تم تقييم تأثيرات الكثافات التخزينية العالية على مظاهر النمو، الإعاشة، الإنتاج الكلي، معامل التحويل الغذائي والتأثير الإقتصادى لأسماك البلطي النيلي. تم تخزين يرقات البلطى النيلى بمتوسط وزن ٠,٨ جرام لليرقه في تسعة أحواض ترابيية مساحة كل منها ٣٥٠٠متر مربع وبمعدل تخزين ٨ ، ١٢ و١٦ سمكة للمتر المربع (وبتكرار ثلاثى) وقد تمت تربيتها بنظام الإستزراع نصف المكثف لمدة ١٥٤ يوما. تم تزويد الأحواض بمياه جوفية وإستخدام نظام الرشاشات المائية في تهويتها. تم إستخدا م التسمبد العضوى فى أجولة وكذلك إستخدام التسميد الكيمبائى لتحفيز نمو الفيتوبلانكتون والزوبلانكتون في جميع الأحواض. تم تغذية الأسماك على عليقة صناعية محببة تحتوى على ٢٥% بروتين خام ، وبمعدل تغذية ٣% من وزن الأسماك.

وجد أن معدل النمو يرتبط عكسيا مع الكثافة التخزينية ، وكان متوسط الوزن النهائى ١٨٦,٦، ١٦٢,٢، ١١٧,٨ جرام للسمكة وذلك للكثافات المنخفضة والمتوسطة والعالية على التوالى وبإختلاف معنوى (إختبار معنوية فى مستوى ٠,٠٥). وكان معدل التحويل الغذائى الفعلى ١,٦٣، ١,٧٣، ٢,٠٠ بينما كان معدل الإعاشة (البقاء) ٩٢، ٨٧، ٧٩% للكثافات المنخفضة والمتوسطة والعالية على التوالى. ووجد أن المتوسط الكلى لمعامل الحالة ومعدل النمو النوعى وكذلك متوسط الزيادة اليومية فى الوزن لهم إرتباطا سلبيا مع الزيادة فى الكثافة التخزينية.

كان متوسط الإنتاج الكلى عند الحصاد ٤٨٠,٧، ٦٠٦,٣، ٥١٤,٦ كيلوجرام للحوض فى الكثافات الثلاثة على التوالى. وهذا يشير إلى أن زيادة الكثافة التخزينية لأسماك البلطى النيلى يتبعه زيادة فى الإنتاج الكلى. بينما من الناحية الإقتصادية فإن الكثافة التخزينية المتوسطة للبلطى النيلى (١٢ سمكة للمتر السربع) وتحت ظروف هذه الدراسة قد حققت أعلى صافى عائد وأيضا أفضل نسبة لصافى العائد إلى المصاريف الكلية مقارنة بالكثافات الأخرى.