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EFFECT OF INORGANIC FERTILIZERS WITH DIFFERENT N:P:K RATIOS WATER QUALITY, PRIMARY PRODUCTIVITY AND PRODUCTION OF NILE TILAPIA (*OREOCHROMIS NILOTICUS L.*) IN EARTHEN PONDS

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Abstract

The effect of inorganic fertilizers with different N:P:K ratios was investigated. Eight earthen ponds (surface area 155 m^2) were used in this study. Each pond was stocked with 150 fish of Nile tilapia; Oreochromis niloticus (10-15 kg/fish). The ponds received inorganic fertilizer with ratios of 20:20:5, 20:40:5, 40:20:5 and 20:20:0 N:P:K at a rate of 40 kg/feddan/month. The obtained results revealed that there were no significant differences in water temperature, dissolved oxygen, pH value, free ammonia, total alkalinity, total hardness, nitrate and total nitrogen during the effect of different N:P:K ratios. Only, Secchi disk reading, water conductivity and orthophosphate concentration were significantly affected by the applied treatments. The mean values of chlorophyll 'a' content over all the rearing period showed non-significant difference. The optimum production of Nile tilapia was obtained at the ratio of 20:20:5. Data of carcass proximate analysis showed that there were no significant differences in dry matter, crude protein and ash contents of different N:P:K ratios, while, the highest lipid content was obtained at 20:20:5.

INTRODUCTION

In Egypt, tilapias are widespread in the River Nile and its attributes as well as in the lakes. Nile tilapia, *Oreochromis niloticus* is an important food fish and it seems to be the most suitable species for fish farming, where it is extensively cultured in several countries in the world.

The productivity of natural food should be considered in tilapia farms where 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, Bowen (1982) and Diana *et al.* (1991) reported that tilapia less than 35 g appeared to be particulate feeders, selecting individual plankton especially crustaceans from the water column, and at about 35 g tilapia made a shift to filter feeding and utilize mainly phytoplankton and smaller zooplankton such as rotifers.

Furthermore, some investigators reported that Nile tilapia was phytoplanktivore and facultative detritivore (Abdel-Tawwab, 2000). It had also a very diversified diet with a dominant vegetable component as well as animal component, however, 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). Inorganic fertilizer had been promoted as favourable due to its lower loading rates due to higher nutrient contents and lower oxygen demand (Yamada, 1986).

On the other hand, inorganic fertilization of fishponds has been widely studied, with conflicting results depending on the local conditions. Therefore, this work was carried out to evaluate the effect of inorganic fertilizers with different ratios of NPK on water quality, and the production of Nile tilapia (*O. niloticus* L.) in earthen ponds in Abbassa fishponds.

MATERIALS AND METHODS

Eight earthen ponds (surface area 155 m^2 each) at Central Laboratory of Aquaculture Research, Abbassa, Sharqia, 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 14 May 1990 and continued for 155 days.

Eight earthen ponds were randomly assigned for four treatments (two replicates for each). The ingredient 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, 20:40:5, 40:20:5 and 20:20:0 N:P:K. The fertilizers were weekly applied to the ponds at a rate of 40 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 chemical analysis. To each pond, 150 fish of Nile tilapia; *Oreochromis niloticus* L. (15-20 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 30cm 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 according to APHA (1985); orthophosphate was colorimetrically determined by stannous chloride method and nitrate was colorimetrically determined by phenoldisulphonic acid method (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). In the same time, water samples (1 liter bottle) were collected for phytoplankton determination at the same depth and preserved by 4% formalin. Samples were allowed to settle for 15 days and the supernatant was siphoned to 50ml. 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 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. Mean separations were determined using Tukey's test at the 5% probability level. Production data were compared with one way ANOVA and means differences were done at the 5% probability level with Duncan' s new multiple range tests (Duncan, 1955). Statistical analysis were conducted with SPSS software program ver 8 as described by Dytham (1999).

RESULTS

1. Physico-Chemical Parameters

Results in Table 1 show the mean values of different parameters of water quality in ponds which received inorganic fertilizer with different N:P:K ratios. Table 1 shows that there were no significant differences in water temperature which ranged from 22.3 to 28.4 °C in all ponds. The mean pH values were approximately similar (8.8) and ranged from 7.7 to 9.1. Dissolved oxygen ranged from 3.23 to 8.85 mg/L in all ponds with mean value over the time >5.0 mg/L. Data of total alkalinity and total hardness indicated to high hardness of pond's water where their mean values were >200 mg/L and >150 mg/L, respectively (Fig.1).

Unionized (free) ammonia was low to be toxic to fish, and it was <0.5 mg/L. Nitrate concentrations were decreased by time and increased again to the end of experiment. The mean value was insignificantly changed with changing the fertilizer ratio and ranged from 5.79 to 28.96 mg/L. Total nitrogen contents exhibited the same trend of nitrate at all N:P:K ratios except that of 20:40:5, where, it increased to reach the maximum value at July and decreased again to the end of experiment (Fig. 2).

Secchi disk visibility was significantly affected by different N:P:K ratios ($P<0.05$; Fig. 3). The maximum mean values were obtained at the ratios 20:40:5 and 40:20:5 (15.3 and 16.2 cm, respectively), whereas, the other two treatments were the lowest. Also, electric conductivity of ponds water was significantly affected by different N:P:K ratios ($P<0.05$). The maximum mean values were recorded at the ratios 20:20:0 and 20:20:5 (0.64 and 0.59 mMohs/cm, respectively), while, the other ratios were approximately the same. Orthophosphate concentration showed gradual increase over the experimental period due to fertilizer application. The mean values of orthophosphate at the ratios 20:20:5, 20:40:5 and 20:20:0 insignificantly differed (1.185, 1.505 and 1.224 mg/L, respectively), while, the lowest one was obtained at the ratio 40:20:5 (0.81 mg/L).

2. Chlorophyll 'a' Content

Results in Fig. 4 indicated that the maximum value of chlorophyll 'a' content in fish ponds was recorded at the ratio 20:20:0 followed by the ratio 20:20:5 (162.6 and 105.1 mg/L, respectively) during Oct. The least content was obtained at the ratio 20:20:0 during May (37.73 mg/L). On the other hand, the mean values of chlorophyll 'a' content over all the rearing period slightly differed (72.60-76.51 mg/L) and the least mean value was obtained at the ratio 20:20:0 (62.54 mg/L).

3. Fish Production

Application of inorganic fertilizers with ratios of 20:20:5, 20:40:5, 40:20:5 and 20:20:0 N:P:K led to subsequent increase in the total fish production (Table 2, Fig. 5). The maximum total fish yield was obviously recorded after the application of 20:20: 5 N:P:K fertilizer, whereas, the yield slightly decreased by about 13% at 20:20:0 and 40:20:5 with an approximately equal values as compared with 20:20:5. The least fish yield was obtained at 20:40:5 N:P:K fertilizer.

Regarding to the more effective N:P:K ratio for marketing fish (adult form), it was obvious that the application of 20:20:5 and 40:20:5 to fishponds were valuable (Fig. 5), since both of them produced about 70 to 72% of the total fish production as an adult form, followed by the ratios of 20:20:0 and 20:40:5. These results led to conclude that the application of the ratio 20:20:5 to fishponds led to assign economic valuable fish yield. Moreover, the production of fish fingerlings was approximately the same (4.5, 4.5 and 4.75 kg/pond with ratios of 20:20:5, 20:40:5 and 20:20:0, respectively, while, the lowest one was obtained at the ratio of 40:20:5 (3.95 kg/pond).

Concerning the chemical composition of whole fish body as a percentage of the dry matter, Table 3 shows that there were no significant variations in dry matter, protein and ash contents. High protein content was obtained at the ratios 40:20:5 and 20:20:0 (65.71% and 65.68%, respectively) with slight differences with the other ratios. Moreover, total lipids were approximately similar at the ratios 20:40:5, 40:20:5 and 20:20:0 (6.97%, 7.37% and 7.76%, respectively), and showed significantly lower values than those obtained at the ratio 20:20:5 (11.84%). Ash content were approximately similar with the ratios of 20:40:5, 40:20:5 and 20:20:0 (25.71%, 25.37% and 25.37%, respectively. The three ratios gave significantly higher values than the ratio 20:20:5 (22.65%).

DISCUSSION

Effective water management in fishponds is one of the important factors contributing to the success of fish culture. Fertilization of earthen fishponds as one of the most important management process had been studied with conflicting results. Yamada (1986) reported that temperate ponds with low stocking density seemed to require phosphorus only. In contrast, subtropical or tropical ponds with higher stocking density achieved higher yield with nitrogen and phosphorus addition (Boyd, 1976). Therefore, the compositional ratios of fertilizer are very critical and widely depending on local conditions (Diana *et al.*, 1991).

In this study, there was no significant difference in temperature observed among treatments. McNabb *et al.* (1988) found that, due to warm climate and shallowness of most tropical fish ponds (~1.0 m), temperature and light were not likely to be limiting. On the other hand, the lowering of Secchi disk visibility was due to the high turbidity, which may have resulted from colloidal clay particles, the suspended organic particles that resulted from fish movement in pond, and the high abundance of phytoplankton (Boyd, 1990). Moreover, the concentration of dissolved oxygen which was not affected in this study, may be also due to the abundance of phytoplankton indicated by chlorophyll 'a' content, subsequently, the photosynthetic activity of phytoplankton population was approximately similar.

The high concentration of orthophosphate was observed with the high-phosphorus ratio (20:40:5) with insignificant difference with the ratios 20:20:5 and 20:20:0. These results may be due to the absorption and accumulation of phosphorus by bacteria, phytoplankton and pond sediments (Boyd, 1990; Munsiri *et al.*, 1995). On the other hand, 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 were related to total alkalinity. On the other hand, nitrate concentration was insignificantly varied with different N:P:K ratios. Accordingly, large application of inorganic nitrogen added to fishponds was transformed through denitrification and/or transferred to ammonia that volatiled to the atmosphere (Gross *et al.*, 1999).

It is well known that, the change in physico-chemical characteristics of water ponds leads to concomitant and quantitative changes in phytoplankton organisms. In this study, phytoplankton biomass was represented by chlorophyll 'a' content, which monthly fluctuated and changed more or less with approximately similar mean values. These results supposed similar phytoplankton abundance, although the occurrence of seasonal and quantitative fluctuations in phytoplankton populations is a common phenomenon depending on many factors.

The growth of Nile tilapia was influenced by the different N:P:K ratios. The obtained results led to conclude that the application of 20:20:5 ratio to fish ponds led to assign economic valuable results and the largest production of Nile tilapia. Also, there were no significant trend in proximate chemical composition of whole fish body. These results were due to the deposition of nutrients in fish tissues which were achieved through fish grazing and accumulation of planktonic organisms which differ in their nutritive values from species to species (Boyd, 1990).

It could be concluded that, there was no significant variation in water physico-chemical parameters of earthen ponds which received inorganic fertilizers with different N:P:K ratios.On the contrary, Secchi disk reading, water conductivity and orthophosphate concentration were significantly affected by the same treatments. The optimum N:P:K ratio for production of Nile tilapia without artificial feeding was 20:20:5 N:P:K.

Table 1. Changes in water physico-chemical parameters mean and range) of earthen ponds which received inorganic fertilizers with different N:P:K ratios.

	Inorganic fertilizers (N:P:K)			
	20:20:05	20:40:05	40:20:05	20:20:00
Temperature (°C)	25.9 a (22.3-28.4)	25.9 a (22.3-28.4)	25.9 a (22.3-28.4)	25.9 a (22.3-28.4)
Secchi disk (cm)	12.5 b (10.7-16.5)	15.3 a (11.2-19.0)	16.2 a (14.5-17.8)	11.1 b (8.8-15.2)
Dissolved oxygen (mg/L)	5.66 a (4.23-8.17)	5.18 a (3.70-8.85)	5.71 a (3.67-8.10)	5.30 a (3.23-8.60)
The pH value	8.8 a (8.6-8.9)	8.8 a (8.7-8.9)	8.8 a (8.5-9.1)	8.8 a (7.7-9.1)
Free ammonia (mg/L)	0.26 a (0.13-0.43)	0.26 a (0.18-0.41)	0.26 a (0.18-0.37)	0.25 a (0.12-0.32)
Conductivity (mMohs/cm)	0.59 ab (0.47-0.68)	0.53 b (0.40-0.63)	0.52 b (0.43-0.62)	0.64 a (0.55-0.78)
Total alkalinity (mg/L as $CaCO_3$)	294 a (237-347)	271 a (209-350)	269 a (216-345)	309 a (248-352)
Total hardness (mg/L as $CaCO_3$)	202 a (172-243)	201 a (164-241)	179 a (155-219)	202 a (161-247)
Orthophosphate (mg/L)	1.185 ab (0.91-1.87)	1.505 a (0.80-1.97)	0.810 b (0.57-1.14)	1.224 a (0.83-1.54)
Nitrate (mg/L)	14.41 a (5.79-28.9)	11.94 a (6.21-22.6)	12.07 a (6.00-19.7)	13.41 a (6.41-20.7)
Total nitrogen (mg/L)	7.34 a (6.23-7.90)	9.05 a (6.95-10.7)	7.10 a (4.60-9.13)	7.65 a (4.60-9.87

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

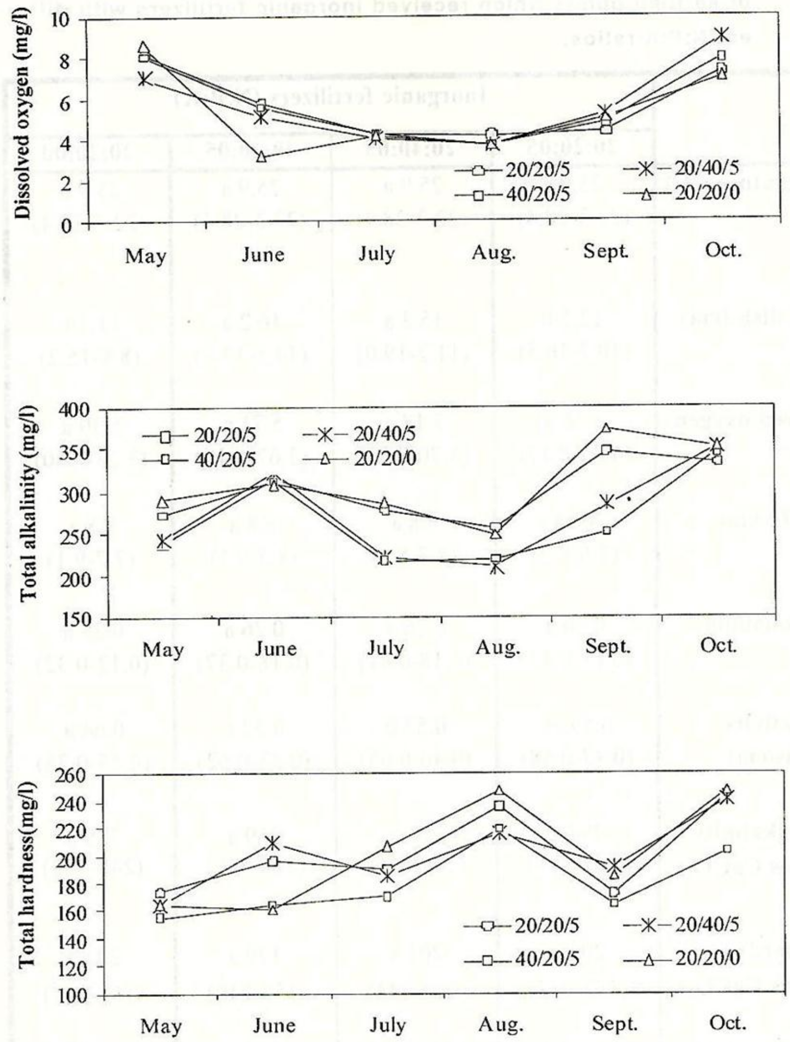

Fig 1. Monthly variations of dissolved oxygen (mg/L), total alkalinity and total hardness (mg/L as CaCO3) in ponds water affected by inorganic fertilizers with different N:P:K ratios.

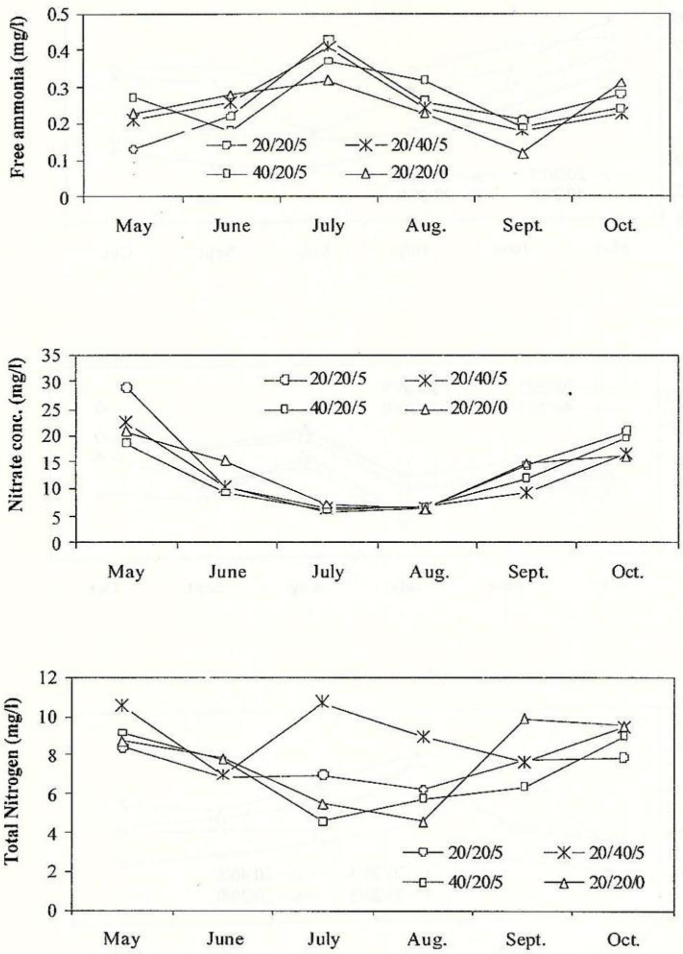

Fig 2. Monthly variations of free ammonia, nitrate concentration total nitrogen concentration (mg/L) in ponds water affected by inorganic fertilizers with different N:P:K ratios.

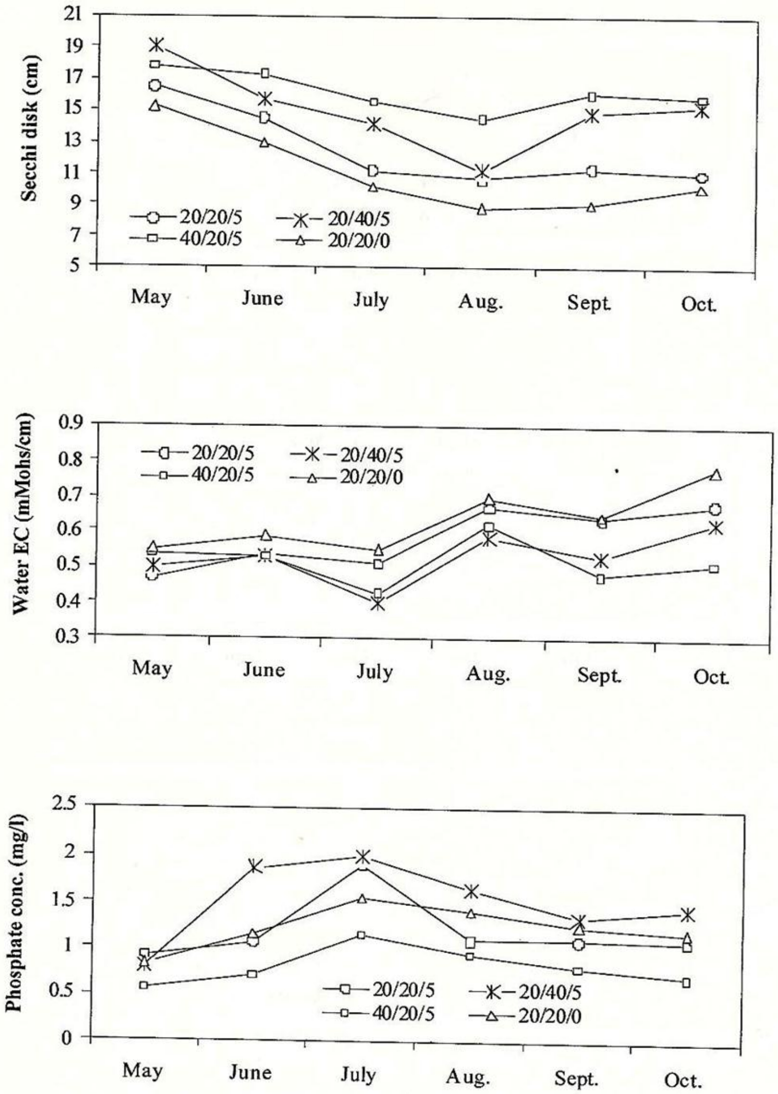

Fig 3. Monthly variation of Secchi disk visibility (cm), water conductivity (mMohs/cm) and phosphate concentration (mg/L) in ponds water affected by inorganic fertilizers with different N:P:K ratios.

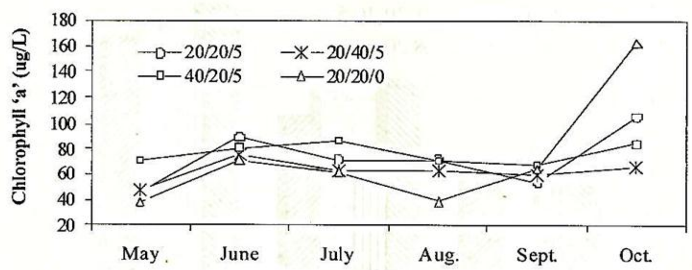

Fig 4. Monthly variation of chlorophyll 'a' content (mg/L) in ponds water affected by inorganic fertilizers with different N:P:K ratios.

Table 2. The total production (kg/pond) of Nile tilapia (O. niloticus) reared in ponds received inorganic fertilizers with different N:P:K ratios.

N:P:K ratios	Fingerlings	Adult	Total fish yield
20:20:05	4.50 ± 0.17 a	10.75 ± 0.26 a	15.25 ± 0.43 a
20:40:05	4.50 ± 0.35 a	6.50 ± 0.67 c	10.75 ± 0.15 c
40:20:05	3.95 ± 0.41 a	10.00 ± 0.81 ab	13.95 ± 0.15 b
20:20:00	4.75 ± 0.17 a	8.63 ± 0.23 b	13.38 ± 0.25 b

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

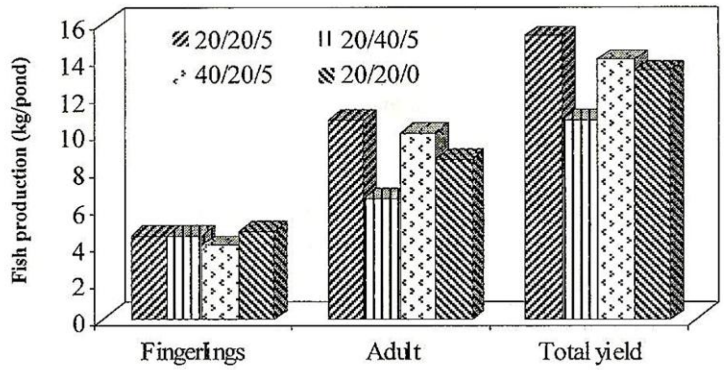

Fig 5. The total production of Nile tilapia (kg/pond) in ponds received inorganic fertilizers with different N:P:K ratios.

Table 3. Carcass proximate chemical analysis of Nile tilapia *(O.niloticus)* reared in ponds which received inorganic with different ratios of N:P:K.

N:P:K ratios	Dry matter	Crude protein	Total lipids	Ash
20:20:05	26.64 ± 0.53 a	61.51 ± 0.65 a	11.84 ± 0.15 a	22.65 ± 0.85 a
20:40:05	23.81 ± 0.27 a	62.41 ± 1.40 a	6.97 ± 0.12 b	25.71 ± 1.56 a
40:20:05	23.25 ± 0.31 a	65.71 ± 0.53 a	7.37 ± 0.18 b	25.43 ± 1.04 a
20:20:00	23.06 ± 0.24 a	65.68 ± 0.67 a	7.76 ± 0.08 b	25.37 ± 0.54 a

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

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تأثير الأسمدة الغير عضوية ذات نسب مختلفة من N:P:K على خصائص المياه و الإنتاجية الأولية وإنتاجية البلطى النيلى فى أحواض ترابية

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تمت هذه الدراسة بغرض تقييم بعض الأسمدة الغير عضوية ذات نسب مختلفة من N:P:K فى أحواض ترابية بالعباسة. كانت النسب المختلفة وهى ٢٠/٢٠/٥ و ٢٠/٤٠/٥ و ٤٠/٢٠/٥ و ٢٠/٢٠/٠. تضاف بمعدل ٤٠ كجم للفدان كل شهر وتم استزراع ١٥٠ سمكة بلطى نيلى (١٥-٢٠جم) فى كل حوض. لم تظهر النتائج وجود اختلافات معنوية فى درجة الحرارة و الأكسجين الذائب و درجة الأس الهيدروجينى والأمونيا والقاعدية الكلية والعسر الكلى نتيجة تأثير الأسمدة المختلفة بينما كانت الاختلافات معنوية فى كل من شفافية المياه و درجة التوصيل الكهربى و تركيز الفوسفات. كذلك لم يظهر اختلاف معنوى فى متوسط محتوى الكلوروفيل أ. كانت افضل إنتاجية للبلطى النيلى عند استخدام النسبة ٢٠/٢٠/٥ وان كانت لم تظهر أى اختلافات فى محتوى البروتين الكلى و الرماد فى جسم البلطى النيلى بينما كان أعلى محتوى للدهن عند استخدام النسبة ٢٠/٢٠/٥، لذلك ينصح باستخدام سماد غير عضوى (٢٠/٥/٢٠) N:P:K فى مزارع البلطى النيلى.