INFLUENCE OF FERTILIZERS' TYPES AND STOCKING DENSITY ON WATER QUALITY AND GROWTH PERFORMANCE OF NILE TILAPIA- AFRICAN CATFISH IN POLYCULTURE SYSTEM

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Abstract

The effects of fertilizer types and stocking density were investigated on water quality parameters that expected to affect growth performance of the polyculture of Nile tilapia (*Oreochromis niloticus*), African catfish (*Claris gariepinus*) and silver carp (*hypophthalmichthys molitrix*). The stocking ratios of the three species were 85% tilapia: 15% catfish along with 300 specimens silver carp in each hectare, fish were stocked at two stocking densities of 3 or 5 fish/m^2 with the same stocking ratios. The experiment was conducted in sixteen 400 m^2 earthen ponds from 22/4/07 to 29/10/07. Ponds were fertilized with organic fertilizers (chicken letter) or chemical fertilizer (mono superphosphate with urea) for the first 60 days with the rate of 0.5 mg P/L and 2.0 mg N/L. Four treatments were randomly applied with four replicates each as follows: 3fish/m^2 with chemical fertilizers (3-chem), 3fish/m^2 with organic fertilizer (3-org), 5fish/m^2 with chemical fertilizer (5-chem) and 5fish/m^2 with organic fertilizer (5-org). Commercial floating fish feed (25% crude protein) was used for all treatments to 100% satiation levels starting from day 61 till the end of the experiment.

Dissolved oxygen, water temperature and Secchi disk visibility were measured 3 times a week at 700 h. and other water quality parameters were measured once a week. Results of two-way ANOVA indicated that most of water quality parameters were influenced by fertilization type while stocking density had a little effect. Factor analysis demonstrated that, three factors (phytoplankton abundance Vs. decomposition, chemical transformation and photosynthesis) were responsible for more than 60 % of the total variability. All water quality parameters were in the proper range of the growth of all fish species used in this experiment.

Both high stocking density treatments (5-chem and 5-org) had the lowest tilapia survival with the highest catfish production. 5-org treatment had the highest values of total production, net production and total daily gain, (8.62 ton/ha, 8.59 ton/ha, 44.89 kg/ha/day), and also feed consumed and FCR, (13.35 ton/ha and 1.65 respectively). The best FCR (i.e. the lowest) was achieved by 3-chem treatment (1.21).

From the present results it could be concluded that water quality and consequently fish production can be optimized with the stocking density of 3fish/m^2 with fertilization rate of 0.5 mg P/L and 2.0 mg N/L, regardless of the type of fertilizer whether it is organic or chemical along with fish feed containing 25% protein.

INTRODUCTION

Semi-intensive culture of Nile Tilapia *Oreochromis niloticus* commonly utilizes organic and inorganic (chemical) fertilizers to increase primary production and ultimately fish yield. This system could be useful and applicable in fish farms or fish culture stations where water supplies are readily available and water loss through evaporation or by seepage is replaced regularly. Fertilization research have been essentially trial and error studies evaluated primarily by yield comparisons, rather than focusing on a actual dynamic process which rarely determine the effectiveness of particular fertilization strategy (Ibrahim, 2001). Consequently recommendations and conclusions based on such researches are frequently too general and sometimes may be contrary to established ecological relationships. This is compatible with the results of Knud-Hansen (1998) who reported that each pond is unique and will respond differentially to identical fertilization. Traditionally, organic fertilizers such as animal manures (Beyerle, 1979) Soybean meal (Fox *et al.*, 1989, Harding and Summerfelt, 1993) alfalfa meal (Qin *et al.,* 1995), yeast (Tice *et al.*, 1996) and chicken litter (Knud-Hansen *et al.*, 2003) have been used. However the excessive application of organic matter into fish ponds can reduce dissolved oxygen and cause fish kills (Qin and Culver, 1992, Middleton and Reeder, 2003, Tew *et al,* 2006) and the low nitrogen to phosphorus ratio (N: P) of some organic fertilizers favors the growth of nitrogen-fixing blue-green algae that are poor zooplankton food and may be toxic (Culver, 1991). Using of chemical fertilizer sources of N and P (rather than organic fertilizers) also helps maintain high water quality, i.e., high dissolved oxygen (DO) and moderate pH (Ibrahim and Nagdi, 2006). Increasing amount of fertilizers will increase phytoplankton production provided that inorganic carbon is sufficient. However, too high abundance of phytoplankton can cause low DO in the water during the night, on cloudy days, or when phytoplankton die and decay (Dobbins and Boyd, 1976). High algal abundance may cause increased photosynthetic activity during the day resulting in high pH values, a condition that can be directly lethal to fish (Bergerhouse, 1992), or indirectly by increasing the proportion of unionized ammonia (Emerson *et al.*, 1975, Stickney, 1994). Optimal fertilization rates in Abbassa ponds were determined to be 0.5 mg P/L and 2.0 mg N/L (N: P ration of 4:1) based on former studies by Ibrahim (1997), Ibrahim (2001), Nagdi, *et al.*, (2003), and Ibrahim and Nagdi (2006).

Culturing fish in polyculture system makes better use of land and water as it results in greater fish yields, together with higher economic returns than monoculture (Giap *et al.*, 2005, Ibrahim and El-Naggar, in press), as well as polyculture system consider one of the most effective ways to overcome overpopulation of tilapia fry when tilapia polycultured (co-cultivated) with fry-consuming fish such as catfish. El Naggar (2007) concluded that introduction of catfish is at the rate of 13% of total tilapia stocked has not only eliminated 70% of total tilapia recruitment but also enhanced total pond production of marketable size. Using of filter-feeding phytoplanktivorous fish species such as Silver carp can effectively reduces the growth of harmful algae and preventing bloom of other algae as well as increasing fish production, Zhang *et al.* (2006) indicated that the phytoplanktivorous silver carp can be an efficient biomanipulation fish to reduce nuisance blooms cyanobacteria.

By understanding basic principles of pond ecology and the limited number of identifiable variables which impact fertilization responses, the farmer can make intelligent decisions on a pond-by pond basis as to what fertilizer to use, the frequency and rate of application, when not to fertilize, how efficiency utilize available natural resources, what kind (species) of fish to cultivate and what stocking density and rate to apply. Ultimately how to maximize fish yields while minimizing expenses and environmental degradation.

The purpose of this study was to determine the best type of fertilizer to use and stocking density to apply which maximizing fish yields while minimizing expenses and environmental degradation.

MATERIALS AND METHODS

This experiment was conducted in sixteen 400 m^2 earthen ponds with an average depth of 1.2 m. at the WorldFish Center, Abbassa, Egypt, from 22/4/2007 to 29/10/2007.ponds were drained, cleaned and supplied by fresh water from Ismailia Canal (Branched from Nile River), and water level was maintained at a depth of approximately 1m. Supply and drainage pipes were equipped by nylon screen to prevent fish escape and/or entry. Ponds were fertilized for the first 60 days with the relevant fertilizer type (Organic "chicken manure" with the rate of 22 kg/pond/week or chemical "Urea and mono superphosphate (MSP)" with the rate of 1.8 Kg urea /week and 2.9 Kg MSP/pond/week as described in table (1) to produce an amount of 2.0 mg N/L and 0.5 mg P/L with N:P ratio of 4:1. After fertilization, ponds were filled to 20 cm with water, then after two weeks water level was raised to 1m and fish were then stocked.

Table 1. Amounts of chemical and organic fertilizers as kg/pond (400m^2)

Treatment	Chicken manure (3.4% N +1% P)	Urea 46% N	MSP 15.5% P_2O_5
3-Chem	---	1.8	2.9
3-Org	22	---	---
5-Chem	---	1.8	2.9
5-Org	22	---	---

Nile tilapia (*Oreochromis niloticus*) was stocked after two weeks of pond fertilization with an average weight of 0.30 g on 22 April 2007. After one week of tilapia cultivation 12 silver carp specimens were added to each pond with an average weight of 100 g. then catfish fingerlings (131.9 ± 14.82) were cultivated at 20 June 2007. Final stocking densities were 3 to 5 fish/m^2 with the same species ratio 85% tilapia: 15% catfish as shown in the following table

Table 2. Stocking densities of fish species used in this experiment (fish/ha)

Treatment	Tilapia Fish/Pond	Catfish 46%	Silver carp	Total Fish/m^2
3-Chem	25500	4500	300	3
3-Org	25500	4500	300	3
5-Chem	42500	7500	300	5
5-Org	42500	7500	300	5

Pelleted floating fish feed containing 25% crude protein was introduced to fish in all treatments starting from day 61 till the end of the experiment at starvation level with feeding frequency twice daily at 1000 and 1400 h six days a week, total amount of feed added too each pond was used as an estimate of feed consumption. The food conversion ratio (FCR) was calculated by the following equation:

Weight of feed added/increase in wet fish weight

Because of the fact that silver carp is phytoplankton feeder (Opuszynski, 1981, Burke, 1984, Smith, 1988, Ibrahim, 1997, Zhang *et al.,* 2006) it wasn't included in FCR calculations.

Four treatments were allocated in sixteen earthen ponds in completely random design, the first treatment was the addition of chemical fertilizers (Urea an MSP) with the rates mentioned above and stocking density of 3 fish/m^2 (3-Chem), the second treatment was the addition of organic fertilizer (chicken letter) with the same stocking density 3 fish/m^2 (3-org), the third treatment was the addition of chemical fertilizers with the stocking density of 5 fish/m^2 (5-Chem), and the fourth treatment was the addition of organic fertilizer with the stocking density of 5 fish/m^2 (5-org). All fertilizers were added throughout the first 60 days then from day 61 fertilization was stopped and fish feed was started to apply.

Water quality samples were collected weekly from each pond manually from the middle of water column by putting a closed sample bottle and opened in the desired depth, this procedure was done in different five spots in each pond then samples were mixed in a plastic bucket and 1 litter sample was taken as a representative water sample of each pond. These samples were taken 1 week after fertilizer application. At the time of sampling, water temperature, dissolved oxygen and Secchi disk visibility were measured in addition to their measurements two times weekly. Water temperature and dissolved oxygen were measure at 700 h using dissolved oxygen meter model Orion 835 A, pH was measured by Accumet 25 meter, total hardness, total alkalinity, orthophosphate (Po_4) nitrate (No_3), total ammonia nitrogen (TAN,$NH_{3/4}$) were measured according to Boyd (1990) and APHA (1985). Chlorophyll "a" was calculated using vollenweider (1969) equation.

Samples of each fish species from each pond were collected monthly, and then fish was weighed and immediately returned to the water of the same pond. At the end of the experiment, all fish were harvested, weighted and counted.

One-way ANOVA in completely randomized design was used to test the effect of the treatments on water quality and fish growth. Two-way ANOVA was used to test the effect of fertilizer and/or stocking density as well as their interaction on water quality and growth parameters. Duncan's multiple range test were performed to compare the significance of means. Differences were considered significant at $p \leq 0.05$. Ecological processes that account for the main variability of the measured variables were identified through factor analysis (Kim and Mueller, 1978, Kadir *et al.* 2006), run from the correlation matrix among water quality variables. The purpose of factor analysis is to reduce the number of variables by extracting new latent variables (Factors) which are assumed to be responsible for the most explained variance. The first factor extracted from that matrix is the linear combination of the original variables that accounts for as much of the variation contained in the samples as possible. The second factor is the second linear function of the original variables that accounts for most of the remaining variability, and so on. The coefficients of the linear functions defining the factors are used to interpret their meaning, using the sign and relative size of the coefficients as an indication of the weight to be placed upon variable. All statistics were done using SAS program ver. 9.1 (SAS, 2005).

RESULTS AND DISCUSSION

As shown in Table (3) most of water quality parameters were affected by treatments except for water temperature and orthophosphate which didn't differ among treatments ($P>0.05$)

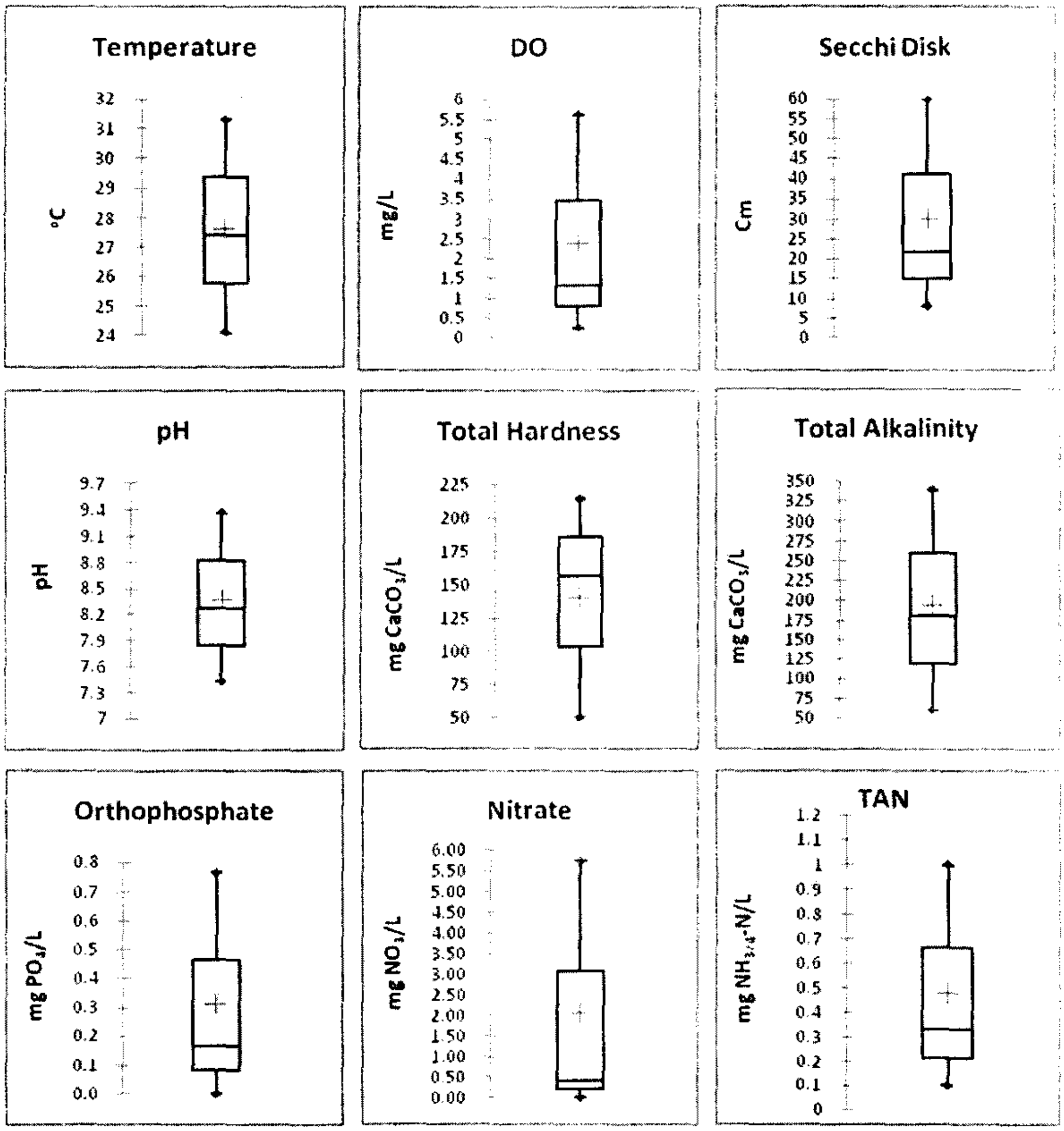
Water temperature ranged from 24.1 to 31.3 ^oc over the culture period with an average of 27.5 ^oc, early morning dissolved oxygen from 0.3 to 5.6 mg/L, Secchi disk visibility from 8 to 60 cm, pH from 7.4 to 9.4, total hardness from 50 to 214 mg/L, total alkalinity from 60 to 340 mg/L orthophosphate (Po_4) from 0.01 to 0.77 mg/L, nitrate (No_3) from 0.01 to 5.8 mg/L,TAN ($NH_{3/4}$-N) from 0.1 to 1.0 mg/L and chlorophyll "a" from 10.4 to 285.4 mg/L (Figure, 1). All ponds were within acceptable range of water quality parameters during the study.

Table 3. Average concentrations of water quality parameters for all treatments of fertilization and stocking density

Treatment	Temp (C°)	DO (mg/l)	SD (cm)	pH	PO_4 (mg/l)	NO_3 (mg/l)	NH_4 (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)	Chl. "a" (µg/l)
3-Chem	27.5 ^{a}	1.58 ^{a}	18.7 ^{b}	8.5 ^{a}	0.159 ^{a}	0.36 ^{a}	0.33 ^{a}	153.1 ^{b}	180.4 ^{b}	75.2 ^{ab}
3-Org	27.6 ^{a}	1.05 ^{b}	20.8 ^{ab}	8.2 ^{b}	0.154 ^{a}	0.30 ^{ab}	0.29 ^{b}	153.6 ^{b}	176.1 ^{bc}	86.2 ^{a}
5-Chem	27.5 ^{a}	1.47 ^{a}	19.0 ^{b}	8.3 ^{b}	0.156 ^{a}	0.36 ^{a}	0.33 ^{a}	173.9 ^{a}	197.1 ^{a}	54.1 ^{b}
5-Org	27.5 ^{a}	1.00 ^{b}	21.4 ^{a}	8.2 ^{b}	0.157 ^{a}	0.26 ^{b}	0.34 ^{a}	152.2 ^{b}	170.6 ^{c}	63.6 ^{ab}

Means with different letters in the same column are significantly different (Duncan's multiple range test at $P<0.05$).

Tow-way ANOVA (Table, 4) indicated that fertilizer type was effective than stocking density on water quality parameters except for TAN and chlorophyll "a" which were more affected by stocking density than fertilizer type. The higher stocking density (5 fish/m^2) had the highest ($p<0.05$) TAN concentration and the lowest chlorophyll concentration which attributed to the higher fish biomass that consume natural food and release ammonia in a form of feces much greater than that in the lower stocking density (3 fish/m^2). On the other hand both of water temperature and orthophosphate concentration were not affected neither by fertilizer type nor by stocking density. Both of total hardness and total alkalinity had significantly higher concentrations when ponds treated with chemical fertilizers than ponds treated with organic fertilizers, this mainly due to 1-the addition of calcium in a form of calcium sulfate (gypsum) which used as a filter in the MSP fertilizer 2-increases in photosynthesis activity in ponds treated with organic fertilizers (algal density 74.9 µg chlorophyll "a" /L) than that in ponds treated with chemical fertilizers (algal density 63.2 µg chlorophyll "a"/L). Boyd (1990) stated that the increase in the rate of photosynthesis leads to the consumption of carbon dioxide (Co_2) and hydrolysis of bicarbonate (HCo_3).



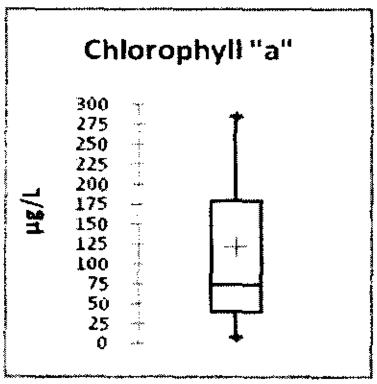


Figure 1. Box plot of water quality variables showing maximum, minimum, mean (+) and median values.

Table 4. Two-Way ANOVA and main effects by fertilization and stocking density on water quality parameters.

	Temp. (°C)	DO (mg/l)	SD (cm)	pH	PO_4 (mg/l)	NO_3 (mg/l)	TAN (mg $NH_{3/4}$/l)	T. Hard. (mg $CaCO_3$/l)	T.Alk. (mg $CaCO_3$/l)	Chl. "a" µg/l
ANOVA models										
Sign.	ns	**	*	**	ns	*	**	**	**	ns
r^2	0.28	0.63	0.19	0.43	0.02	0.16	0.26	0.59	0.53	0.16
Source of variation										
Fertilization	ns	**	**	**	ns	**	ns	**	**	ns
Stocking density	ns	ns	ns	ns	ns	ns	*	**	*	*
Fertilization*Stocking	ns	ns	ns	*	ns	ns	*	**	**	ns
Main Effects										
Fertilization										
Organic	27.6^{a}	1.0^{b}	21.1^{a}	8.2^{b}	0.155^{a}	0.279^{b}	0.311^{a}	152.9^{b}	173.0^{b}	74.9^{a}
Chemical	27.5^{a}	1.5^{a}	18.9^{b}	8.4^{a}	0.160^{a}	0.364^{a}	0.328^{a}	165.0^{a}	188.8^{a}	63.2^{a}
Stocking density										
3 Fish/m^2	27.6^{a}	1.3^{a}	19.8^{a}	8.3^{a}	0.158^{a}	0.330^{a}	0.307^{b}	153.4^{b}	178.6^{a}	81.5^{a}
5 Fish/m^2	27.5^{a}	1.2^{a}	20.1^{a}	8.3^{a}	0.158^{a}	0.313^{a}	0.333^{a}	163.1^{a}	183.9^{a}	58.9^{b}

Sign. = significance level * $P \le 0.05$, ** $P \le 0.01$, and ns not significant. r^2 determination coefficient.

Means with different letters in the same column in each main effect are significantly different (Duncan's multiple range test at $P<0.05$).

Results of factor analysis (Table, 5) showed that three factors were responsible for more than 60% of the explained variability that affected all water quality variables. The first factor had adverse (positive) correlation with water temperature, phosphorus and chlorophyll concentrations while it had reverse (negative) correlation with dissolved oxygen, Secchi disk and pH, these relationships reflects the opposition between phytoplankton abundance (the increase in water temperature and phosphorus contents promotes phytoplankton growth that decreases Secchi depth) and decomposition of phytoplankton cells (after blooms phytoplankton cells decays that liberates phosphate into water reducing pH while fermentation reduces oxygen content.

Table 5. Results of factor analysis, the three main effective factors those were responsible for 60 % of explained variance.

Variable	Factor 1	Factor 2	Factor 3
Temp.	**0.86**	**0.50**	0.15
DO	**-0.82**	0.04	0.32
SD	**-0.50**	0.28	0.17
pH	**-0.57**	-0.36	-0.01
Hard.	0.03	**-0.59**	**0.59**
Alk.	-0.07	-0.38	**0.80**
PO_4	**0.57**	**-0.75**	-0.11
NO_3	0.22	**-0.73**	-0.33
NH_4	-0.03	0.18	0.22
Chl.	**0.58**	0.21	**0.66**
Explained variance (%)	26	20	14
Interpretation	Phytoplankton abundance vs. decomposition	Chemical transformation (reactions)	Photosynthesis

Bold numbers are significant coefficients used for factor interpretation

The second factor positively correlated with water temperature and negatively correlated with total hardness available phosphorus and nitrate, reflects the chemical transformations (the increase in water temperature accelerates the chemical reactions that transform $CaCo_3$, Po_4; NO_3 to other forms of calcium phosphorus and nitrogen compounds reduces hardness, alkalinity, orthophosphate and nitrate concentrations).

The third factor shows positive correlation between total hardness and total alkalinity in one hand with chlorophyll "a" content in the other hand, which interpreted as photosynthesis process (significant correlation between the availability of carbon measured by both hardness and alkalinity with phytoplankton cells measured by chlorophyll "a" in the water column interpreted as photosynthesis). Figure (2) illustrates the relationships between all water quality variables on the light of the first most important two factors (phytoplankton abundance vs. decomposition and chemical transformation) which responsible for about 46% of the total variability of the water quality.

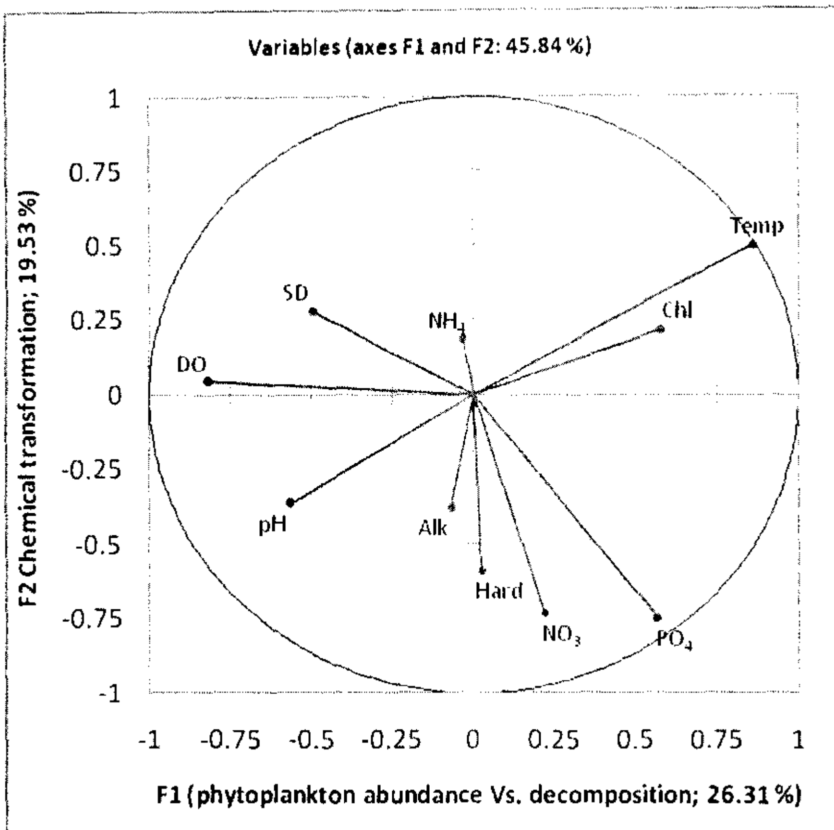


Figure 2. Correlation chart of water quality variables on the light of Factor 1 and Factor 2, that responsible for 45.84 % of total variability.

Initial weight, final weight, daily gain, fish production and survival for tilapia, catfish and silver carp separately presented for each fish species and each treatment in table (6). 5-chem treatment had the lowest fish weight and daily gain for all fish species. Both high stocking density treatments (5-chem and 5-org) had the lowest tilapia survival (57.3% and 74.3% respectively) with the highest catfish production (2.36 and 2.68 ton/ha respectively) which may indicated that predation behavior of catfish increased in the higher stocking density. Similar results were found by

Fessehaye *et al.* (2006) who reported that Cannibalism with density of 2 fish/L was significantly higher than mortalities with densities of 0.33 and 1 fish/L.

Table 6. Production parameters of Nile tilapia, African catfish and Silver carp in all treatments.

Treatment	Initial Wt. (g/fish)	Final Wt. (g/fish)	Daily Gain (g/day)	Production (ton/ha)	Survival (%)
			Tilapia		
3-Chem	0.30 [a]	142.80 [a]	0.74 [a]	3.40 [b]	93.62 [a]
3-Org	0.30 [a]	155.37 [a]	0.81 [a]	3.82 [ab]	96.96 [a]
5-Chem	0.30 [a]	88.14 [b]	0.46 [b]	2.15 [b]	57.33 [c]
5-Org	0.30 [a]	172.90 [a]	0.90 [a]	5.49 [a]	74.28 [b]
			Catfish		
3-Chem	146.02 [a]	446.95 [a]	1.56 [a]	1.94 [bc]	96.48 [a]
3-Org	163.20 [a]	413.87 [ab]	1.31 [a]	1.79 [c]	95.84 [a]
5-Chem	95.84 [b]	330.08 [b]	1.27 [a]	2.36 [ab]	93.17 [a]
5-Org	119.29 [a]	400.60 [ab]	1.47 [a]	2.68 [a]	90.25 [a]
			Silver Carp		
3-Chem	100.00 [a]	1835.86 [a]	9.04 [a]	0.54 [a]	97.22 [a]
3-Org	100.00 [a]	1573.49 [a]	7.67 [a]	0.44 [a]	93.75 [a]
5-Chem	100.00 [a]	1556.80 [a]	7.59 [a]	0.43 [a]	91.67 [a]
5-Org	100.00 [a]	1856.33 [a]	9.15 [a]	0.45 [a]	62.50 [a]

Means with different letters in the same column are significantly different (Duncan's multiple range test at $P<0.05$).

As presented in table (7), 5-org treatment had the highest ($p<0.05$) total production, net production and total daily gain, followed by 3-org treatment then 3-chem treatment while 5-chem treatment was the lowest. Feed consumed followed the same manner of production parameters however FCR has the highest value in 5-org treatment (1.65) while the best FCR (i.e. the lowest) was achieved by 3-chem treatment (1.21). Although 3-chem treatment had lower fish biomass than 5-org treatment, chlorophyll "a" concentration was higher in 3-chem treatment than 5-org treatment (however it was not significant) which mean that available natural food was higher in 3-chem treatment than that in 5-org treatment, that explain the lower FCR in 3-chem treatment than 5-org treatment, thus part of consumed food in 3-Chem treatment was natural food that reduced the consumption of artificial feed.

Table 7. Total production, Net production, Total daily gain, Feed consumed and Feed conversion ratio (FCR) for all fish in all treatments.

Treatment	Total prod. (ton/ha)	Net prod. (ton/ha)	Total D. Gain (kg/ha/day)	Feed consumed (ton/ha)	FCR
3-Chem	5.87 [b]	5.85 [b]	30.59 [b]	6.44 [b]	1.21 [b]
3-Org	6.06 [b]	6.03 [b]	31.55 [b]	7.10 [b]	1.28 [b]
5-Chem	4.93 [b]	4.90 [b]	25.68 [b]	6.37 [b]	1.43 [b]
5-Org	8.62 [a]	8.59 [a]	44.89 [a]	13.35 [a]	1.65 [a]

Means with different letters in the same column are significantly different (Duncan's multiple range test at $P<0.05$).

From the present results it could be concluded that:

water quality and consequently fish production can be optimized with stocking density of 3 fish /m^2 with fertilization rate of 0.5 mg P/L and 2.0 mg N/L regardless the type of fertilizer weather it is organic or chemical.

More research should be conducted on fertilization regimes and to what extent (i.e. period and/or percent), ponds can depend on fertilizers instead of feed either completely or partially.

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تأثير أنواع الأسمدة وكثافة التحميل على جوده المياه ونمو أسماك البلطي النيلي والقرموط الأفريقي في الاستزراع المتعدد

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في هذا البحث تم دراسة تأثير كل من أنواع الأسمدة وكثافة التحميل على بعض خصائص المياه التي تؤثر على نمو الأسماك عند استزراعها في نظام الاستزراع المتعدد لأسماك البلطي النيلي والقرموط الأفريقي والمبروك الفضي بمعدلات تحميل ٨٥% للبلطي : ١٥% للقرموط بالإضافة إلى ٣٠٠ سمكه مبروك فضي لكل هكتار. تم تخزين الأسماك بكثافتين ٣ أو ٥ سمكات/م٢ . أجريت التجربة في ستة عشر حوض ترابي مساحة كل منها ٤٠٠ م٢ وذلك في الفترة من ٢٠٠٧/٤/٢٢ الى ٢٠٠٧/١٠/٢٩. قسمت الأحواض إلى مجموعتين الأولى سمدت بسماد عضوي (فرشة الدواجن) والأخرى بسماد كيماوي (سوبر فوسفات أحادى مع اليوريا) وذلك لمده الـــ٦٠ يوم الأولى بمعدل ٠،٥ ملجم فو/لتر و ٢ ملجم ن/لتر. تم توزيع الأحواض عشوائيا على أربعه معاملات لكل معامله أربعه تكرارات على النحو التالي: ٣ سمكات/م٢ مع سماد كيماوي (3-chem) ٣ سمكات/م٢ مع سماد عضوي (3-Org)، ٥ سمكات/م٢ مع سماد كيماوي (5-chem)، ٥ سمكات/م٢ مع سماد عضوي (5-org). بداية من اليوم الواحد والستين تم أضافه علف الأسماك الطافي ٢٥% بروتين حتى مستوى الشبع التام. تم قياس الأكسجين الذائب ودرجه الحرارة وعمق سيكى ثلاث مرات أسبوعيا في حوالي الساعة السابعة صباحا وباقي مقاييس المياه تم قياسها مره واحده أسبوعيا. دلت نتائج تحليل التباين ثنائي المسار أن مقاييس جوده المياه تأثرت بشكل كبير بنوع السماد بينما أثرت كثافة التحميل بدرجه اقل. اظهر التحليل العاملي أن هناك ثلاثة عوامل مسئولة عن ٦٠% من التباين المفسر في مقاييس جوده المياه. العامل الأول هو التضاد بين نمو الطحالب وتحللها والعامل الثاني هو التحولات الكيمائية والثالث هو البناء الضوئي. عموما كانت كل مقاييس المياه في المدى المناسب لنمو كل أنواع الأسماك المستخدمة في التجربة. انخفضت نسبه الحياة لأسماك البلطي في معاملتي الكثافة العالية 5-chem,5-Org مع ارتفاع ملحوظ في إنتاج اسماك القراميط في هاتان المعاملتان. كانت معامله 5-org صاحبه أعلى إنتاج كلى و إنتاج صافى ومعدل نمو يومي (٨،٦٢ طن/هكتار، ٨،٥٩ طن/هكتار، ٤٤،٨٩ كجم/هكتار/يوم وكذلك كميه الغذاء المستهلك و FCR (١٣،٣٥ طن/هكتار و ١،٦٥ على التوالي). أفضل FCR (الأقل) كان فى معامله 3-chem (١،٢١). من النتائج المتحصل عليها من هذه الدراسة يمكن التوصية بان كثافة التحميل الأقل (٣سمكات/م٢) كانت الأفضل ويمكن استخدامها مع التسميد بمعدل ٠،٥ ملجم فو/لتر + ٢ ملجم ن/لتر من اى نوع من أنواع السماد (عضوي أو كيماوي) للحصول على أفضل جوده للمياه وبالتالي نمو للأسماك.