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INTENSIFICATION OF NILE TILAPIA (*Oreochromis niloticus*) PRODUCTION IN EARTHEN PONDS:
(1) EFFECT OF POND AREA AND STOCKING DENSITY.

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ABSTRACT

Twenty four earthen ponds of different areas (500,1000,1500 and 2000 m^2 area and 1m depth) were used for Nile tilapia (*Oreochromis niloticus*) production. Tilapia fingerlings (about 26g initial body weight/ fish) were stocked at 5,10 and 15 fish/m^2 in each earthen pond area and reared for 210 days. Fish in each pond was fed on a commercial complete diet containing 30% crude protein, 2 times daily at feeding rates of 6,5,4,3 and 2.5% of fish biomass during 1st, 2nd,3rd and 4th and thereafter months respectively.

The obtained results showed that growth performance, survival rate and total yield/feddan significantly ($P<0.05$) decreased with increasing pond area from 500 m^2 to 2000 m^2. Under each tested pond area, it was noted a significant ($P<0.05$) decrease in growth performance and survival rate due to the increase in the stocking density from 5 to 15 fish/m^2. Fish yield/feddan increased significantly ($P<0.05$) with increasing the stocking density from 5 to 15 fish/m^2.

Feed and protein utilization improved with fish reared in small pond area (500m^2) than larger pond areas(1000,1500 and 2000 m^2). Also, increasing the stocking density from 5 to 15 fish/m2 resulted in lower feed and protein utilization by tilapia fingerlings.

Economical evaluation of the obtained results showed that the small pond area (500m^2) with high stocking rate 15 fish/m^2 achieved higher income (101430 LE/ feddan) and higher profit (19044 LE/feddan). However, the economic evaluation results showed that the optimum economical condition among the 12 tested treatments was the 2nd treatment (500m^2 pond and 10 fish/m^2).

From the above mentained results it could be concluded that small earthen pond ares (500m^2) and high stocking density (15 fish/m^2) with *O. niloticus* fingerlings are recommended for higher yield and income. Nevertheless, the % income /cost was infavour of 10 fish /m^2 along with 500 m^2 ponds.

Keywords:Ponds- Nile tilapia- Stocking density- Performance- Economics.

INTRODUCTION

Intensification in aquaculture is defined as management in which more fish are produced per area unit, by complementing of substituting the natural food web in culture environments with external inputs such as feeds and fertilizers and by supporting cultured populations with oxygen and biofiltration whenever necessary (Mires,1995).

The semi-intensive culture of tilapia is particularly ideal in developing countries because it provides a wide variety of options in management and capital investments. Management strategies in lower levels of intensification involves the use of fertilizers to encourage natural productivity and to improve the levels of dissolved oxygen. The stocking rate is ranged between 5 and 10 fish/m^3. Fish yields from such techniques have been found to be higher than those from natural unfertilized systems (Green,1992).Semi-intensive fish culture provides about 75% of the Egyptian's total aquaculture production (El-Gamal,2001) and most farms are located in the northern or eastern parts of the Nile Delta. The water supply for these farms comes from agriculture drainage water. There is great variation in the degree of intensity, types of input, level of management and the size and type of infrastructure. The average productivity ranges between 0.7 to 4.3 tons/feddan/year. Tilapia contributes 44% of the annual harvest. Today, there are a total area of 60.000 feddan used as fish farms in Kafr El-Sheikh Governorate. These farms are supplied with agriculture drainage water and produce 150.000 tons/year with an average of 3.5 tons/feddan and a net return of 8.000-10.000 LE/ feddan was recorded (Soltan,2003).

Availability of tilapia hatcheries is one reason for the fast development of fish farming in Kafr El-Sheikh Governorate. Today there are about 235 tilapia hatcheries produce more than 600 million of Nile tilapia (*O. niloticus*)fry units annually in Egypt (Soltan,2003).Also, there were attempts to produce tilapia fry at earlier February by supplying fish hatcheries with water boilers and greenhouse for fry rearing. By this method, fingerlings will be available earlier than normal spawing season and this helps the farmers to obtain two crops(two production cycles)/year and doubled the fish yield for the same production area.

The present experiment aims to study the effects of earthen pond area and stocking density on the production performances of Nile tilapia, *Oreochromis niloticus,* fingerlings.

MATERIALS AND METHODS

The present experiment was carried out at the Fish Farm of the Arab Fisheries Company located in Bersseq, Abbo-Homous , Behira Governorate.Twenty four earthen ponds, six of each averaged 500, 1000,1500 and 2000 m^2 in area and 1m depth, were used. Water was obtained from Berseeq Drain. Increasing rates of water supply were replaced daily,being 5,10,15 and 20% of the pond,s water volume using continuous water current for 24 hours at the first two months, 3^{rd} - 4^{th} months, the following 5^{th}-6^{th} and for the rest of the rearing season, respectively. Each pond was supplied with 2HP (Model NR-Air110) paddle wheel. Air was supplied using these aerators all night and early in the morning throughout the late summer and only for emergency in the first four months..

Nile tilapia (*Oreochromis niloticus*) averaging 26 gram were stocked on first May 1999 and reared for 210 days. All ponds were sampled monthly using a cast net. Average individual weight of fish was calculated to determine growth rates and to adjust the feed amount for the following month.Fish fingerlings at three stocking densities 5.10 or 15 fish/m^2 were stocked in double ponds of each pond area (500,1000, 1500 and 2000 m^2)

and fed on an experimental diet containing 30% crude protein (Table 1), 2 times per day and 6 days weekly.The daily feeding rate as a present of tilapia total biommass in each pond was 6% for the first month, 5% for the second month, 4% for the third month, 3% for the fourth month and 2.5% thereafter.

Table (1): Feed ingredients(%) and proximate chemical analysis(%) of the diet used in the present experiment.

Item	% Diet
Ingredients (%)	
Fish meal	17
Soybean meal	33
Wheat middling by products	17
Wheat bran	10
Yellow corn	18
Corn oil	3
Vitamin mixture[1]	1
Mineral mixture[2]	1
Nutrients (% on dry matter basis)	
Crude protein (CP)	30.80
Ether extract (EE)	6.520
Crude fiber (CF)	2.25
Ash	10.92
Nitrogen-free extract (NFE)	49.51
Gross energy (GE ,kcal/ 100g DM)	439
Protein/energy ratio (mgCP/kcal GE)	70.16

1)Vitamin mixture ,each Kg contain:
Vitamin A : 8000 I.U, Vitamin D_3 : 4000 I.U, Vitamin E : 50 mg, Vitamin k : 19 mg, Vitamin B_1 : 40 mg, VitaminB_2 : 125 mg,: VitaminB_6 : 69 mg, : VitaminB_{12}: 40 mg. : Pantothenic acid : 40 mg, Nicotinic acid: 125 mg, Folic acid: 400 mg, Biotin 20 mg, and Cholin cholride: 80 mg.
2- Mineral mixture ,each Kg contain :-
Copper : 400 mg, Iodine : 40 mg, Iorn : 120 mg, Manganese: 220 mg, Zink : 22 mg, and Selenium: 4 mg.

Water temperature, dissolved oxygen (DO_2), pH and unionized ammonia were monitored weekly during the experimental period. Dissolved oxygen in the experimental ponds was measured daily at sunrise and sunset using oxygen meter. The water temperature was measured with simple thermometer. The pH was measured by pH-meter. Un-ionized ammonia was determined by the Nessler method using Spectrophotometer UV-120-01 after the filtration of water samples according to Jacson (1958).Chemical analysis of the experimental diet was done according to AOAC (1984).

The price of 1000 fingerlings of tilapia (26 g) was 300L.E., and sale price of harvested fish was 7.0 L.E /Kg. The price of 30% crude protein diet was 1200 L.E / ton. Feed ingredients prices were 3600,2600,400,850,1265,4000,5000 and 2000 for fish meal, soybean meal, wheat middling by-product , wheat bran, yellow corn, corn oil,vitamin mixture and mineral mixture, respectively.

The annual rent of each feddan of different ponds area 500, 1000,1500 and 2000 m^2 was 5000,4000,3000 and 2000 L.E, respectively.Other production costs include electricity, fuel and oil, labor, fishing and maintenance of ponds

The initial weight , final weight , total gain, average daily gain (ADG), specific growth rate (SGR%), survival rate, feed intake, feed conversion ratio(FCR), protein effeciency ratio (PER), yield and income were subjected to multiple comparsion analysis of variance using the software package (SPSS 10) programe.

RESULTS AND DISCUSSION

A commercial complete diet containing 30.8% crude protein,439Kcal gross energy/100g dry matter and a protein to energy ratio of 70.20 mg CP/Kcal gross energy as indicated in Table (1) was used in feeding *O. niloticus* fingerlings in the present experiment.

Water quality that collected from different ponds during the experimental period from May to November,1999,showed the following averages (mean ±SE):

(1) temperature : 27.30^0C ± 0.40,

(2) dissolved oxygen : 7.20 mg DO_2/l ± 0.50,

(3) pH : 7.70 ±0.10 and

(4) ammonia (mg NH_3/l) 0.09 ±0.02.

Water temperature throughout the experiment ranged between 23(in November) and 30 ^0C (in August) with an average of 27.3 ^0C which was closely related to the average optimal value for tilapia (Broussard, 1985).

The values of dissolved oxygen in the water used in the present experiment were between 6.6 and 8.3 mg DO_2/l with the overall mean of 7.2 mg DO_2/l. In general, dissolved oxygen levels were within the high standards and higher than that cited by Boyd (1979) for tilapia (4.2-5.9 mg DO_2/l) reared in earthen ponds. To avoid oxygen depletion, airators were oprated at the late summer from sunset to sunrise, moreover, emergency aeration was applied at day light when wind velocity was low. The dissolved oxygen content in earthen ponds depends on the pond water temperature, fish biomass and rate of water change (Hute,1972).

Water pH values throughout the present experiment ranged between 7.3± 0.10 and 8.30 ± 0.10 with an overall mean of 7.70 ± 0.10.The present water pH values are suitable for rearing tilapia in earthen ponds as recommended by Johnson(1986) within the range between 6.5 to 9.0 for most freshwater fish spicies.

Un-ionized ammonia (NH_3) concentration in water used in the present expriment ranged between 0.02 and 0.15 with an average of 0.09 ± 0.02 mg/l. These valuse were generally remained below levels which could cause chroinc toxicity problems in tilapia. Johnson (1986) reported that tilapia are more tolerant to elevated levels of ammonia than other sensitive species such as salmonids. The author showed that the levels of un-ionized NH_3 which may adversely affect growth in tilapia range from 1mg /l to 2mg/l where temperature and pH are within normal range.

Results in Table (2) show the effect of pond area and stocking density on growth performance, survival rate and total yield (ton/pond and ton/feddan) of Nile tilapia. The results clearly showed that growth preformance criteria of tilapia fingerlings (gain, average daily gain(ADG)and specific growth rate (SGR%)) were significantly ($P<0.05$) decreased with increasing pond area from 500 m^2 to 1000, 1500 and 2000 m^2, respectively. Also, the results showed that increasing the stocking density more than 5 fish/m^2 significantly ($P<0.05$) decrease the growth performance. The most common practice in fish culture in Egypt is pond culture (Hamza,1989). The area of fish ponds ranges from one to 30 feddan stocked with 1-3 fish/m^2 and the average water depth is 0.5m within a range of 0.3 to 1.5 m (Soltan ,2003).

The significant ($P<0.05$) decline in harvested fish body weights with increasing the stocking density may be attributed to the reduced feed intake due to the compitition among individuals at higher stocking densities. Zonneveld and Fadholi (1991) noted that tilapia (phenotypically *O.niloticus)* reared in stagnant water had highligted the importance of stocking densities as an important factor affecting growth rate.The authors reported that stocking density of 12 fish/m^3 had resulted in a relative growth rate close to zero although feed was still consumed. The authors related the retardation of fish growth to the effect of stocking density on the feed intake which in turn is linearly related to the relative growth rate.

The prestent results showed that the lower stocking denesity of 5 fish /m^2 was the best stocking density to obtain higher growth performance for *O.niloticus* reared in earthen ponds. Similar results were obtained by Omar *et al*. (1988) who showed that the best growth performance criteria were obtained for fish stocked at 6 fish /m^3.

The results showed that survival rates (%)were significantly ($P<0.05$) decreased with increasing pond area or stocking density (Table 2).Small area ponds (500m^2) significantly ($P<0.05$) produce higher yield than larger pond area (1000,1500 and 2000 m^2, respectively). Values of fish yield were 11.2,9.81,8.27 and 6.99 ton/feddan for 500,1000,1500 and 2000 m^2 ponds, respectively. These results clearly indicated that higher growth performance and survival rates resulted in higher values of production obtained from small ponds (500m^2).

Table (3) shows the effects of pond area and stocking density on feed and protein utilization of tilapia.The results clearly indicated a significant($P<0.05$) decrease in feed intake with increasing the pond area or the stocking density of fish , particularly at the smallest two areas(500 and 1000m3). On the other hand, the results showed that feed utilization (expressed as feed conversion ratio (FCR) improved significantly ($P<0.05$) with decreasing the pond size or the stocking density.The FCR is a coefficient of exploitation of the supplementary feed (Yashouv and Halevy,1972) and is an indicator of the nutritional value of the feed. The present results confirm the findings of Jorgensen *et al* (1993), who reported that the FCR was always significantly lower at lower stocking densities than that of fish stocked at higher densities.

Table (2): Effect of pond area and stocking density on growth performance, survival rate and yield of Nile tilapia (O. niloticus) fingerlings reared in earthen ponds.

Pond area (m^2)		Stocking Density (fish/m^2)		Growth Performance		Survival Rate %		Yield (1000 kg)	
		Initial weight (w_1, g/fish)	Final weight (w_2, g/fish)	Gain (W_2-w_1g/fish)	ADG[1] (g/fish)	SGR[2] (%/day)		Pond	Feddan
500	5	27.00^{a}	320.00^{a}	293.00^{a}	1.40^{a}	1.18^{a}	100	0.8^{c}	6.72^{c}
	10	26.00^{b}	285.00^{b}	259.00^{b}	1.23^{b}	1.14^{b}	100	1.43^{b}	11.97^{b}
	15	27.00^{a}	237.00^{c}	210.00^{c}	1.00^{c}	1.03^{b}	100	1.78^{a}	14.49^{a}
	General mean	**26.67^{B}**	**280.67^{A}**	**254.00^{A}**	**1.21^{A}**	**1.12^{A}**	**100^{A}**	**1.34^{D}**	**11.2^{A}**
1000	5	28.00^{a}	273.00^{a}	245.00^{a}	1.17^{a}	1.08^{a}	100	1.37^{c}	5.73^{c}
	10	26.00^{b}	247.00^{b}	221.00^{b}	1.05^{b}	1.07^{a}	100	2.4^{b}	10.37^{b}
	15	25.00^{c}	216.00^{c}	191.00^{c}	0.91^{c}	1.03^{b}	98	3.18^{a}	13.43^{a}
	General mean	**26.33^{BC}**	**245.33^{B}**	**219.00^{B}**	**1.04^{B}**	**1.06^{B}**	**99.33^{B}**	**2.34^{C}**	**9.81^{B}**
1500	5	27.00^{b}	245.00^{a}	218.00^{a}	1.03^{a}	1.05^{a}	96	1.77^{c}	4.84^{c}
	10	28.00^{a}	211.00^{b}	183.00^{b}	0.87^{b}	0.96^{b}	95	3.01^{b}	8.42^{b}
	15	26.00^{c}	193.00^{c}	167.00^{c}	0.80^{c}	0.95^{b}	95	4.13^{a}	11.55^{a}
	General mean	**27.00^{A}**	**216.33^{C}**	**189.33^{C}**	**0.90^{C}**	**0.98^{C}**	**95.33^{C}**	**2.97^{B}**	**8.27^{C}**
2000	5	27.00^{a}	220.00^{a}	193.00^{a}	0.92^{a}	0.99^{a}	90	1.98^{c}	4.16^{c}
	10	25.00^{c}	191.00^{b}	166.00^{b}	0.79^{b}	0.97^{a}	87	3.23^{b}	6.98^{b}
	15	26.00^{b}	184.00^{c}	158.00^{c}	0.75^{c}	0.93^{b}	85	4.69^{a}	9.84^{a}
	General mean	**26.00^{C}**	**198.33^{C}**	**172.33^{D}**	**0.82^{D}**	**0.96^{D}**	**87^{a}**	**3.30^{D}**	**6.99^{D}**

Values/each general means in the same coulm having different superscripts are significantly(at 0.05 level) different.

Averages/pond area or fish stocking density in the same columu/each iteam having different superscripts are significantly(at 0.05% level)different

1-ADG : average daily gain (g/fish/day : W_2-W_1/expermintal period (days).

2-SGR%-specific growth rate (SGR)% per day : 100 (Ln w_2-Ln w_1)/t, where in Ln is the natural logarithm, w_2 is final weight, w_1 is the initial weight, t is the experimental period

Protein utilization (expressed as protein efficiency ratio, PER) by tilapia showed better values in small area ponds(Table 3). However, the results showed that the best PER values were obtained from fish stocked at 5 fish/m^2 compared to those stocked at 10 and 15 fish /m^2, respectively. Increasing stocking density of common carp (*Cyprinus carpio*) from 10 to 40 fish per aquarium decreased PER. Yet, Al-Azab(2001) reported that PER values were improved with each increase in stocking density of fish.

Table (3) Effect of pond area and stocking density on feed and protein effeciency ratio of Nile Tilapia (*O. niloticus*) fingerlings reared in earthen ponds.

Pond area (m^2)	Stocking density fish/m^3	Feed Intake (g DM/fish)	Feed Conversion Ratio(FCR)[1]	Protein effeciency ratio (PER)[2]
	5	580^{a}	1.98^{c}	1.64^{a}
	10	547^{b}	2.11^{b}	1.54^{b}
	15	462^{c}	2.20^{a}	1.48^{c}
500	General mean	**529.67^{A}**	**2.09^{D}**	**1.56^{A}**
	5	495^{a}	2.02^{c}	1.61^{a}
	10	484^{b}	2.19^{b}	1.48^{b}
	15	430^{c}	2.25^{a}	1.44^{c}
1000	General mean	**469.67^{B}**	**2.15^{C}**	**1.51^{B}**
	5	456^{a}	2.09^{b}	1.55^{b}
	10	379^{c}	2.07^{b}	1.58^{a}
	15	446^{b}	2.67^{a}	1.22^{b}
1500	General mean	**427^{C}**	**2.26^{A}**	**1.44^{C}**
	5	359^{c}	1.86^{c}	1.75^{a}
	10	390^{a}	2.35^{b}	1.38^{b}
	15	387^{b}	2.45^{a}	1.33^{b}
2000	General mean	**378.67^{D}**	**2.20^{B}**	**1.48^{BC}**

Values/each general means in the same coulm having different superscripts are significantly (at 0.05 level)different.
Averages/pond area or fish stocking density in the same columu/each item having different superscripts are significantly(at 0.05 level)different
1) **FCR : Fedd intake (gDM/fish)/total gain (g/fish)**
2) **PER : total gain(g/fish)/protein intake(g protein intake/fish).**

Results in Table (4) show the econmical evaluation of Nile tilapia production/feddan. Total income was improved with increasing the stocking density from 5 to 15 fish/m^2. But the total income was decreased with increasing the pond area from 500 m^2 up to 2000 m^2 .On the other hand ,total costs/feddan were increased with decreasing the pond area and increasing the stocking density. The profit /feddan reached its maximum for tilapia reared in the smallest pond area (500 m^2) and stocked with 15 fish/m^2 followed by 10 and 5 fish/m^2, respectively. A less profits were obtained from the larger area ponds(1000 and 1500 m^2, respectively).

Table (4): Economical evaluation of Nile tilapia (*Oreochromis niloticus*) production/feddan reared in different arthen pond area at different stocking densities for 210 days.

Item												
Pond area (m^2)	500			1000			1500			2000		
Stocking density (fish /m^2)	5	10	15	5	10	15	5	10	15	5	10	15
Total Income (1000 LE)	**47.040**	**83.790**	**101.430**	**40.110**	**72.590**	**94.010**	**33.880**	**58.940**	**80.850**	**29.120**	**48.860**	**68.880**
Costs(L.E.)												
Feed cost	29.282	55.044	70.136	29.854	49.962	66.484	22.264	38.346	67.848	17.028	36.080	53.042
Fingerlings	0.750	1.500	2.250	1.500	3.000	4.500	2.250	4.500	6.750	3.000	6.000	9.000
Annual Rent	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Other Costs	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Total Costs	**40.032**	**66.544**	**82.386**	**41.354**	**62.962**	**80.984**	**34.514**	**52.846**	**84.598**	**30.028**	**52.08**	**72.042**
Profit	**7.008**	**17.246**	**19.044**	**-1.244**	**9.628**	**13.026**	**-0.634**	**6.094**	**-3.748**	**-0.908**	**-3.22**	**-3.162**
% Income /cost	17.52	25.92	23.12	-3.01	15.29	16.08	-1.84	11.53	-4.43	-3.02	-6.18	-4.39

All calculations were estimated on 1 feddan area and according to the average market prices in 2003.

However, no profits were achieved with 2000 m^2 as well as with 1500m2 pond stocked with 5 and 15 fish/m^2. The present results clealy showed that the net return /feddan for cultured Nile tilapia in earthen ponds was greatly affected by pond area and the stocking density. The present results showed that the higher income and profit(101 430 LE and 19044 LE/feddan, respectively) were obtained from 500 m^2 ponds and stocked with 15 fish /m^2. El- Sagheer (2001) noted that the higher income and net return (87479.54 and 3207 LE/feddan, respectively) were obtained from ponds stocked with 15 fish /m^3 and offered 32% dietary protein fed 6 times daily.

Finally it could be concluded that the optimum values of growth performance, survival rates and feed utilization of tilapia reared in different earthen pond area and different stocking densities of Nile tilapa (*O. niloticus*) were obtained from small area ponds (500m^2/pond) and low stocking density (5 fish/m^2). However, higher values of income and net return/feddan were obtained from small area pond (500 m^2) stocked with 15fish/m^2.Nevertheless the % income /cost was infavour of 10 fish / m^2 with 500 m^2 ponds.

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تكثيف إنتاج البلطى النيلى فى أحواض ترابية ١-أثر مساحة الحوض وكثافة التخزين

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٢- قسم الاقتصاد الزراعى – كلية الزراعة – جامعة الإسكندرية .

تم استخدام ٢٤ حوض ترابى بمساحات مختلفة (٥٠٠ ، ١٠٠٠ ، ١٥٠٠، ٢٠٠٠ م٢ مساحة وعمق ١م) وفى داخل كل حجم تم تخزين إصبعيات البلطى (وزن أولى ٢٦ جرام فى المتوسط) بمعدلات (٥، ١٠، ١٥ سمكة/م٢) لمدة ٢١٠ يوما.

وغذيت الأسماك على عليقة تجارية كاملة محتوية على ٣٠% بروتين خام مرتين فى اليوم بمعدلات تغذية (٦، ٥، ٤، ٣، ٢,٥%) من الوزن الطازج للأسماك أثناء الشهور(١، ٢، ٣، ٤ وما يليها على التوالى). وتشير النتائج إلى أن كفاءة النمو ومعدلات البقاء والإنتاجية الكلية للفدان كانت تقل معنويا بزيادة مساحة الحوض من ٥٠٠ م٢ إلى ٢٠٠٠ م٢ . وفى داخل كل مساحة للحوض تم اختباره كان هناك انخفاض فى كفاءات النمو ومعدلات البقاء نتيجة لزيادة كثافة تخزين الأسماك من ٥ إلى ١٥ سمكة/م٢ . وقد تحسنت الاستفادة من الغذاء ومن البروتين فى الأحواض الصغيرة عن الكبيرة المساحة وبالكثافات الأقل. صغر مساحة الحوض مع زيادة معدل تخزين السمك حققت دخل وربح أكبر.