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EFFECT OF DIFFERENT DOSES OF INORGANIC FERTILIZERS ON WATER QUALITY, PRIMARY PRODUCTIVITY AND PRODUCTION OF NILE TILAPIA (OREOCHROMIS NILOTICUS L.) IN EARTHEN PONDS

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Abstract

Earthen ponds (surface area 155 m^2 each) were used to study the effect of different doses of inorganic fertilizer on water quality and fish production. Each pond was stocked with 150 fish of Nile tilapia; *Oreochromis niloticus* (25-30 g/fish). The ponds received inorganic fertilizer (20:20:5 N:P:K) with doses of 0, 20, 40, 60 and 100 kg/fed/mth. The obtained results revealed that there were no significant differences in water temperature, dissolved oxygen, pH value, free ammonia water conductivity, nitrate concentration, total hardness, and total alkalinity due to the effect of different doses of inorganic fertilizer. Only Secchi disk reading, orthophosphate concentration and total nitrogen were significantly affected by treatments. Chlorophyll 'a' content over all the rearing period was increased by increasing the applied doses and the highest one was obtained with using 100 kg/fed/mth. The optimum production of Nile tilapia was obtained with the dose of 60 kg/fed/mth. Data of carcass proximate analysis showed that there were no significant differences in dry matter, while crude protein total lipids and ash contents differed significantly by different doses.

INTRODUCTION

The productivity of natural food should be taken into account in tilapia farms especially tilapias in general are herbivores and detritivores, although they show ontogenetic shifts from zooplankton at young ages to phytoplankton, macrophytes, and detritus at advanced ages. In this respect, some investigators reported that Nile tilapia is phytoplanktivore and facultative detritivore where it has a very diversified diet with a dominant vegetable component as well as animal component (Abdel-Tawwab, 2000). That wide dietary breadth could have made it a more adaptable species in eutrophic environment.

Inorganic fertilizers are usually added to fish ponds to stimulate and maintain the production of natural food needed for fish growth i.e. increase the population and density of phytoplankton and zooplankton. However, the increase in fish productivity in fertilized ponds had been attributed to an increase in the primary productivity (Boyd, 1990; Diana *et al.*, 1991; El-Ayouty *et al.*, 1994). Subsequently, the increase in nutrients budget would increase the primary productivity that would be turned to increase fish production (Batterson *et al.*, 1989).

Inorganic fertilizer has been promoted as favorable due to its lower loading rates due to higher nutrient contents and lower oxygen demand (Colman and Edwards, 1987). In Abbassa fishponds, Abdel-Tawwab *et al.* (2002) compared inorganic fertilizers with different NPK ratios, and found that the ratio 20:20:5 N:P:K produced the highest yield of Nile tilapia. The present study aimed at finding out the optimum dose of inorganic fertilizer (20:20:5 N:P:K) that could be applied to produce the optimum yield of Nile tilapia (*O. niloticus* L.) in earthen fishponds under Egyptian conditions.

MATERIALS AND METHODS

Ten earthen ponds (surface area 155 m^2 each) at Central Laboratory of Aquaculture Research, Abbassa, Sharqia Governorate, were used in this study. The ponds had been drained, cleaned and refilled with new freshwater from El-Wadi Canal derived from El-Ismailia Canal. The water level was adjusted at 80 cm depth. The experiment was started on 3 July 1991 and continued for 126 days.

The ponds were randomly assigned to four treatments (two replicates for each). The ingredients sources were urea (46.5% N), monosuperphosphate (15.5% P2O5) and potassium chloride (63.1% K_2O). These sources were used to prepare the ratios of 20:20:5 N:P:K. The fertilizers were weekly applied to the ponds at a rate of 0, 20, 40, 60 and 100 kg/feddan/month where they were dissolved and splashed on the water surface of fishpond.

Cultured fish were obtained from the nursery ponds and acclimatized in indoor tanks for 15 days. Fifty fish were frozen at -20 °C for initial chemical analyses. To each pond, 150 fish of Nile tilapia; *Oreochromis niloticus* L. (25-30 g/fish) were stocked. Every two weeks, 25 fish from each pond were sampled by using pure seines, and individual weight was measured.

Water samples for chemical analysis were collected biweekly by a 90-cm water sampler between 08:30 and 09:30 at 30 cm depth from each pond. Dissolved oxygen and temperature were measured at 30 cm depth with a YSI model 58 oxygen meter

(Yellow Spring Instrument Co., Yellow Springs, Ohio, USA) and water conductivity was measured with a YSI model 33 conductivity meter (Yellow Spring Instrument Co., Yellow Springs, Ohio, USA). The pH value and ammonia were measured by using Hach kits (Hach Co., Loveland, Colorado, USA). The chemical parameters were analyzed as described by Boyd (1984).

For determination of chlorophyll 'a' content, 100 ml of water sample was filtered throughout Millipore acetyl cellulose filter (0.45mm) and then extracted by 90% acetone and measured spectrophotometrically according to Boyd (1984). At the same time, water samples (1 liter bottle) were collected for phytoplankton determination at the same depth and preserved by 4% neutral formalin. Samples were allowed to settle for 15 days and the supernatant was siphoned to 50 ml. The counts of phytoplankton were performed using Sedgwick-Rafter cell under a binocular microscope using suitable magnification power.

At the end of the experiment, the ponds were drained and fish were harvested, counted and weighed. Fish samples were subjected to proximate chemical analysis according to standard methods of A.O.A.C. (1990) for determination of moisture, protein, fat and ash.

Water quality data were analyzed among treatments with Kruskal-Wallis One Way Analysis of Variance on Ranks, using dates as blocks to determine significant differences, and significant variations were determined using Tukey's test at the 5% probability level. Fish data were compared with one-way ANOVA, and means differences were done at the 5% probability level with Duncan's test (Duncan, 1955). Bivariate correlations, stepwise regression and all statistical analysis were conducted with SPSS software program ver 8 as described by Dytham (1999).

RESULTS

1. Physico-Chemical Parameters

Results in Table 1 showed the mean values of different parameters of water quality in ponds received different doses of inorganic fertilizer. Values showed that there were no significant differences in water temperature, which was approximately similar (25.5-25.7 ^{o}C) and ranged from 21.8 to 28.3 ^{o}C in all ponds. The mean pH values were approximately similar (8.1) and ranged from 7.9 to 8.7. Water conductivity was only lower in control pond (0.42 mMohs/cm) than the fertilized ponds, which ranged from 0.47 to 0.52 mMohs/cm. Data of total alkalinity showed insignificant differences among different treatments and it was >200 mg/L in all ponds. Total hardness of ponds water tended to increase in all treatments from July to October with an average value of >150 mg/L (Fig 1).

Secchi disk visibility was inversely affected by increasing fertilizer doses (r = -0.569; P<0.05). The maximum mean value was obtained with control ponds (20.7 cm), while the lowest ones were obtained at using the doses of 60 and 100 kg/fed/mth (17.0 and 17.1 cm, respectively; P>0.05). Dissolved oxygen was significantly affected by fertilizer doses (r = 0.146; P>0.05), and it increased by increasing rearing period and ranged from 3.13 to 6.95 mg/L in all ponds with mean value over the time >4.0 mg/L. Orthophosphate concentrations increased gradually with increasing the fertilizer dose (r = 0.816; P<0.05). The mean values of orthophosphate of control, 20 and 40 kg/fed/mth were differed insignificantly (0.361, 0.571 and 0.753 mg/L, respectively), while the highest ones were obtained with the doses of 60 and 100 kg/fed/mth (1.306 and 1.363 mg/L, respectively).

Unionized (free) ammonia was low to be toxic to fish, and it was <0.5 mg/L and the highest values were observed during September. The mean values of Nitrate were insignificantly changed with changing the fertilizer dose (r = 0.271; P>0.05), and the mean values had ranged from 10.91 to 17.62 mg/L. On the other hand, total nitrogen contents were significantly affected by fertilizer doses (P<0.05), and the higher values were obtained in fertilized ponds (7.14 to 8.55 mg/L), while the lowest value was obtained with control pond (6.14 mg/L; Fig 3).

2. Chlorophyll 'a' Content

Results in Fig. 4 indicated that chlorophyll 'a' content in fishpond was increased by increasing the applied doses (r = 0.65) to reach the maximum contents with 100 kg/fed/mth. The mean values of chlorophyll 'a' content over all the rearing period were recorded at the dose of 100 kg/fed/mth followed by that of 60 kg/fed/mth (91.95 and 76.32 mg/L, respectively; (Table 1). The least ones were obtained in the other treatments (47.5-63.5 mg/L). On the other hand, the maximum value of chlorophyll 'a' content in fishpond was obtained in Oct. at 100 kg/fed/mth (93.9 mg/L) and the least value was obtained in Oct. at control ponds (37.5 mg/L).

3. Fish Production

Application of different doses of inorganic fertilizer (20:20:5 N:P:K) led to subsequent increase in fish growth (r = 0.563) where the maximum growth was obtained at 60 kg/fed/mth (Fig 5). Fish production including adult and offspring is illustrated in Fig. 6, where total production of Nile tilapia and its constituents were subsequently increased with increasing the fertilizer dose to reach the maximum yield at 100 kg/fed/mth except the adult form which was maximized at 60 kg/fed/mth. The lowest total fish yield was obtained by control ponds. These data indicated that the dose of 60 kg/fed/mth represented the most economical dose for total fish production and its constituents where there was no significant increase in fish production between 60 and 100 kg/fed/mth (P>0.05).

Concerning the chemical composition of whole fish body as a percentage of the dry matter, data of Table 2 revealed that there were no significant variations in dry matter, while crude protein, total lipids and ash contents differed significantly between treatments. The high protein content was obtained at the doses of 20-100 kg/fed/mth with insignificant differences (57.56-59.26%), while the least protein content was obtained with control ponds (54.46%). Moreover, total lipids were slightly affected by the applied doses of 20, 40, 60 and 100 kg/fed/mth; 11.65, 12.04, 12.46 and 13.25%, respectively except that of control (13.02%). Ash contents were gradually increased with the doses of 20, 40 and 60 kg/fed/mth; 23.79, 25.48 and 27.97%, respectively, while the highest dose led to low ash content (24.67%). The ash content of control samples (29.08%) was superior compared with the treated ones.

DISCUSSION

Effective water management in fishponds is one of the important factors contributing to the success of fish culture. Fertilization of fishponds as one of the most important management process had been studied with conflicting results depending on the local conditions. In Abbassa fishponds, Abdel-Tawwab *et al.* (2002) compared inorganic fertilizers with different N:P:K ratios, and found that the inorganic fertilizer with the ratio of 20:20:5 N:P:K produced the highest growth of Nile tilapia.

In the present study, there was no significant difference in temperature observed among the different treatment ponds. This result is due to warm climate and shallowness of most tropical fish ponds (~1.0 m depth). So, temperature and light are not likely to be limiting (McNabb *et al.*, 1988). On the other hand, the lowered Secchi disk visibility in fertilized pond is due to the high abundance of phytoplankton and/or the high turbidity, which may have resulted from colloidal clay particles, and the suspended organic particles that resulted from fish movement in pond (Boyd, 1990). The concentration of dissolved oxygen was not affected in this study although phytoplankton biomass indicated by chlorophyll 'a' content increased (r = 0.147).

The high concentrations of orthophosphate were observed with the doses of 60 and 100 kg/fed/mth with insignificant differences. These results may be due to the increase of nutrients load through the increase of fertilizer dose although there are many pathways for phosphorus in aquatic ecosystem. On the other hand, phosphorus could be absorbed and accumulated by bacteria, phytoplankton and ponds sediments (Boyd, 1990; Munsiri *et al.*, 1995). Also, phosphate in hard water could react quickly with calcium to form calcium phosphate, which would settle from the water slowly within hours or days (Masuda and Boyd, 1994). Also, Boyd and Tucker (1998) reported that phosphorus requirements also are related to total alkalinity. On the other hand, there were no changes in nitrate levels due to fertilizer doses. This result is due to the fact that large application of inorganic nitrogen added to fishponds was transformed through denitrification and/or transferred to ammonia that volatilized to the atmosphere (Gross *et al.*, 2000). Also, nitrogen could be quickly absorbed and accumulated inside phytoplankton cells (Boyd, 1990).

It is well known that, the changes in physico-chemical characteristics of water body lead to concomitant and quantitative changes in phytoplankton organisms. In this study, phytoplankton biomass as represented by chlorophyll 'a' content increased with increasing the fertilizer dose (r = 0.65) due to the increase in nutrients budget in ponds. This result means that, where nutrients concentration increased, the managed ponds have denser phytoplankton than unfertilized ponds, therefore, there was an obvious increase in chlorophyll 'a' contents. Similar results were obtained by Diana *et al.* (1991) who found that fish ponds that received higher doses of fertilizer exhibited higher primary productivity as compared with fish ponds received low doses of fertilizer.

The stepwise regression, for phytoplankton abundance (indicated by chlorophyll 'a' content) in ponds received inorganic fertilizer, evoked that the best model is:

$$\text{Chlorophyll 'a' content} = 164.21 + 1.51\ (PO4) + 13.08\ (NO3) + 0.34\ (\text{Fertilizer dose}) - 1.55\ (\text{Fish growth}) - 2.69\ (\text{Temperature})$$

This means that the model represented 60.8% of the total data where chlorophyll 'a' content in this experiment was inversely proportional to fish growth and temperature, while it is directly proportional to phosphate level, nitrate level and fertilizer dose. Also, this model evoked that these relationships were highly significant and linearly fitted with tilapia growth ($r^2 = 0.608$; $P<0.001$).

The growth of Nile tilapia was increased by increasing the fertilizer dose to reach the maximum one with 100 kg/fed/mth. Also, the obtained data indicated that the dose of 60 kg/fed/mth seems to be the optimum dose for an economical valuable production of Nile tilapia (adult and fry) especially there is no significant difference between 60 and 100 kg/fed/mth ($P>0.05$). These results were in agreement with Batterson *et al.* (1989) and Diana *et al.* (1991), who reported that the yield of cultured fish was linearly increased by increasing the applied fertilizer. On the other hand, the slight difference between 60 and 100 kg/fed/mth may be due to phytoplankton flourishing and blooming at the dose 100 kg/fed/mth, which interfered with fish production and became limiting factor in fishponds causing problems with water quality.

The stepwise regression, for tilapia growth in ponds that received inorganic fertilizer, evoked that the best model is:

Fish growth = 135.83 + 0.53 (PO4) + 0.06 (Fertilizer doses) + 2.05 (DO) – 1.48 (Temperature) _ 0.12 (Chl a) – 6.17 (pH) – 0.52 (Secchi disk)

This means that the model represents 85.1% of the total data where fish growth in this experiment was inversely proportional to temperature, phytoplankton abundance (indicated by chlorophyll 'a' content, pH values and Secchi disk reading), otherwise it is directly proportional to phosphate level, fertilizer dose and dissolved oxygen. Also, this model evoked that these relationships were highly significant and linearly fitted with tilapia growth ($r2 = 0.851$; $P<0.001$).

Fertilization did not affect significantly dry matter content of fish body, whereas, it increased significantly crude protein content without significant difference between fertilization treatments. Regarding total lipids, values decreased at 20, 40 and 60 kg/fed/mth. At 100 kg/fed/mth, values showed significant increase as compared to lower doses of fertilization. Ash content of fish body with fertilization treatments differed significantly. Values of 20, 40 and 100 kg/fed/mth decreased as compared to the control, whereas 60 kg/fed/mth did not differ significantly. Theses results were due to the deposition of nutrients in fish tissues achieved through fish grazing and accumulation of planktonic organisms, which differ in their nutritive values from species to species (Boyd, 1990). In this respect, Abdel-Tawwab (2000) reported that Nile tilapia is phytoplanktivore and facultative detritivore where it had a very diversified diet with a dominant vegetable component as well as scarce animal component. Moreover, the increase in fertilizer dose stimulated phytoplankton productivity, so, the activity of fish grazing and accumulation of nutrients into fish body may be increased by increasing the availability of organisms in ponds.

It could be concluded from this study that only Secchi disk reading, orthophosphate, total nitrogen concentrations and chlorophyll 'a' content were significantly affected by the fertilizer doses. The optimum dose of inorganic fertilizer (20:20:5 N:P:K) for production of Nile tilapia without artificial feeding was 60 kg/fed/mth. On the other hand, further work is needed to evaluate the combination of inorganic fertilization with organic fertilization and artificial feeding in monoculture and polyculture systems.

Table 1. Changes in water physico-chemical parameters of earthen ponds as affected with different doses of inorganic fertilizer.

Parameters	Doses of inorganic fertilizer (kg/feddan/month)					P-value
	Control	20	40	60	100	
Temperature (°C)	25.5 a (21.8-28.2)	25.7 a (21.9-28.3)	25.6 a (22.0-28.1)	25.7 a (22.1-28.3)	25.6 a (22.0-28.1)	0.997
Secchi disk (cm)	20.7 a (19.5-21.5)	18.7 b (17.5-20.1)	18.1 b (16.7-19.5)	17.0 b (16.2-18.0)	17.1 b (15.5-18.5)	0.021
Dissolved oxygen (mg/L)	4.64 a (3.13-5.77)	5.34 a (4.10-6.63)	5.05 a (3.63-6.33)	5.06 a (3.94-6.45)	5.08 a (3.58-6.95)	0.894
The pH value	8.1 a (7.9-8.3)	8.2 a (7.9-8.7)	8.1 a (7.8-8.6)	8.2 a (7.9-8.5)	8.2 a (8.0-8.5)	0.97
Free ammonia (mg/L)	0.07 a (0.4-0.11)	0.09 a (0.06-0.13)	0.09 a (0.05-0.12)	0.10 a (0.06-0.18)	0.11 a (0.06-0.14)	0.513
Conductivity mMohs/cm	0.42 a (0.26-0.57)	0.47 a (0.36-0.57)	0.50 a (0.33-0.67)	0.52 a (0.43-0.61)	0.52 a (0.39-0.64)	0.521
Total alkalinity (mg/L)	256 a (220-265)	239 a (201-270)	233 a (170-290)	239 a (203-270)	253 a (217-285)	0.9
Total hardness (mg/L)	179 a (154-198)	175 a (155-195)	179 a (151-206)	192 a (174-216)	192 a (167-221)	0.73
Orthophosphate (µg/L)	0.361 b (0.32-0.40)	0.571 b (0.39-0.69)	0.753 ab (0.45-1.014)	1.306 a (0.80-1.614)	1.363 a (1.0-2.049)	0.004
Nitrate (mg/L)	10.91 a (7.38-13.45)	13.43 a (9.93-19.66)	13.71 a (9.45-17.85)	17.62 a (10.7-24.57)	16.03 a (10.5-18.47)	0.305
Total nitrogen (mg/L)	6.41 b (5.50-6.93)	7.14 ab (6.58-7.96)	7.24 ab (6.77-7.70)	7.42 ab (7.38-8.73)	8.55 a (7.38-10.53)	0.042
Chlorophyll 'a' (µg/L)	47.51 c (37.5-58.3)	51.63 c (39.3-77.9)	63.5 bc (47.1-93.43)	76.32 b (62.2-95.8)	91.95 a (87.3-99.1)	0.019

Means with the same letter in the same row are not significantly different at $P<0.05$.

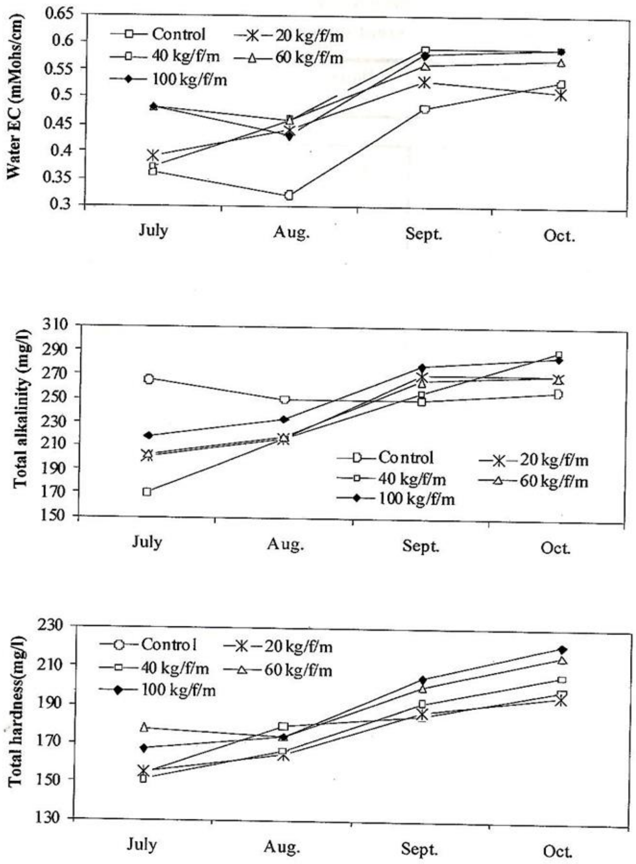

Fig 1. Monthly variations of water conductivity (mMohs/cm), total alkalinity and total hardness (mg/L $CaCO_3$) in ponds water as affected by different doses of inorganic fertilizer.

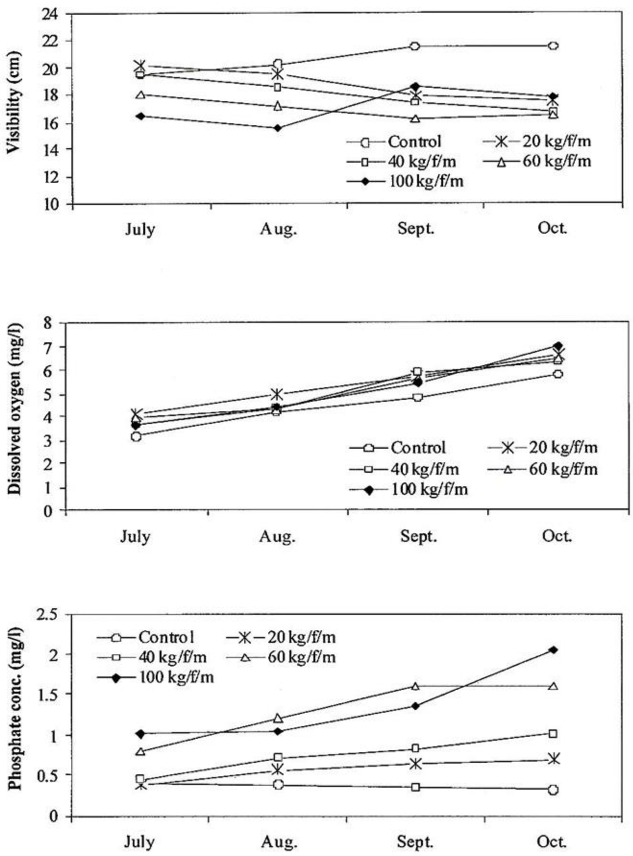

Fig 2. Monthly variations of visibility (cm), dissolved oxygen (mg/L) and phosphate oncentration (mg/L) in ponds water as affected by different doses of inorganic fertilizer.

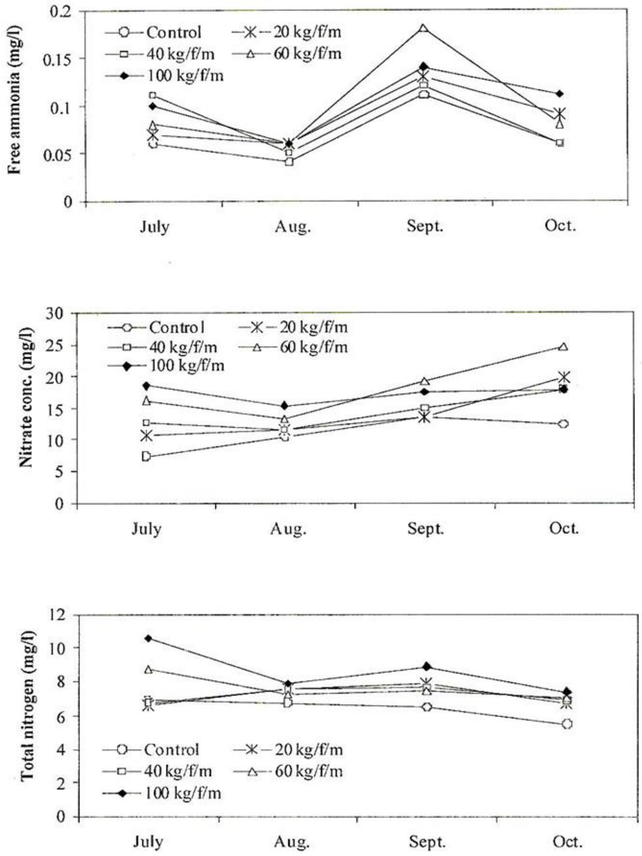

Fig 3. Monthly variations of free ammonia, nitrate and total nitrogen concentration (mg/L) in ponds water as affected by different doses of inorganic fertilizer.

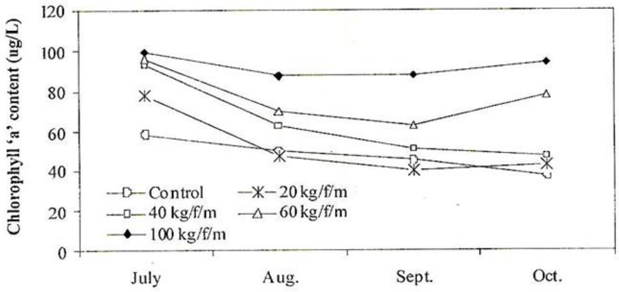

Fig 4. Monthly variation of chlorophyll 'a' content (mg/L) in ponds water that received different doses of inorganic fertilizer.

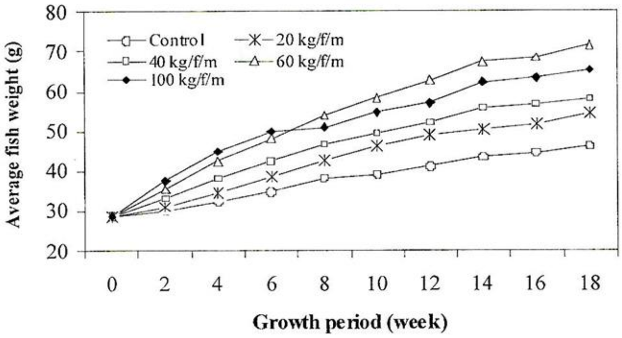

Fig 5. Changes in fish growth of Nile tilapia reared in ponds received different doses of inorganic fertilizer.

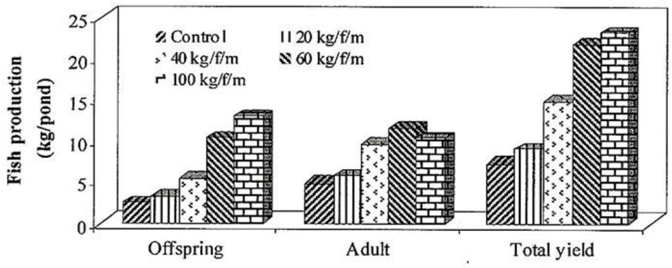

Fig 6. The total production of Nile tilapia (kg/pond) in ponds that received different doses of inorganic fertilizer.

Table 2. Carcass proximate chemical analyses of Nile tilapia (O. niloticus) reared in ponds that received different doses of inorganic fertilizer.

Fertilizer doses	Dry matter	Crude protein	Total lipids	Ash
Control	23.6 a ± 0.39	54.46 b ± 0.80	13.02 a ± 0.04	29.18 a ± 0.33
20 kg/acre/month	23.6 a ± 0.13	57.56 a ± 0.33	11.65 b ± 0.02	23.79 c ± 0.29
40 kg/acre/month	24.8 a ± 0.13	58.03 a ± 0.42	12.04 b ± 0.05	25.48 b ± 0.02
60 kg/acre/month	24.3 a ± 0.13	58.5 a ± 0.18	12.46 b ± 0.12	27.97 a ± 0.10
100 kg/acre/month	24.7 a ± 0.17	59.26 a ± 0.33	13.25 a ± 0.01	24.67 bc ± 0.25

Means in the same column not having the same letters are significantly different ($P < 0.05$).

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تأثير استخدام جرعات مختلفة من السماد الغير عضوي على خصائص المياه والإنتاجية الأولية وإنتاجية البلطى النيلى فى أحواض ترابية

محسن عبد التواب١، على عز الدين عبد الغنى١، ياسين محمود العيوطى٢، عبد الفتاح أحمد العيسوى٢

١ *المعمل المركزى لبحوث الثروة السمكية بالعباسة - مركز البحوث الزراعية وزارة الزراعة- دقي- جيزة - مصر*
٢ *كلية العلوم - جامعة الزقازيق .*

تمت هذه الدراسة بغرض تقييم استخدام جرعات مختلفة من السماد الغير عضوي (٢٠/٢٠/٥ **N:P:K)** فى أحواض ترابية بالعباسة. تم استزراع ١٥٠ سمكة بلطى نيلى (٢٥-٣٠جم) فى كل حوض وتمت إضافة السماد المعدنى بمعدل صفر و ٢٠ و ٤٠ و ٦٠ و ١٠٠ كجم للفدان كل شهر . لم تظهر النتائج وجود اختلافات معنوية فى درجة الحرارة و الأكسجين الذائب و درجة الأس الهيدروجينى والأمونيا الحرة و درجة التوصيل الكهربى و تركيز النترات والقاعدية الكلية والعسر الكلى نتيجة تأثير الجرعات المختلفة من السماد المستخدم بينما كانت الاختلافات معنوية فى كل من شفافية المياه و تركيز الفوسفات و النيتروجين الكلى. كذلك كان الاختلاف معنوى فى متوسط محتوى الكلوروفيل (أ) الذى بلغ أعلى قيمة عند ١٠٠ كجم للفدان كل شهر. كانت افضل إنتاجية للبلطى النيلى عند استخدام ٦٠ كجم للفدان كل شهر لذلك ينصح باستخدام هذا المعدل السمادى فى مزارع البلطى النيلى .