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Effect of Fertilization on Production of Nile Tilapia in Earthen Ponds II) Effect of an untraditional organic fertilizer and stocking density on the fish yield of Mixed-sex Nile tilapia (*Oreochromis niloticus*)

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ABSTRACT

The experiment was designed to determine the optimal fertilizing rate of Abis organic fertilizer and to investigate the effect of stocking density on mixed-sex Nile tilapia performance. Six-200 m^2 earthen ponds were assigned for 3 treatments: fertilizing rate of 50 g fertilizer / m^2 wk^{-1} in ponds stocked at 5 fish / m^2; fertilizing rate of 100 g Abis fertilizer / m^2 wk^{-1} in ponds stocked at 5 fish / m^2; or fertilizing rate of 100 g Abis fertilizer / m^2 wk^{-1} in ponds stocked at 8 fish / m^2. Fish in this experiment were fed to apparent satiation level in 20 min. This experiment lasted for 112 days. Water quality parameters were monitored weekly in each experiment. Growth rate, specific growth rate, gross yield did not significantly differ among treatments, due to variation between replicates within treatments. Gross yield showed a positive trend with both the fertilizing rate and stocking density. The effect of the treatments on water quality parameters was discussed.

Key words: Fertilization, organic fertilizer, Nile tilapia fish, earthen pond, fish production

INTRODUCTION

Tilapia culture in tropical and subtropical countries is practiced at either extensive or semi-intensive levels. The semi-intensive of tilapia is particularly ideal in developing countries because it provides a wide variety of options in management and capital investments. Management strategies in the lower levels of intensification involve the use of fertilizer to encourage natural productivity and to improve the levels of dissolved oxygen. Fish yields from such techniques have been found to be higher than those from natural unfertilized systems (Hickling, 1962; Hepher, 1963 and Green, 1992). Moreover, increases in fish yields above those attained by fertilization only can be achieved by using of feed-fertilizer combinations, which result in higher critical standing crop (Hepher, 1978).

A number of studies have been done on feed and fertilizer combinations. Such combinations may be very effective because fertilization rates can be reduced

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due to enrichment gained from fish excreta. In such combination, rapid growth rate of tilapia and large size could be attained in shorter time than in fertilizer alone (Green, 1992; Diana *et al.*, 1996a; Diana, 1997 and Brown *et al.,* 2000).

The growth rate of tilapia is the most critical factor to the success of any aquaculture industry. Hence, achieving the maximum growth rate is the main goal of any aquaculture effort; aquaculturists are trying to provide better nutrition and environmental conditions to improve the growth rate of tilapia. When all conditions are optimal, tilapia will grow at astonishing rates which have led to the popular descriptions as "miracle fish" (Fitzsimmons, 1997). It is only under favorable conditions, which termed "water quality", that rapid growth for whole populations can be achieved (Fitzsimmons, 1997). On the one hand, water quality in fish ponds is a major factor determining the production of fish. On the other hand, water quality is dramatically influenced by pond management practices, such as stocking density of fish, fertilization strategy, and supplemental feeding. Thus, it could overcome the limitations to pond production via water quality's manipulating. Manipulation of pond water quality is a major management way in the semi-intensive production of tilapia and may become an important limitation in intensive production (Diana *et al*., 997).

The present study aimed to reduce the production's costs by determining the optimal rate of weekly fertilizer application and fish stocking density for keeping the high primary production and water quality to achieve the maximum fish production in combination with feeding practice.

MATERIALS AND METHODS

Six–200 m^2 earthen ponds, at The Fish Farm of The Faculty of Agriculture (Saba–Basha), Alexandria University, were assigned for the three treatments during the experimental course.

Before the experiment, the ponds (average depths of 85-90 cm) were drained before refilling. In all ponds, inlet pipes were covered with a fine saran screen to prevent the entry of wild fish. Water source was a mixture of freshwater and agricultural drainage water. Throughout the experimental period, there was an adjusted daily water flow rate to replace the whole water volume every week. That water flow continued from 08:00 until 15:00 o'clock 6 days a week.

Mixed-sex Nile tilapia *Oreochromis niloticus* fry, with an average weight of 1.24 ± 0.129 g produced by the hatchery of The Fish Farm of The Faculty of Agriculture (Saba-Basha), Alexandria University, were stocked in the experimental ponds at different densities. Two ponds were stocked at a density of 8 fish / m^2 and the other four ponds at a density of 5 fish / m^2. Fish were sampled in two occasions by seining about 10% of the initial number stocked.

Fish fed on a commercial floating fish feed, 20% protein – Joe Trade Co., at a satiation rate twice a day (at 8:00 and 15:00 o'clock) 6 days a week. The floating pellets were dropped inside a floating plastic rings (made of electrical plastic tube) to adjust the amount of feed. The amount of feed was adjusted weekly by collecting the remaining amount of feed after 20 minutes, which was deducted in the next meal. The experiment lasted for 112 days, from 6 / 7 to 3 /11 / 2002.

The organic fertilizer was added in two rates 50, or 100 g dry matter / m^2 / wk in two and four ponds, respectively. Urea and mono-superphosphate were added at a rate of 2.8 g nitrogen (N) and 0.7 g phosphorus (P)/ m^2 / wk, respectively to bring N:P ratio to 4:1 (Knud-Hansen *et al*., 1991 and Yi *et al.*, 2001). The Abis organic fertilizer was packaged into polypropylene bags and dropped into the ponds. The bags were resettled in new places weekly. The two ponds received 50g fertilizer/m^2/wk were stocked at a density of 5 fish/m^2, and two of the four ponds received 100g fertilizer/m^2/wk were stocked with 5 fish/m^2. The remaining two ponds, received 100g fertilizer, were stocked at 8 fish/m^2.

For physical parameters and chemical analysis, water samples were collected at 07.00 – 08.00 o'clock using Van Dorv bottle (1 L), from each pond weekly at the third day after fertilizers were applied. Pond water analyses included temperature; DO; pH; total and unionized ammonia; nitrate; nitrite; total phosphorus and orthophosphate were carried out according to Boyd and Tucker (1992).

The experiment was terminated on November 3rd 2002 after 112days of the intitiation. Total yield (TY) and final number were determined. Overall total gain (TG), daily net yield (DNY), specific growth rate (SGR) and daily gain (g/fish/day) were calculated and so the FCR.

Statistical analysis

The data of fertilizer analysis, water quality and fish production were statistically analyzed according to the SAS statistical package (SAS 1998). The least significant difference test was utilized to evaluate the difference among treatments' means for all variables.

RESULTS

Water quality

Over the course of the experiment, the temperature ranged from 23ºC to 30ºC with an average of 25.8 ± 0.1ºC. Overall mean of dissolved oxygen was 5.14 ± 0.1 mg/L with means of 4.97 ± 0.19, 5.23 ± 0.16 and 5.23 ± 0.16 mg/L in the first, second and third treatments respectively. Generally, the pH values ranged from 8.7 to 9.3 in the first treatment, from 8.5 to 9.2 in the second treatment, and from 8.3 to 9.5 in the third treatment.

Total ammonia showed significant differences ($P < 0.05$) among treatments only in the 8th and 13th weeks of the experiment (Fig. 1A). It fluctuated during the course of the experiment in an increased manner in all treatments with time. However, it didn't show any particular relation with either the fertilizing rate or fish stocking density. This may due to the high variability in readings among replicates within each treatment. Unionized ammonia showed significant differences among treatments (Fig. 1B). In general, it increased in all treatments from 0.056-0.099 mg/L at the beginning of the experiment to 0.222- 0.477 mg/L at the termination of the experiment in fluctuated pattern. Unionized ammonia showed a positive relationship with fish stocking density. However there was no clear relationship between fertilizing rate and unionized ammonia.

Nitrate concentrations showed significant differences among treatments (Fig. 1C). In general, nitrate concentration did not go above 1.015 mg/L over the experimental course. Overall means indicated that, the fertilizing rate had a positive effect on nitrate concentration. Overall mean went up from 0.387 ± 0.065 to 0.409 ± 0.066 mg/L by increasing fertilizing rate from 50 to 100 g/m^2/wk. On the other hand, fish stocking density had a negative impact on the nitrate concentration. It caused a reduction in nitrate overall mean from 0.409 ± 0.066 to 0.362 ± 0.064 mg/L by increasing from 5 to 8 fry/m^2. In regard to nitrite, it showed significant differences among treatments (Fig.1D). There was a remarkable increase in nitrite concentration especially in the first and third treatments at the 10th week. Overall mean of nitrite proposed that there was a negative relationship between nitrite and fertilizing rate. Higher fertilizing rate caused a lower nitrite concentration and subsequently lower overall mean in the second treatment (0.0415 ± 0.006 mg/L). Overall mean of nitrite also suggested that there was a minor positive effect of fish stocking density. Higher stocking density in the third treatment produced relatively higher overall mean of nitrite (0.048 ± 0.011mg/L) than the second treatment.

Total phosphorus concentration showed significant differences among treatment since the first week of the experiment (Fig.1E). The fertilizing rate had a positive effect on the total phosphorus concentration until the 12th week. However, a negative relationship was noticed between fish stocking density and total phosphorus concentration. The third treatment had a lower total phosphorus concentration, significantly ($P < 0.05$) in many occasions, than the second treatment. In regard to ortho-phosphate concentrations, there were significant differences among treatments since the first week (Fig1 F). Three periods can be distinguished in this experiment, 1^{st}–4^{th}, 5^{th}–12^{th} and 13^{th}–16^{th} week. In the first and third periods, a positive relationship was noticed between the fertilizing rate and ortho-phosphate concentration. Higher fertilizing rate in the second treatment resulted in higher concentration of the ortho-phosphate, significant ($P < 0.05$) in several occasions, than the lower one in the first treatment. In the second period from 5^{th} to 12^{th} week, the relationship between the fertilizing rate and ortho-phosphate concentration turned to a negative relationship. Significantly ($P < 0.05$) higher ortho-phosphate level in the first treatment was noticed. Overall mean of ortho-phosphate was higher in the first treatment than in the second treatment. With respect to the relationship between fish stocking density and ortho-phosphate concentration, there were two distinguished periods. In the first period, from the 1^{st} week until the 12^{th} week, there were significant ($P < 0.05$) differences in favor of higher stocking density in the third treatment. In the second period, the last four weeks, there were significant ($P < 0.05$) differences in favor of the lower stocking density in the second treatment. Overall means of ortho-phosphate concentration showed that, the higher fish stocking density in the third treatment had higher ortho-phosphate concentration than the lower stocking density in the second treatment.

Growth Performance

Fish specific growth rate (SGR) and daily gain didn't show any significant differences among treatments (Table 1). But it was noticed that the stocking density had a negative effect on them, while doubling the fertilizing rate had a positive effect. With respect to the final body weight (FBW, g/fish) and the monthly fish weights, the results revealed that there were significant differences ($P < 0.05$) among treatments (Table1). The highest final body weight was recorded in the treatment (1), while the treatment (3) had the lowest FBW. The final body weights among treatments had the same trend of fish daily gain. Again, this implies to the inverse relationship between fish stocking density and fish final body weights. Also, it proposed that doubling the fertilizing rate somehow had a negative effect on fish final body weight.

In regard to the total yield, total gain and daily net yield, statistical analysis revealed that all these parameters in treatment (3) were higher, but not significantly, than those in the other two

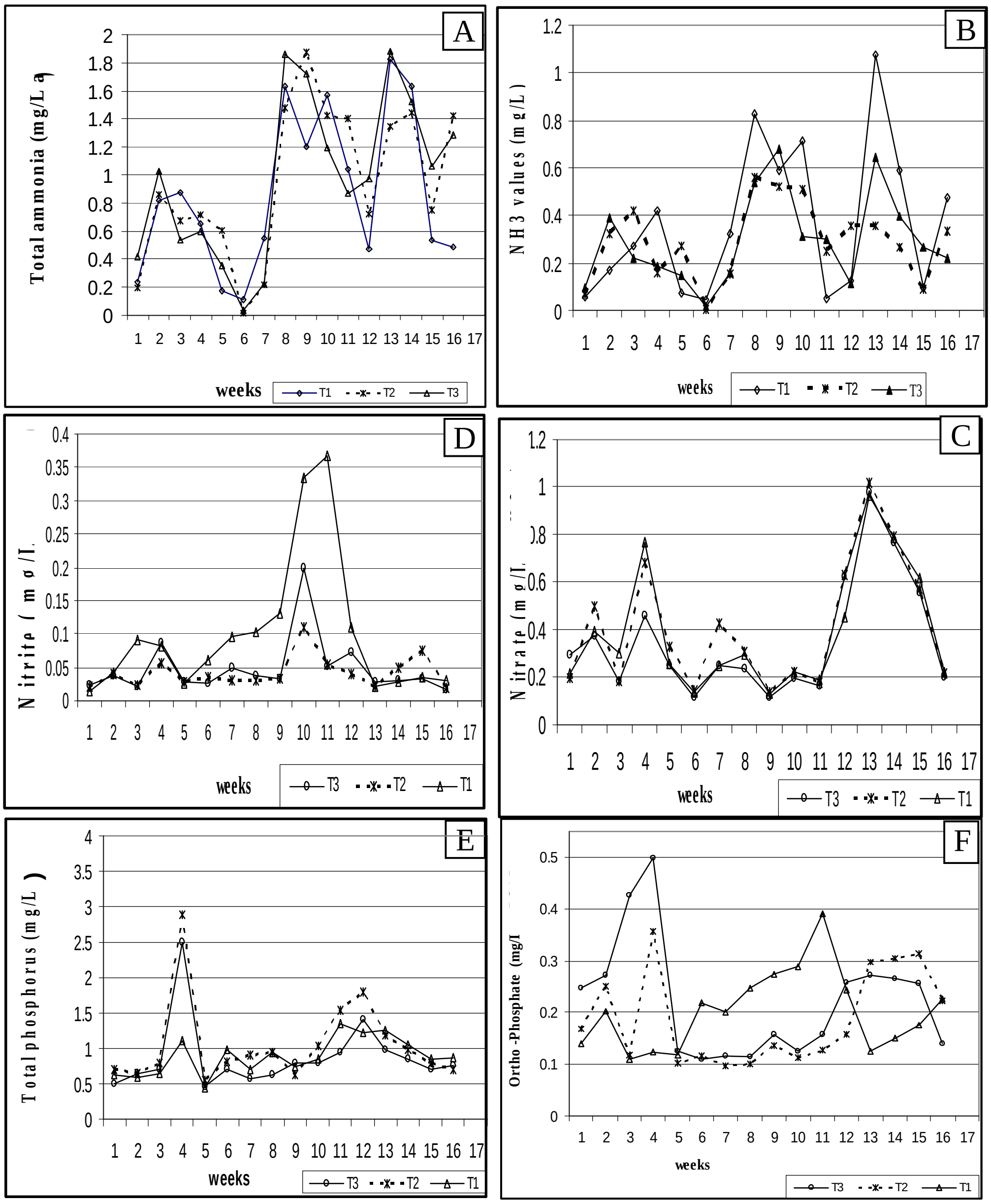

Fig (1): *The relationship between time (in weeks) and (A) Total ammonia (mg/l), (B) Unionized ammonia (mg/l), (C) Nitrite(mg/l), (D) Nitrate (mg/l), (E) Total phosphorus (mg/l), (F) Ortho-phosphate(mg/l).*

Table (1) : *Monthly, body weight and growth measurements (mean ± S.E.) of mixed- sex Nile tilapia Oreochromis niloticus during the present experiment*

	Treatment (1)	Treatment (2)	Treatment (3)
Initial body weight (g/ fish)	1.15 ± 0.05	1.15 ± 0.03	1.56 ± 0.04
body weight after 30 days (g/ fish)	22.06 ± 1.54	20.4 ± 1.58	18.14 ± 0.76
body weight after 60 days (g/ fish)	41.67 ± 2.9	38.45 ± 3.1	33.69 ± 1.4
final body weight (g/ fish)	* 74.34±5.16 a	68.54±5.66ab	59.6±2.80b
SGR (%/d)	3.59±0.21	3.65 ± 0.12	3.26 ± 0.003
Daily gain (g/ fish/day)	0.65 ± 0.045	0.6 ± 0.05	0.52 ± 0.02

In each column, means followed by different letters are significantly different.

* *P< 0.05*

treatments (Table 2). The lowest total yield and total gain were in treatment (1). The results indicate that both stocking density and fertilizing rate had a positive effect on the total yield, total gain and daily net yield.

Food conversion ratio (FCR)

Fertilizing rate and stocking density had non-significant effect on FCR. The lower fertilizing rate treatment had the lowest FCR, in the treatment (1).

Yield of initial stock and the yield classes

The gross yield of initial stock was calculated by deduction the recruitment biomass kg/200m^2 from the total yield (Table 2). Statistical analysis of the gross yield of initial stock revealed that, there were significant differences (P < 0.05) among treatments. The highest gross yield was in the treatment (3), being 97.5 ± 2.8 kg/200m^2. It was significantly higher than those of the other two treatments. The intermediate gross yield was noticed in the treatment (1). It wasn't significantly different from the lowest one in the treatment (2). This suggested that the stocking density had a significant positive effect on the gross yield of initial stock. However, fertilizing rate had a negative effect on the gross yield of initial stock.

The trends in gross yield of initial stock were reflected in the net yield of initial stock, with similar results but at different significance level.

Interestingly, recruitment amounts revealed remarkable differences, but not significant, among treatments (Table 3). The produced recruitment was higher in the treatment (2) than those in the other treatments. Intermediate was found in the treatment (3). These results showed some interesting out comes. Stocking density had a negative effect on the produced recruitment. But fertilizing rate had a positive effect on the produced recruitment. This may stimulate the negative effects of increasing stocking density in the treatment (2) on the daily gain, final body weight, and gross yield of initial stock and subsequently net yield of initial stock.

Table (2): *Harvest result and feed conversion ratio of mixed sex Nile tilapia reared in dirt ponds in the present study (mean ± S.E.)*

Treat **$g/m^2/wk$**	Treatment (1)	Treatment (2)	Treatment (3)
Initial biomass (Kg fish/$200m^2$) M ± S.E.	1.18 ± 0.04	1.23± 0.01	2.54 ± 0.05
Total yield (Kg fish/$200m^2$) M ± S.E.	82.85 ± 5.55	90.05 ± 13.85	105.67 ± 3.80
Total gain (Kg fish/$200m^2$) M ± S.E.	81.68 ± 5.47	88.83 ± 13.87	103.07 ± 3.72
Daily net yield (g/m^2/day) M ± S.E.	3.65 ± 0.25	3.97 ± 0.62	4.61 ± 0.17
Offered feed (Kg/$200m^2$) M ± S.E.	90.4 ± 1.76	117.1 ± 11.72	136.2 ± 4.29
FCR M ±SE	1.108 ± 0.037	1.32 ± 0.024	1.322 ± 0.025
Gross yield of initial stock (Kg fish/$200m^2$) M ± S.E.	* 76.0 ± 4.1 b	73.5 ± 8.5 b	97.5 ± 2.8 a
Net yield of initial stock (Kg fish/$200m^2$) M ± S.E.	74.79 ± 3.97	72.24 ± 8.46	94.97 ± 2.72

In each column, means followed by different letters are significantly different.
* *P< 0.05*

Table (3): *Yield in classes of mixed sex Nile tilapia reared in dirt ponds in the present study (M ± S.E. Kg fish /200 m^2).*

Treat	1st	2nd	3rd	4th	Other	Recruitment (Kg fish/$200m^2$) M ± S.E.
Treatment (1)	16.87 ± 1.13	9.1 ± 5.25	0.0 ± 0.0	25.3 ± 3.18	24.67 ± 0.9	6.9 ± 1.5
Treatment (2)	14.03 ± 8.11	4.0 ± 2.31	16.43 ± 2.02	0.0 ± 0.0	39.0 ± 2.94	16.6 ± 5.4
Treatment (3)	0.0 ± 0.0	17.8 ± 1.65	0.0 ± 0.0	39.5 ± 3.7	40.2 ± 3.7	8.15 ± 0.95

With regard to classes of the yield (Table 3), the treatment (1) had higher amount of fish in the first and second grades, while the treatment (3) had the lowest amount of fish under these grades. In the point of marketing view, the treatment (3) had a higher amount of fish that could be sold (57.3 Kg), while the treatment (2) had the lowest amount of marketable fish (34.46 Kg). On the other hand, treatment (2) had the higher amount of recruitment than the other treatments by far.

DISCUSSION

Water quality parameters

Water temperature ranged from 22 through 30°C during the experimental course (July – October). Hickling (1962) reported that the high temperature (about 30°C in grow-out period) leads to much faster growth in fish. The appetite of fish increases as the temperature rises. Gui *et al.* (1989) found that an average temperature of 28°C was optimal for growth of Nile tilapia fry. Water dissolved oxygen never went below 3 mg/l, with a range of 3.0- 7.3 mg/l. Denzer (1968), AIT (1986), and Hassan *et al.* (1997) reported that 2.3 mg DO/l is above the normal tolerance level of tilapia. pH ranged between 8.3 and 9.5 throughout the experiment. Ellis (1937) and Boyd (1998) reported that waters with a pH range of 6.5 - 9 are the most suitable for fish production.

Total ammonia concentrations decreased with increasing the rate of fertilization over the experimental course, it never surpassed 1.9 mg/l. Unionized ammonia was never a problem during this experiment. It didn't exceed the 1.0 mg/l concentration, except in one occasion. Unionized ammonia percent increased at high pH and temperature (Wurts 2003). The ammonia concentrations in this experiment are lower than those recorded in other studies. Knud-Hansen *et al*. (1993) determined ammonia-N concentrations reached nearly 5 mg/l in both inorganically fertilized ponds (29.6 kg / ha wk^{-1} urea and 9.9 kg /ha wk^{-1} TSP) and manured ponds (300 kg dry weight / ha wk^{-1}), with mean ranged from 1.5 through 2.5 mg/l. Zhu *et al*. (1990) noticed high concentration of NH_4–N in daily manure ponds (1.65mg /l) and (1.25mg /l) in weekly manured ponds. On the other hand, some studies showed lower ammonia concentrations than the present experiment, Diana and Lin (1998) reported ammonia concentrations of 0.374–0.410mg/l in ponds fertilized with both chicken manure and inorganic fertilizers in combination. These low concentrations of total ammonia may be attributed to ammonia utilization by phytoplankton (Knud- Hansen and Pautong, 1993 and Boyd, 1998) or to oxidation of ammonia to nitrate, especially in high dissolved oxygen conditions (Boyd 2000).

Nitrite concentrations didn't exceed 0.2 mg/l in the present experiment, except in two occasions, in which it reached 0.335 and 0.365 mg/l. Nitrite was never a problem over the course of the experiment. Nitrate concentrations ranged between 0.118 and 1.015 mg/l in this experiment. Diana and Lin (1998) noticed nitrite and nitrate concentrations ranging between 0.374–0.410 mg/l and 0.438–0.461 mg/l respectively, in ponds fertilized with both chicken manure and inorganic fertilizers together. Higher concentrations of nitrite (0.14-0.22 mg/l) were reported in fertilized ponds stocked with mixed-sex tilapia and predatory snakehead fish (Yi *et al.,* 2001). The concentrations of nitrate in the present experiment were similar to those reported in fertilized ponds stocked with mixed-six tilapia and predatory snakehead fish, 0.49 – 0.79 mg NO_3/l (Yi *et al.* 2001).

Orthophosphate showed a positive relationship with increasing the level of fertilization. Phosphorus was acting as a limiting factor for phytoplankton production in this experiment. This conclusion was borne out from the results of several studies. Newman *et al.* (1993) reported that dissolved orthophosphate ranged between 0.6 and 7.9 mg/l when P was added at rates of 1.0, 2.4, 3.8, and 5.1 kg/ha/d, and N:P ratio was 1:1. The highest net fish production occurred in ponds received 3.8 kg / ha/d. However, the best fish growth performance was achieved at N:P ratio of 3.75 : 1 and at N input of 30 Kg / ha wk^{-1} (this means 8 kg P/ ha wk^{-1}) in Thailand (Lin *et al.,* 1999). These results, compared to the present study, revealed that the orthophosphate levels of the present experiment are lower than the needed level for maximum fish production. The low orthophosphate level in the present work may be attributed to that, the ponds were relatively new and never received fertilizers, thus they still have high phosphorus adsorption capacity (PAC). Thomas and Peaslee (1973), Masuda and Boyd (1994) and Boyd and Munsiri (1996) found that the PAC of the soils and necessary fertilizer dose in fish ponds decreases over time as the degree of saturation of phosphorus adsorption in bottom soil increases in response to added phosphorus . As ponds get older, sediments become more saturated with P, and less P input may produce similar yields (Boyd, 1971 and Eren *et al.,* 1977).

Fish growth

The daily gain did not significantly differ among treatments. But it showed negative trend with the initial stocking density. Similar trend was noticed when sex-reversed Nile tilapia stocked at 3, 6, and 9 fish/m^2, and fed to satiation in fertilized ponds. The growth decreased from 2.9 through 1.73 gd^{-1} with increasing the stocking density from 3 to 9 fish/m^2 (Diana *et al.,*1995). Diana *et al.*

(1996b) also achieved 3.04-1.55g / fish d^{-1} of sex- reversed Nile tilapia stocked at 3, 6 or 9 fish per m^2 and fed to 50% of satiation (30% crude protein) in fertilized pond. However, the daily gain in this experiment was comparable to that 0.73 ± 0.08 and 0.75 ± 0.07 – 0.78 ± 0.8 g / fish d^{-1}) of mixed-sex tilapia cultured in mono culture and polyculture (with predatory snakehead fish) systems in fertilized ponds, respectively (Yi *et al.,* 2001).

In regard to the effect of initial stocking density and recruitment, growth had a negative trend with increasing initial stocking density. Teichert-Coddington *et al.* (1990) and Diana *et al.* (1991) found that daily gain of adults was inversely proportional to density, indicating strong density-depend growth. Diana *et al.* (1994, and 1996b) determined that stocking density of 3 fish per m^2 would cause density–related declines in growth for fish in fertilized ponds. Diana *et al.* (1995 and 1996b) found that growth declined as stocking density of sex-reversed Nile tilapia increased from 3 to 9 fish m^{-2}. They stated that reduction in growth occurred as a resulted of behavioral or physiological response to density, not to water quality (which didn't differ significantly among densities). They also noticed that density-dependent growth occurred under *ad-libitum* feeding.

The lower overall daily gain than those reported in similar studies (Green, 1992; Diana *et al.,* 1994; 1996a, Brown *et al.,*2000) indicates that either phytoplankton may not be enough to meet protein requirement of fish or that fish could not efficiently assimilate the produced phytoplankton in these ponds. Similar findings were reported (Colman *et al.,* 1990), they noticed poor fish growth in fertilized concrete tank, and attributed it to the predomination of the green algae *Scenedesmus* and its poor assimilation. Moriarty and Moriarty (1973) and McDonald (1985a) reported substantially reduced assimilation rate of green algae compared to blue-green algae by tilapia. Fertilized tank experiments involving green algae and tilapia have shown low fish productivity (Gaigher, 1982 and McDonald, 1985b) or even have shown specifically that fish did not gain nutrition from green algae (Schroeder, 1983). The above studies give a plausible partial explanation of low growth of fish in this experiment although the high chlorophyll "a" concentrations.

The second reasonable explanation of low daily gain is the increase of fish density as a result of reproduction activity during the grow–out period in the present work, in spite of the high initial stocking density in the ponds that was applied as a controlling method of reproduction. The final density reached up to 13.4 fish/ m^2 in some ponds. Hickling (1962) reported that over-crowding inhibits growth. However, age and size of fish appeare to influence feeding rate at satiation of fish in aquaria. At an average temperature of 26 °C , maximum feed consumption dropped from 5% BW/day on 8^{th} day of feed offering to only 2.8%BW/d after 28 days (Popma *et al.*, 1993). They attributed this drop to territorial behavior of maturing fish.

The SGR didn't show significant differences among treatments, it also didn't show a particular trend with the level of fertilization. However, there was a negative relationship between the specific growth rate and stocking density in this experiment. Tidwell *et al.* (2000) reported specific growth rates between 1.74 and 2.13 %d for mixed-sex tilapia fed on experimental feed (22.5-30.7% crude protein) in cages. Green (1992) demonstrated that it could reduce feeding rate as little as 1.5% of biomass daily without significantly affecting tilapia yield in fertilized ponds. Diana *et al.* (1994) reported that 50 to 75 % satiation feeding rate were most efficient in fertilized ponds. Brown *et al.* (2001) reported that, sex-reversed Nile tilapia had higher mean final body weight when fed at 67% satiation than when fed at 100% satiation using 28.6% crude protein diet in fertilized ponds. Lin and Yi (2003) demonstrated that tilapia production was not reduced when the fish were offered prepared feed at a rate of as little as 50% satiation daily. Therefore, recommended feeding rate for tilapia (more than 100g body weight) was 3% of biomass (Lim, 1989). Moreover, other researchers reduced tilapia feeding rate as the fish grew (Marek, 1975 and Hepher and Pruginin, 1981).

There was a noticeable positive relationship between feed conversion ratio (FCR) and fertilization rate, which indicates that contribution of natural food in fish nourishment increases as the level of fertilization increases, since artificial feed was introduced to satiation level in all treatments over the experimental course. Brown *et al.* (2001) found that sex-reversed Nile tilapia of the Genetically Improved Farmed Tilapia (GIFT) strain, stocked at a rate of 4 fish / m^2 in fertilized ponds, had FCR of 2.38 and 3.4 when fed at 67% and 100% of satiation of the experimental diet (28.6% protein), respectively. Diana and Lin (1998) noticed that FCR had increased from (0.7) through (1.42) with the increase of feeding input from 25 to 100% of satiation for sex-reversed Nile tilapia stocked at 3 per m^2 and fed 30% protein floating feed in fertilized ponds. Also, Green (1992) reported that FCR increased from 0.95 to 1.83 when (23% protein) feed was applied at a rate of 1.5% of fish biomass/ day with organic manure, and feed only at 3% feeding rate, respectively. This indicates that natural food contributes to fish growth. Lim (1989) reported that up to half food intake of tilapia in intensively fed ponds was natural food, which demonstrated its substantial contribution to tilapia growth. Since fish's efficiency to convert feeds to fish production decreases as they become nearer to satiation which is well showed in Diana and Lin (1998). FCR increases as the feeding rate increases in fertilized ponds. This provides a plausible explanation of high FCR in the higher fertilizing rate. Therefore many studies recommended a 10% reduction in scheduled feeding rate (Lovell, 1977) or continuous reduction as fish grew (Marek, 1975; Hepher 1978 and Hepher and Pruginin 1981). Lovshin *et al.* (1990) found that FCR increased (from 2.2 to 2.4) with higher stocking density of mixed–sex *O. niloticus* (5g) stocked at 5000 and 10000 fish/ ha, respectively, and fed on 40 and 36% crude protein feeds in fertilized ponds. Similar FCR behavior was noticed in the second and third treatments of this experiment.

Total yield showed a positive relationship with both of the fertilization rate and stocking density. It increased from 82.85 to 90.05 Kg fish/200m^2/112days by increasing the fertilization rate from 50 to 100 g/m^2/wk, and increased from 90.05 to 105.67 Kg fish/200m^2/112days with elevating the stocking density from 5 to 8 fish/m^2. Similar trends were found for fertilization rate (Burns and Sticking, 1980; Zhu et al., 1990 and Knud-Hansen *et al.,* 1991) who found that gross yield of tilapia increased with the increased organic manure application. Furthermore, Knud-Hansen (1992) demonstrated that there are positive effects on net fish yield from previous manure inputs. Several studies reported the positive effect of stocking density on the gross yield (Colman *et al.,* 1990; Diana *et al.,* 1995; 1996b, and Knud-Hansen and Lin, 1996). Teichert-Coddington *et al.* (1990) and Kund-Hansen and Lin (1996) reported that stocking density has a positive effect on the fish yield. However, stocking density has a negative effect on the individual fish size (Colman *et al.,* 1990; Teichert- Coddington *et al.,* 1990 and Diana *et al.* 1995, 1996b). This negative effect also was noticed in the present work, the lower density treatments had larger fish. Somewhat lower forecasted annual yield (Kg ha^{-1} yr^{-1}) was reported (2,887-6,576 kg/ ha yr^{-1}) by using chemical and organic fertilizers only (Diana and Lin, 1995). Agarwal (1992) reported fish productivity at 3 t/ ha/ yr from fish / poultry integrated farming with a stocking density of 10.000 fingerlings / ha and 550 birds. Also, 3,702kg fish/ha per 162 day was achieved by using combination of fertilization and feeding 30% crude protein, at satiation (Diana *et al.,* 1994). Diana *et al.* (1996a) reported extrapolated annual yield ranged from 10,420 through 28,178 kg/ha/yr under fertilization and feeding. The forecasted annual yield in the present experiment was 13,500, 14,673 and

17,218 kg fish / ha/ yr in the first, second, and third treatments, respectively. However, Diana *et al.* (1996b) reported higher extrapolated annual yield (23,661-36,816 kg/ha/yr) by using 50% satiation feeding rate in fertilized ponds stock with sex-reversed Nile tilapia at 3, 6 and 9 fish / m^2 stocking densities.

Recruitment did not show significant differences among treatments. But it showed a positive trend with fertilizing rate and a negative trend with initial stocking density. The higher recruitment production (16.6 ± 5.4 kg fish/200m^2) was found in the second treatment (5 fry/ m^2 and 100g/ m^2/ wk fertilizing rate). Similarly, Kund-Hansen *et al.* (1991) found that fry represent 11.3, 10.3, 12.8 and 38.6% of the total harvest weight of hand-sexing male *O.niloticus* in ponds receiving chicken manure at rates of 12.5, 25, 50 and 100g dry weight/m^2 wk^{-1}, respectively. Also, similar trends were reported (Diana *et al.,* 1989 and 1991) who stated that stocking density strongly affected reproduction, resulting in lower offspring production in higher density ponds. This may explain the reason of having lower gross yield of initial stock in this treatment than the other treatments.

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تأثير التسميد على إنتاج أسماك البلطى النيلى فى الأحواض الترابية

٢. تأثير سماد عضوى غير تقليدى و كثافة الأسماك على إنتاج أسماك البلطى النيلى المختلطة الجنس

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صممت هذه التجربة لتقدير أفضل معدل تسميد بسماد أبيس العضوى ولدراسة تأثير كثافة الأسماك على أداء أسماك البلطى مختلط الجنس. تم تخصيص (٦) أحواض ترابية بسعة ٢٠٠متر مربع /حوض لثلاث معاملات: معدل تسميد ٥٠جم/م^{٢}/أسبوع مع كثافة أسماك ٥ أسماك/م^{٢} ، معدل تسميد ١٠٠جم/م^{٢}/أسبوع مع كثافة أسماك ٥ أسماك/م^{٢} ، معدل تسميد ١٠٠جم/م^{٢}/أسبوع مع كثافة أسماك ٨ أسماك/م^{٢}. و خلال هذه التجربة تم تغذية الأسماك لمستوى الأشباع لمدة ٢٠ دقيقة. وأستمرت التجربة لمدة ١١٢ يوما . وكان يتم تقدير مواصفات المياه أسبوعيا خلال فترة التجربة . لم تختلف قيم معدل النمو ، معدل النموالنوعى ، إجمالى الإنتاج السمكى معنويا فيما بين المعاملات ، نظرا للتباين الإنتاج السمكى بين المكررات داخل المعاملات. أظهر إجمالى الإنتاج السمكى سلوك إيجابى مع كل من معدل التسميد و الكثافة السمكية. و قد تم مناقشة تأثير المعاملات على خواص جودة المياه.