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Effect of initial weights and stocking densities on growth parameters and culture economics of Nile tilapia fish raised in earthen ponds

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Abstract

This study aimed to evaluate the effect of both different initial weights and stocking densities on growth performance, productivity and the total economic revenue of Nile tilapia reared in earthen ponds under Egyptian conditions. Twelve earthen ponds with an area of 2 feddans were divided into two groups according to the initial fish weight, fingerlings (10 g) and fry (0.3 g.), Each group had three carrying capacities of 30, 40, and 50 thousand fish / pond. The water quality measurements were sustained at recommended limits, temperature ranged from 23 to 29ºc and the pH from 7.5 to 8.8, while the dissolved oxygen was kept at range from 5.4 to 7.9 mg/l. The growth measurements revealed that the Fing 50 treatment had superior total production, though the percentage of larger fish were accomplished by both group Fing 40 and Fing 30. This was reflected by economics of production, where the highest return was generated by treatments Fing 40, followed by Fing 50, and the best return on costs was in favor of the Fing 30 treatment. In reference to this study findings, a stocking density of 30 and 40 thousand monosex tilapia fingerlings are recommended for culture in earthen ponds under the similar conditions in Egypt.

Keywords: *Nile tilapia, earthen ponds, stocking density, initial weight, production, economical yield*

Introduction

Tilapia is one of the most cultivated fish around the world and perfectly compatible with intensive aquaculture demands. This due to, its ability to handle high density, their growth is higher than other species under intensive farming systems, the consistency of the meat is outstanding, and the reception of the market is strong (Herrera, 2015). Tilapia is the main fish crop in the Egyptian aquaculture industry with approximate production of 1,051,444 tons; 90% of the total aquaculture production (GAFRD 2018). Moreover, it is one of the most consumed protein sources by Egyptians due to, its price, availability, and nutritional benefits. However, aquaculture farms face great deal of problems need to be tackled by the aquaculture experts such as, water quality problems, diseases and feeds high prices Macfadyan *et al.,* (2011) concerns about the sharp fluctuation of fish prices from farm gate depending on the offered quantities in the markets. Khattab *et al.,* (2001) stated that, there are a host of factors contributing to the final growth performance such as, genetics, quality and quantity of fish feed, environmental conditions, social interactions, and fish density. The latter consequently influence the efficiency and utilization of fish feeds predominately in heavily stocked pond, which suffers from uneven feed distribution. Hence, create a competition on both feed and space (Khattab *et al.,* 2001), as well as the rapid water quality deterioration and loose managemental_practices. The option of fish stocking densities depends mainly on economic conditions and consumer demands. Increased stocking density will reduce the average fish size. Resulting in farmer preference to stock suboptimal densities to produce sufficiently large fish and less yield. Moreover, stocking density could be indicator on the feasibility of the production system (**Aksungu & Aksungur, 2007** and **Herrera, 2015**).

Depending on the new given variables in Egyptian aquaculture industry and the expected water scarcity. Our study aimed to formulate a refined recommendation regarding the fish size upon stocking and economics of Nile tilapia culture under earthen ponds condition to minimize production deficiencies per water unit available. Which accomplish both high yield with the minimal production costs.

Materials and methods

The current experiment was performed at Wady El-Rayan, El Fayoum Governorate during the culture season, which extends from late March to end of October 2018. The experiment lasted for 180 days. Hence, the main target of our research is to strike a balance between the costs during the culture season through using various initial weights; and stocking densities to maximize growth rate and profitability output from the same unit area.

The experimental ponds were twelve earthen ponds two feddans /each water surface with average depth of 1.5 m. The ponds water depth maintained at 1.5 m by compensation of the water loss because of evaporation and / or seepage every 2 days. The last 80 days around 5 % of the water total volume was changed daily. That provided healthier pond bottom conditions and enhanced the overall water quality and contribute to expelling the solid wastes from the pond's bed.

Experimental fish

Monosex fries and overwintered fingerlings of *Oreochromis niloticus* were randomly stoked at three stocking densities 30, 40 and 50 thousand fish / two feddans with two different initial weights for fries were 0.3 g, while the fingerlings were 10 grams initial weight. The fish were transported in transportation plastic bag to the farm then thermal adaptation were applied to avoid thermal shock upon release.

Water quality measurements:

The main water parameters were recorded daily and the general trend for temperature was from 23 to 29ºc and the pH from 7.5 to 8.8, while, the dissolved oxygen was kept at range from 5.4 to 7.9 mg/l by using 2 horsepower paddle wheel aerator.

Experimental diet

All the experimental ponds were fed on commercial extruded diet (Aller Aqua Egypt®) 30% crude protein and 4227.57 kcal gross energy/kg. The fish were fed daily at a rate of 3% of its biomass for six days and one day starvation till the end of the experiment. The total daily feed allowance was divided into three portions introduced to fish three times/day at 8:00 am, 12:00 and16:00.

Growth performance parameters

Live body weight

Live body weight (LBW) in g was calculated and recorded from random sampling of 50 fish / pond taken every two weeks. After doing the individual measurements the sampled fish were returned to its allocate pond.

Weight gain

Weight gain (WG) = final weight – initial weight

Specific growth rate (SGR)

(SGR) = (LnW2 - LnW1) / t X 100

Where: Ln = the natural log, W2= Final weight at certain period (g), W1= Initial weight at the same period (g), T = Period (d)

Daily weight gain (DWG)

(DWG) = $(W_2 - W_1) / t$

Where W_2 is the final weight, W_1 initial weight and t is the time in days.

Relative growth rate (RGR %)

(RGR %) = $(W_2 - W_1 / W_1) \times 100$

Where: W_2 and W_1 is the final and initial weight, respectively.

Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) = feed intake/weight gain

Fish grading system:

This study adopted the commercial grading system used in the Egyptian markets by fish mangers to evaluate the different tilapia sizes market price. The grades were as follow; superior grade= 2 or less fish/Kg, Super grade= 3 fish/kg, grad 1= 4 fish/kg, grade 2= 5 fish/kg, grade 3= 6-9 fish/Kg, trash fish grade= more than 9 fish/kg.

Economic evaluation:

The total coasts were calculated by the following equation:

Total costs (US$) = feed cost (US$) + fish fry cost (US$) + operation cost (US$)

Where: Feed cost (US$) = FI (g/fish) * Feed price (US$/Kg)

Fish seeds (Fries/fingerlings) cost (US$) = No. of seeds * Price of fish seeds (US$/1000 fry/fingerling)

Operation costs include labor salary, power, and service.

All experimental diet costs, fish fry cost and operation cost were calculated according to the prices in Egyptian market during the study period.

The economic evaluation was calculated by the following equation:

Net income (US$) = Total fish price (US$) - Total costs (US$)

Where: Total fish price (US$) = ∑ fish weight of each grade (Kg) * Fish price of each grade (US$/Kg)

Fish weight of grade (Kg) = Total fish weight (Kg) * % of fish grade

% income to cost = 100 *(Net income / total cost)

Statistical analysis:

The data of growth parameters and fish size were subjected to two-way ANOVA followed by Tukey's test was used as a post hoc test statistical significance was set at (P < 0.05). All statistical analyses were conducted in SPSS ver. 20 (SPSS, Richmond, VA, USA) according to **Dytham** (**2011**).

Results and Discussion

The findings at the end of culture season indicated that the highest total production /pond (13684.8 kg±0.9) was acquired by overwintered fingerlings (Fing.) and stoking density 50 thousand fish /pond, followed by Fing40, Fry40, Fry50, Fing30 and Fry30, sequentially. Moreover, the data showed statistical differences among the different treatment regarding the total production amount as shown in (Table 1). In this aspect our findings in agreement with (**Ammar**, **2009**) who revealed that, lower stoking densities i.e., 14 up to 16 thousand fish / feddan had notable heaver weight fish at the end of the culture season. Additionally, the same author disclosed that, there were tangible effect of starting with higher weight fish on acquiring higher final body weight and length, SGR at the end of season. Also, **M'balaka *et al*.**, (**2012**) stated that, while heavy stocking can still affect the fish accessibility to food, it may have an increased impact on the overall yield of fish.

The same author added that, this leads to rise in both gross and net returns at a cheaper cost for output. Where land costs, water, manpower and other facilities are scarce, higher stocking densities could be more productive. The fish grading in terms of weight showed that Fing40 obtained the highest harvest in the super grade (8461±0.57Kg) followed by Fings30 and 50 correspondingly, while the least in this grade was Fry 50 as shown in Table 1. Those findings are supported by the findings of (**Tibile *et al*., 2016**) on *Pleuronecte splatessa*, At the beginning of culture all the fish in the same pond have equal opportunity to access to food, however after stocking fish establish its own social scale dominant individuals developed their territory and suppress smaller individuals and reduces the availability of enough food to grow and compete with them.

Furthermore, (**Ronald *et al*., 2014**) indicated that high stoking density contribute in decreasing chronic stress, improve slow grower performance and hinder fast growing individuals due to dominance hierarchy reduction. However, **Wetanabe *et al*.**, (**1990**) and **Huang *et al*.**, (**1997**) contradicted those findings by stating that negative association was found between stocking density and growth homogeneity in red tilapia.

Those findings could be clarified through the findings of, (**Ronald *et al*., 2014**) who stated that, High stocking density in Nile tilapia fry results in homogeneity in both growth and survival rate. Yet, it could lead to numerous individuals never reach their peak potential of growth under such circumstances. Hence, it could lead to minimizing the high size grade fish numbers; this assumption does not include the consumer profitability, which has many variables including the price of the fish.

The growth parameters showed statistical differences among the treated groups at ($P \leq 0.05$). Group Fing40 showed the highest average weight gain 1.82±0.3g, while the lowest one was recorded in fry 50 (1.16±0.3) g / fish as shown in Table 2. The results were partially in agreement with (**Gibtan *et al*., 2008**), who stated that, the maximum (1.15 g / day) and the minimum (0.82 g / day) daily growth rates were observed in 50 fish / m^3 and 200 fish / m^3 treatments, respectively, which the daily growth rate decreased with increasing stocking density.

Table 1: Illustrating the total production and fish grade / experiment

Treatment		Super	Grade I	Grade II	Grade III	Total pond production kg/pond	Total fish production Kg/ feddan
Fish Size	Stoking Density / Pond						
Fingerlings	30000	6719.1^{b} (69.3%)	2221^{f} (22.9%)	591.3^{f} (6.1%)	160.7^{f} (1.7%)	9692.1^{e}	4846.05^{e}
	40000	8461^{a} (62.7%)	3583.2^{b} (26.5%)	1255.6^{d} (9.3%)	202.7^{e} (1.5%)	13502.5^{b}	6751.25^{b}
	50000	6671.2^{c} (48.8%)	2902.1^{d} (21.2%)	3028^{b} (22.1%)	1083.5^{b} (7.9%)	13684.8^{a}	6842.4^{a}
Fry	30000	5573.5^{d} (60.8%)	2353.8^{e} (25.7%)	927.6^{e} (10.1%)	314.3^{d} (3.4%)	9169.2^{f}	4584.6^{f}
	40000	4853.4^{e} (43.8%)	3063.3^{c} (27.6%)	2419.4^{c} (21.8%)	750^{c} (6.8%)	11086.1^{c}	5543.05^{c}
	50000	1679.6^{f} (16.0%)	3809^{a} (36.3%)	3347^{a} (31.9%)	1644.9^{a} (15.8%)	10480.5^{d}	5240.25^{d}
SE ±		0.57	0.01	0.3	0.4	0.02	0.4

Those findings agreeing with **Abdel-Hakim *et al*.**, (**2008**), who indicate that the impact of the initial length of the stocking on the final length of the fish, which means that shorter fish may expand in length but not as long-lived fish at the stocking point. Furthermore, **Abdel-Hakim *et al*** (**2001**) stated that, increasing tilapia stocking density from 50 up to 150 fish / m^3 in culture tanks decreased fish final body weight and length significantly. Moreover, **Khattab *et al*.**, (**2001**) added that, there was significant reduction in growth with increasing stocking density despite increasing protein levels in feeds up to 45%.

The growth efficiency parameters:

Despite, the expected that the lowest carrying capacity will produce higher total growth our findings indicated that the highest stocking rate produced the highest output. However, the grade percentage of the total weight which gives an indication to the quality of harvest and the expected revenue revealed that, Fing30 and Fing40 had the highest super grad quality with 6 % difference (69% and 63%), respectively followed by fry30 (61 %) and the least was 16 % by group fry50 as illustrated in (Figure 1).

The highest values for grade one was noticed in fry50 (36 %) followed by fry40 and Fing40 (28 and 27 %), respectively. The highest values of grade two and three was observed in group fry50 (32 and 16 %) orderly and the lowest in ones were in Fing30 with (6 and 2 %), respectively. The later represents the trash fish grade the farmers least desired. The least feed conversion ratio (FCR) was recorded by Fing30 1.42±0.03 and the highest was in group fry50 (1.79) as presented in Table and Fig. (2). Our findings are supported by the findings of **Azab *et al*.**, (**2018**), who mentioned that notable increase in the total gain with the increase in stocking density. In addition, increased in the FCR with increase in fish stocking density **Ayyat *et al*.** (**2011**), (**Abaho *et al*.**, **2020**).

This could be partially attributed to the availability of natural food in the pond due to the low stocking density as mentioned by **Azab *et al*.**, (**2018**). Group Fing50 recorded the lowest SGR (1.84 %/day) and the highest (3.76%/day) was in fry30 and fry40, respectively as shown in (Table and Fig. 2). (**Gibtan *et al*.**, **2008**) stated that, 50 fish / m^3 attained the maximum mean SGR (1.035 % fish / day) and 200 fish / m^3 the minimum mean SGR (0.787 % fish / day) among the treatments. Results showed that specific growth rates decreased as the stocking density increased.

Table (2). Growth efficiency parameters of the experimental fish

Treatment		Initial Weight g / Fish	Final Weight g / Fish	Total Initial Weight Kg	Total Final Weight Kg	Daily Weight Gain	Feed Intake	FCR	SGR	FER
Fish Size	Stoking Density									
Fing.	30000	10.1[a]	323.07[b]	303[c]	9692.1[e]	1.74[b]	13318.2[f]	1.42[f]	1.93[d]	0.7[a]
	40000	9.96[b]	337.56[a]	398.4[b]	13502.5[b]	1.82[a]	19380.84[a]	1.48[d]	1.96[c]	0.67[c]
	50000	10.02[b]	273.7[e]	501[a]	13684.8[a]	1.46[e]	19106.36[b]	1.45[e]	1.84[e]	0.69[b]
Fry	30000	0.35[c]	305.64[c]	10.5[f]	9169.2[f]	1.7[c]	14132.1[e]	1.54[c]	3.76[a]	0.64[d]
	40000	0.32[c]	277.15[d]	12.8[e]	11086.1[c]	1.54[d]	18621.53[d]	1.68[b]	3.76[a]	0.59[e]
	50000	0.33[c]	209.61[f]	16.5[d]	10480.5[d]	1.16[f]	18738.57[c]	1.79[a]	3.59[b]	0.56[f]
SE ±		0.4	0.2	0.07	0.001	0.3	0.5	0.4	0.25	0.7

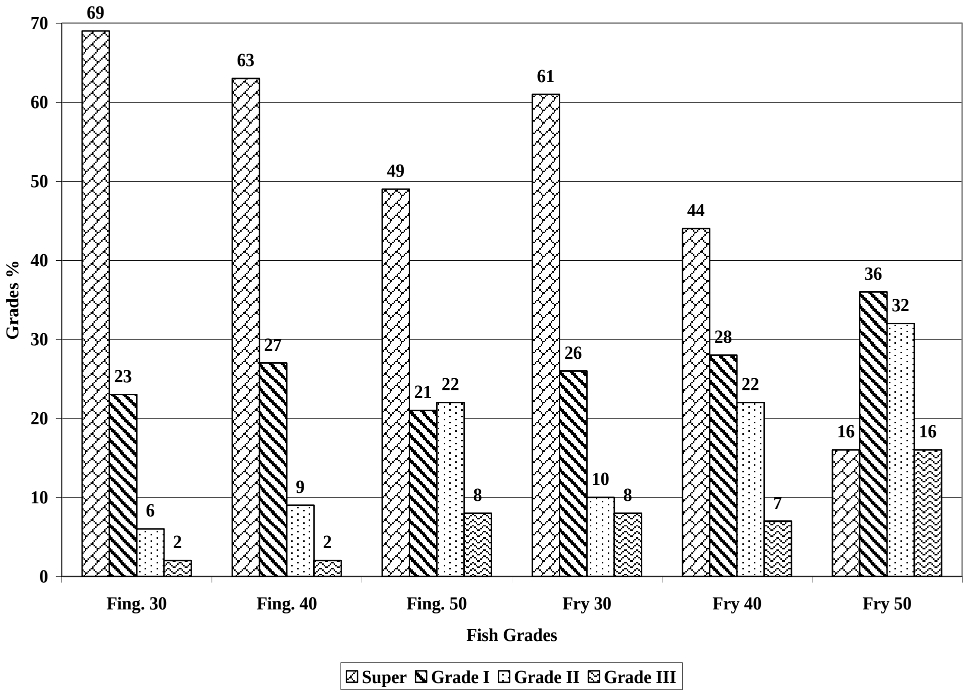

Fig. (1). Showed the % of fish grades

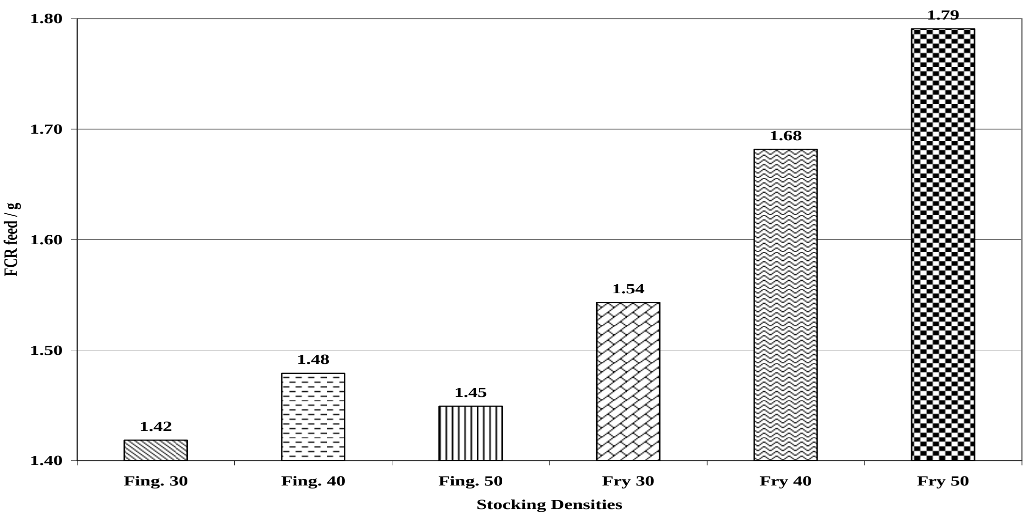

Fig. (2) showed the differences in FCR among all treatments

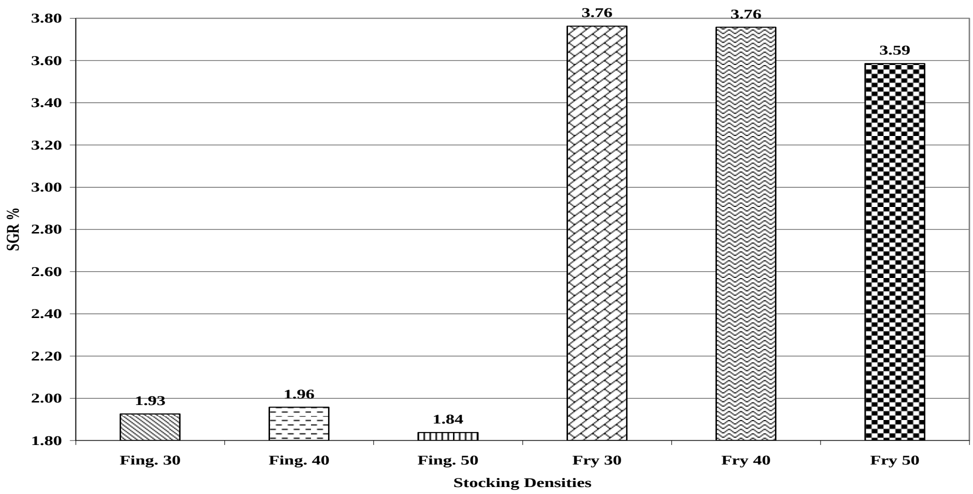

Fig. (3) showed redings of SGR for all treatments at the end of the experimental period

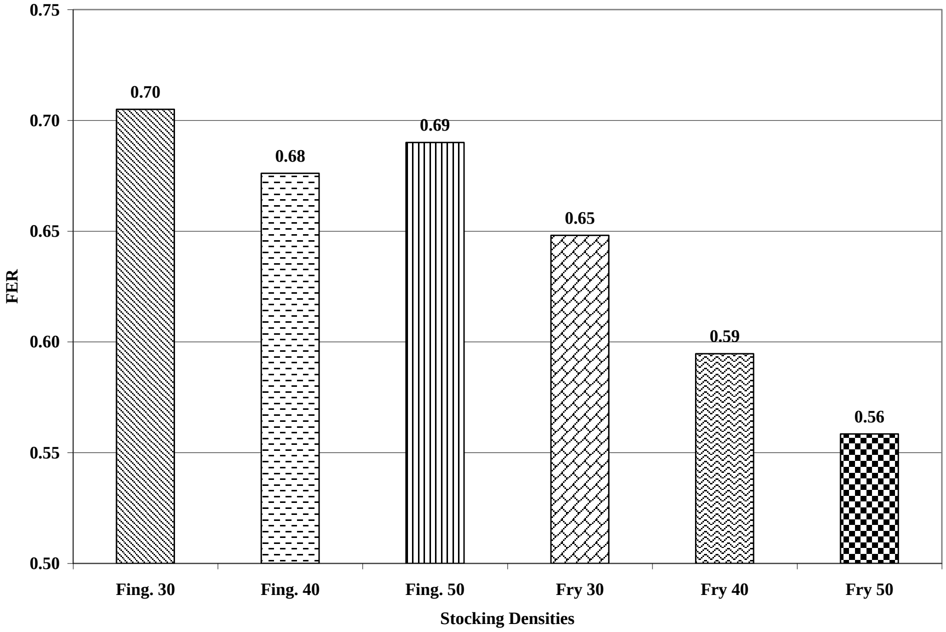

Fig. (4) showed redings of FER for all treatments at the end of the experimental period

Economical efficiency:

The economic study showed that the highest calculated total costs (US$.) including fish seeds, operation cost and feeding was in group Fing50 (13,329.84 US$.) and the lowest total cost was in group Fing30 (8,903.39 US$.). This is may be due to higher operating costs due to increase in the energy consumption of the treatment (Fing50) because of the use of paddlewheels devices more than (Fing30). The total income was calculated from the sum of the produced grads (Super, Grad I, Grad II, Grad III) the maximum total income was obtained by group Fing40 (16,196.99 US$.) and the lowest was produced by fry40 (10853.38 US$.). This may be due to an increase in the amount of larger fish with an increase in total production. Where fish with a larger initial size gave an increase in the total weight produced from fish, as well as a greater percentage of larger sizes. The highest net income was produced by Fing40 and 30 (3,595.68 and 2,827.71 US$.), respectively and the lowest in fry50 group (22,205.6 -). This is because the returns from selling the fish were better in the (Fing.40) and the operating costs were higher in (Fry 50) that did not give large size fish due to the high density, which made them sold at a lower price, which was reflected in the total net return.

Considering the income percentage from the total cost the highest income percentage from the total cost was in group Fing30 (31.8%) and the lowest was in fry50 (-10.08%). This is due to the decrease in operating costs with the increase in the return on sale of fish due to obtaining large-sized fish with a good sales return in (Fing30) and the increase in operating costs compared to the return in (fry50).

Table (3) Economic evaluation for the whole experimental period

Economic evaluation			Unit Price (US $)	Fingers /1000			Fry/1000		
				30	40	50	30	40	50
Costs	Feed Intake (kg)		0.47	13318.20	19380.84	19106.36	14132.10	18621.53	18738.57
	Feed cost (US$)			6240.53	9081.31	8952.69	6621.90	8725.52	8780.36
	Fish Seeds used (1000)	Fingers	17.14	30.00	40.00	50.00	-	-	-
		Fries	5.71	-	-	-	30.00	40.00	50.00
	Fish Seeds cost (US$)			514.29	685.71	857.14	171.43	228.57	285.71
	Operation cost (US$)			2148.57	2834.29	3520.00	2148.57	2834.29	3520.00
	Total Costs (US$)			8903.39	12601.31	13329.84	8941.90	11788.38	12586.07
Income	Fish Grades (%)	Super	1.26	8446.87	10636.69	8386.65	7006.69	6101.42	2111.50
		I	1.14	2538.29	4095.09	3316.69	2690.06	3500.91	4353.14
		II	1.03	608.19	1291.47	3114.51	954.10	608.19	3442.63
		III	0.86	137.74	173.74	928.71	269.40	642.86	1409.91
	Total Income (US$)			11731.09 [c]	16196.99 [a]	15746.57 [b]	10920.25 [e]	10853.38 [f]	11317.18 [d]
	Net Income (US$)			2827.71 [b]	3595.68 [a]	2416.73 [c]	1978.35 [d]	-934.99 [e]	-1268.89 [f]
	%income to cost			31.76 [a]	28.53 [b]	18.13 [d]	22.12 [c]	-7.93 [e]	-10.08 [f]

Conclusion

Regarding to the results from this study, a stocking density of 30 and 40 (T1 and T2) thousand tilapia monosex fingerling / 2 feddan is recommended for culture in earthen ponds in Egypt due to its higher total production, total weight gain, better feed conversion ratios, better and higher production of fish of super grade and higher relative returns, and market price.

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تأثير الأوزان الأولية وكثافة التخزين على معايير النمو واقتصاديات الاستزراع لأسماك البلطي النيلي التي يتم تربيتها في الأحواض الترابية

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2- شعبة إنتاج الأسماك، قسم الإنتاج الحيواني، كلية الزراعة، جامعة عين شمس، القاهرة، مصر.

الملخص العربى

تهدف هذه الدراسة إلى تقييم تأثير كل من الأوزن الابتدائية وكثافة التخزين على أداء النمو، الإنتاجية وإجمالي العائد الاقتصادي لتربية البلطي النيلي في الأحواض الترابية تحت الظروف المصرية. تم استخدام إثنا عشر حوضًا ترابيًا بمساحة 2 فدان/ حوض، حيث تم تقسيمها إلى مجموعتين وفقًا للوزن الأولي للأسماك، إصبعيات (10 جم) وزريعة (0.3 جم) ، كل مجموعة بها ثلاث كثافات للتسكين 30، 40، 50 ألف سمكة / حوض. تم الحفاظ على قياسات جودة المياه عند الحدود الموصي بها، حيث تراوحت درجة الحرارة من 23 إلى 29 درجة مئوية ودرجة الحموضة من 7.5 إلى 8.8 بينما تم الاحتفاظ بالأوكسجين المذاب في نطاق من 5.4 إلى 7.9 مجم / لتر. أظهرت قياسات النمو تفوق المعاملة Fing 50 في إجمالي الإنتاج، على الرغم من أن النسبة المئوية لدرجات الأسماك الأكبر كانت لصالح المجموعتين Fing 40 و Fing 30 ، وقد انعكس هذا في القيمة الاقتصادية للإنتاج، حيث كان أعلى عائد للمعاملة Fing 40 ، متبوعاً بالمعاملة Fing 50 ، وكان أفضل عائد على التكاليف هو في المعاملةFing 30 .

فيما يتعلق بنتائج هذه الدراسة، يوصى باستزراع إصبعيات البلطى النيلى أحادية الجنس من 30 إلى 40 ألف سمكة / حوض ترابى / 2 فدان في مصر.