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Original Article

Influence of Soil Quality, Fertilization on Live Food Production and Water Quality of Nile Tilapia, *Oreochromis Niloticus*, Ponds

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Abstract

Different soil types were studied for supplementing ponds with fertilizers and their effect on water quality parameters with two culture systems. The pond soils were clayey, clay-sandy, and sandy in three different locations in Egypt. The fish ponds were fertilized with organic fertilizers (compost) and inorganic fertilizers with a rate of 500 kg/feddan/week and 14(nitrogen: phosphorus with ratio of 4:1) kg/feddan/week, respectively. Nile tilapia *Oreochromis niloticus* was reared with initial body weight of (5.31g±0.03) in monoculture system with density of 22,000 fish/feddan and with grey mullet *Mugil cephalus* with initial body weight of (9.88g± 0.06) in polyculture system fed on commercial diet (25% crude protein) for 240 days. The results revealed that the dissolved oxygen, total alkalinity, total hardness, and total dissolved solids increased insignificantly in clayey soil more than clay-sandy and sandy soil. In addition, fertilization and monoculture system raised the values not significantly. Total ammonia, unionized ammonia, nitrates (NO_3), and nitrites (NO_2) followed the same trend. Total phosphorus, orthophosphate, chlorophyll"a" and zooplankton (animal/L) were significantly ($P<0.05$) affected by soil type of the three studied locations. Furthermore, the values of these parameters for fertilized ponds were significantly higher than unfertilized ponds for the three soil types. The same pattern was observed for monoculture system results when compared to polyculture especially in sandy soil. Accordingly, the present study indicated that fertilization were more effective in live food production for sandy soil than clay-sandy and clay soil. Also, fertilized ponds irrespective to soil type and culture system produced higher live food and final yield than unfertilized ponds, and polyculture system was better than monoculture regardless of soil type and fertilization on live food and final produced yield.

Keywords: *fertilization, sandy soil, clay soil, water quality, fishculture , tilapia, grey mullet, yield*.

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INTRODUCTION

The successful productivity of fish using ponds depends on the physical–chemical and biological characteristics of soil and water used for fish cropping and nutrition management of cultured species (Ntengwe 2008). Soil is considered an important concern for aqua-culturists, as the soil affects the chemistry of water and the ability of ponds to hold water (Landau and Scarpa 2001). The soil condition is an important environmental factor influencing water quality and controlling various production processes. (Boyd, 1996). High concentrations of organic matter in bottom soil may result in anaerobic conditions in the surface layer of soil and at the soil-water interface (Boyd, 1992). Anaerobic soil does not effectively remove phosphorus from the water, and toxic reduced substances (nitrite and hydrogen sulfide in particular) produced by microbial activity in anaerobic soil layers may enter the pond water if the soil-water interface is anaerobic (Masuda and Boyd, 1994). Ntengwe and Edema (2008) reported that the successful productivity of fish using ponds depends on the physical-chemical and biological characteristics of water used for fish cropping and the nutrition management of the aquaculture species. Although, bottom soil quality has long been recognized as a factor influencing water quality and aquatic animals production (Munsiri et al., 1996). The exchange of substances between soil and water affects water quality, which in turn influences fish production. It is generally recognized that there are strong effects and interactions among soil characteristics, water quality, and fish production in earthen ponds (Boyd, 1995). Alkalinity is important for fish and other aquatic life in freshwater systems because it buffers pH changes that occur naturally as a result of photosynthetic activity of the chlorophyll-bearing vegetation. It is a well-known toxicant for fish and toxicity could be affected by several factors such as pH, dissolved oxygen, nutrition and fish size (Eddy and Williams, 1987). Diana et al. (1996a) recorded ammonia concentrations ranged between 1.3-1.9 mg/L in ponds received inorganic fertilizers and staged feed. In this connection, Diana et al. (1991) and Newman et al. (1993) recorded mean total ammonia concentration 7.3 mg/L with unionized ammonia 2.1 mg/L. Most fish culture ponds in the tropical region are fertilized to increase phytoplanktonic production which, in turn, would increase fish yield (Knud-Hansen et al., 1993; Knud-Hansen and Batterson, 1994). Fertilization of a fish pond actually increases the production of beneficial phytoplankton, microscopic free-floating algae. This increases productivity, thereby increasing the amount of harvestable fish. The harvest of a fertilized pond can be triple that of an unfertilized pond (Brunson et al., 2001). Schroeder (1980) stated that organic fertilizers are believed to increase fish yield by three different processes: (1) direct consumption by fish, (2) utilization by other heterotrophic organisms and (3) as a source of minerals such as N,P and K which used in photosynthetic production of phytoplankton (and hence as one of the first links in a food chain). Amer (2000) investigated the effect of different polyculture ratios of striped mullet (*Mugil cephalus*) and Nile tilapia (*O. niloticus*) under the polyculture system in net enclosure. The results indicated that, with increasing the rate of mullet in the polyculture ratio, final body weight and weight gain of both striped mullet and Nile tilapia fingerlings decreased due to the inter specific competition between mullet and tilapia for food. Moreover, the increase in mullet ration affects its growth due the intra specific competition between mullet fingerlings. The authors found that, the best mixture for high production was 70% tilapia and 30% mullet. Therefore, the objectives of the present study is to assess the effect of soil type on the production of live food and water quality on the productivity of final yield of Nile tilapia and grey mullet. In addition, the study emphasizes the competency of arid lands scarce in soil fertility by inducing fertilizers to alleviate natural production of live food and escalate fish yield.

MATERIALS AND METHODS

The study has been applied for 8 months at three private fish farms in Egypt different in their organic matter, nitrogen, and phosphorus contents (i.e. types of soil). Table1.Two of which were at Behaira governorate (Edko city as a Clayey soil), Kafr Eldawar as a loamy soil and the third city was at Borg El-Arab as a sandy soil, Alexandria governorate. A total of 12 treatments were formed for the three types of soil, each one has four treatments (monoculture and polyculture system; fertilized and unfertilized). Each treatment has its own replicate forming a total of eight ponds in each location. Water quality and soil analysis, and fish measurements were performed monthly at all locations. Each earthen pond was one feddan in surface area, and with average depth of one meter. Water exchange rate varied throughout the experiment with 5%, 10%, 15%, and 20% of the total water volume for the first two months, then the second two months, followed by the third two months, and then for the rest of the experimental period, respectively. Hormonal treated sex-reversed all male *O. niloticus* fingerlings were stocked in all monoculture system ponds was 22,000 fish/ feddan, and 20,000 Nile tilapia along with 2000 grey mullet, *Mugil cephalus* for polyculture system. Initial average body weight (BW) for *O. niloticus* was 5.31±0.03 g/fish, and 9.66±0.06 g/fish *Mugil cephalus*. A pelleted feed with 25% CP was introduced to fish to satiation three times a daily six days a week. Compost as an organic fertilizer was applied at a rate of 500 kg/feddan/week. Urea (with N content of 46.5%) and mono-super phosphate (with P content of 15.5%) were applied as chemical fertilizers at a rate of 2.8 grams of (N) and 0.7 grams of phosphorus (P) /m^2 to bring the ratio of 4: 1 for N : P (Yi and Lin 2001)

Growth measurements were determined as follows:

Weight gain (WG) = final weight – initial weight.

Specific growth rate (SGR%/day) = (log final weight- log initial weight) 100/number of days

Feed Utilization

Feed conversion ratio (FCR), protein efficiency ratio (PER) were calculated as follows:

FCR =dry matter feed intake/ gain.

PER=gain/protein intake

Statistical analysis:

Statistical analyses were conducted using methods from SYSTAT: the system for statistics as described by Wilkinson (1990). The analysis of variance (ANOVA) and least significant differences test were conducted according to Snedecor and Cochran(1981).

Table 1. Sediment logical components and main values of pH, calcium carbonate ($CaCO_3$) and salinity surface layer (0-30 cm) of the different soils in the studied locations.

Soil type	Sand (%)	Silt (%)	Clay (%)	pH	$CaCO_3$	Salinity
Clayey	36.25	13.50	40.00	8.30	6.85	0.23
Sandy clay (Loamy)	58.35	10.00	26.50	8.00	5.70	0.40
Sandy	70.69	10.00	12.00	7.69	2.45	0.58

Results

Water temperature with overall mean of 27.50±0.00°C had no significant differences (P>0.05) between treatments of the 3 soil types. However, DO ranged between 5.97and 7.18 mg/L over the course of the experiment. Whereas for pH value showed no significant differences among treatments (P>0.05) soil type, fertilization, and culture system Table 2 Moreover, no significant differences observed for total dissolved solids, total alkalinity, total hardness,-Table (3) and total ammonia for the different treatments, soil type, fertilization, culture system, and in their interaction. The three different soil type showed no significant effect on total and unionized ammonia with the lowest for clayey soil followed by loamy and sandy soil. In addition, fertilized ponds treatments had a higher total and unionized ammonia than unfertilized ones, but not significantly different. However, polyculture system ponds (Nile tilapia and grey mullet) had lower total and unionized ammonia than monoculture system pond (Nile tilapia). Nevertheless, Nitrate and Nitrite (mg/L) concentrations showed similar pattern for soil types, fertilization, culture systems and their interactions in water samples of the present study (Table 4).

Table 2. Temperature, pH, total dissolved solids (TDS), Total alkalinity (mg/L),and total hardness (mg/L) of water samples from the three studied soil types, clayey (C), loamy (L) and sandy (S), for fertilized (F) and unfertilized (U) treatments, with monoculture (M) and polyculture (P) systems for the present study.

	Temp (^oC)	pH	TDS	Alkalinity (mg/L)	Hardness (mg/L)
C	28.00±0.00	8.90±0.01	2894±433	508±20.0	681.8±35.6
L	28.00±0.00	8.15±0.01	2419±455	443±25.0	580.3±41.1
S	26.00±0.00	7.50±0.02	1824±455	389±16.8	421.4±52.2
F	27.50±0.01	8.33±0.01	2498±325	459±19.0	78.5±45.0
U	27.50±0.01	8.07±0.02	1962±231	365±18.6	534.8±30.1
M	27.50±0.01	8.25±0.02	2400±511	335±9.1	527.5±42.1
P	27.50±0.01	8.21±0.02	2360±532	361±8.1	549.8±35.5

Mean having different letters within column for the same factor are significantly different (P<0.05).

Table 3. Mean (±) SE, values of total ammonia, unionized ammonia, nitrate (NO_3) (mg/L) and nitrites (NO_2) (mg/L) and total phosphorus (mg/L) for the three soil types, clayey (C), loamy (L) and sandy (S), for fertilized (F) and unfertilized (U) treatments, with monoculture (M) and polyculture (P) systems for the present study.

	Totalammonia(mg/L)	Unionized ammonia (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	TP (mg/L)
E	0.836±0.21	0.333±0.05	0.350±0.03	0.051±0.01	1.447±0.35^a
K	0.679±0.19	0.273±0.05	0.288±0.03	0.041±0.01	0.903±0.24^{ab}
B	0.571±0.17	0.196±0.03	0.213±0.05	0.034±0.01	0.718±0.80^b
F	0.790±0.23	0.291±0.05	0.299±0.05	0.045±0.01	1.279±0.9^a
U	0.601±0.24	0.243±0.04	0.268±0.05	0.039±0.01	0.766±0.91^b
M	0.831±0.22	0.310±0.05	0.323±0.03	0.045±0.01	1.067±0.6^a
P	0.560±0.21	0.224±0.05	0.244±0.02	0.039±0.01	0.979±0.5^a

Mean having different letters within column for the same factor are significantly different (P<0.05).

Total phosphorus and orthophosphate (Table 5) were significant different (P<0.05) among soil types. The highest concentration recorded for clayey soil, followed by loamy, then sandy soil. However, a positive correlation was found between fertilizers and total phosphorus and orthophosphate concentrations, as fertilized ponds were significantly (P<0.05) higher than unfertilized ponds. Besides, using monoculture system increased insignificantly total phosphorus and orthophosphate concentrations in water than polyculture system. The same trend was perceived for chlorophyll-"a". However, zooplankton density and secchi disk visibility disclosed a significant (P<0.05) effect with the presence of fertilization and culture system. Correspondingly, ponds with monoculture system disclosed a significant (P<0.05) readings for secchi disk visibility, and Zooplankton density, than polyculture system (*O. niloticus and M. cephalus*).

Initial and final body weight:

Initial and final body weight and specific growth rate showed (Table 6) no significant differences among treatments in initial body weight inducing a random distribution of fish in different treatments at the launch of the experimental. The results indicated that final body weight (FBW), Gain and average daily gain of Nile tilapia and grey mullet was significantly (P<0.05) affected by soil type, fertilization, culture system and interaction among them. The highest FBW for tilapia was found in fertilized ponds for clayey soil with polyculture system, and in fertilized ponds at sandy soil with polyculture system for Grey mullet. The lowest (FBW) was found in unfertilized ponds for sandy soil with monoculture system for *O. niloticus* and polyculture system for *M. cephalus*. However, SGR% decrease significantly (P<0.05) with increasing clayey component of soil, but was not altered with fertilization or culture system.

Table 4. Mean± SE, values of orthophosphate concentrations of chlorophyll-a (mg/L) and zooplankton (animal/L) and Secchi disk visibility (SD) (cm) for the three soil types, clayey (C), loamy (L) and sandy (S), for fertilized (F) and unfertilized (U) treatments, with monoculture (M) and polyculture (P) systems for the present study.

	OP (mg/L)	Chlorophyll-A (mg/L)	Zooplankton (animal/L)	SD(cm)
E	0.575±0.022[a]	352.09±138.62[a]	1153.64±122.93[a]	14.51±4.0[b]
K	0.494±0.029[b]	256.75±78.63[ab]	1067.40±97.64[a]	17.14±4.0[a]
B	0.421±0.028[c]	207.03±108.77[b]	305.51±71.68[b]	19.82±6.5[a]
+	0.409±0.112[a]	360.10±95.89[a]	898.40±429.22[a]	17.21±5.5[b]
-	0.305±0.098[b]	255.63±52.35[b]	759.99±417.76[b]	20.82±6.5[a]
M	0.391±0.008	297.16±137.97	901.72±447.06[a]	17.88±5.6[b]
P	0.324±0.018	246.77±114.01	782.63±397.46[b]	20.15±6.8[a]

Mean having different letters within column for the same factor are significantly different (P<0.05).

Table 5. Mean values of initial biomass, total yield, net yield and survival rate (SUR)(%) for Nile tilapia and Grey mullet) for the three soil types, clayey (C), loamy (L) and sandy (S), for fertilized (F) and unfertilized (U) treatments, with monoculture (M) and polyculture (P) systems for the present study.

	IBM (kg/feddan)		TY (kg/feddan)		NY (kg/feddan)		SUR(%)	
	O. niloticus	*M. cephalus*	*O. niloticus*	*M. cephalus*	*O. niloticus*	*M. cephalus*	*O. niloticus*	*M. cephalus*
C	111.51	19.76	4707.5[a]	1221.04	4596.06 [a]	1201.28 [a]	82.25 [a]	89.84
L	111.51	19.76	3964.5[b]	1083.12	3853.00 [b]	1063.36 [ab]	79.86 [a]	89.38
S	111.51	19.76	2161.69[c]	1007.20	2050.18 [c]	987.44 [b]	70.86 [b]	82.34
F	111.51	19.76	4000.87[a]	1411.62[a]	3889.36 [a]	1391.86 [a]	65.33	89.96
U	111.51	19.76	3221.64 [b]	795.95[b]	3110.13 [b]	776.19 [b]	61.32	84.41
M	111.51	00.00	3619.63	00.00	3508.12	00.00	60.29 [a]	00.00
P	111.51	19.76	3600.88	1103.8	3489.37	1084.03	66.19 [b]	87.18

Mean having different letters within column for the same factor are significantly different (P<0.05).

Feed intake:

Feed intake increased significantly with sandy soil more than loamy or clayey soil. On the other hand, there were positive relationship between fertilization and culture system with fish feed intake. It was highly significant (P<0.05) decreased with using fertilizer or polyculture. FCR and PER improved significantly with increasing clayey component of soil and with presence of fertilization and polyculture system (Table7).The best FCR was obtained from treatments in clayey soils (FCR, 1.27), while the poorest was for sandy soils (FCR, 1.88). Similarly, PER showed a similar pattern as for FCR.

Survival rate (%) of Nile tilapia and Grey mullet in different treatments showed insignificantly decrease for both species in clayey soil treatments to sandy soil ponds. Nevertheless, fertilization did not prompt significantly the survival rate (%) of cultured species regardless of the culture system used in all treatments of the present study. Moreover, the presence of *M. cephalus* in polyculture system triggered insignificant survival rate of Nile tilapia. Concurrently, survival rate for gray mullet decreased insignificant among the three soil types as the highest was with the clayey and the lowest was with the sandy soil.

Survival rate (%):

Table 6. Mean values of Final body weight (FBW, g/fish), feed consumption, feed conversion rate, protein efficiency ratio, and specific growth rate for Nile tilapia and Grey mullet in three soil types, clayey (C), loamy (L) and sandy (S), with fertilized (F) and unfertilized (U) treatments, in monoculture (M) and polyculture (P) systems.

	FBW (g/fish)		Feed Consumption	FCR	PER	SGR (%)	
	O. niloticus	*M. cephalus*	(kg/fish)			*O. niloticus*	*M. cephalus*
C	305.8±2.7[a]	684.5±58.1	7931.7±19[a]	1.27±0.2[c]	3.20±0.4[a]	1.67±0.01[a]	1.76±0.01
L	264.5±32[b]	606.77±64.3	7791.4±12[a]	1.50±0.2[b]	2.71±0.4[b]	1.61±0.00[a]	1.67±0.02
S	199.3±54[c]	600.73±98.1	5146.0±12[b]	1.88±0.7[a]	2.30±0.8[c]	1.49±0.04[b]	1.68±0.02
F	278.1±48[a]	789.22±66.5[a]	7155.0±19[a]	1.34±0.5[b]	3.07±0.5[a]	1.63±0.01	1.82±0.02
U	235.7±52[b]	472.11±69.1[b]	6757.8±11[b]	1.75±0.5[a]	2.40±0.7[b]	1.55±0.01	1.60±0.02
M	249.6±524[b]	000.0±0.0	6857.73±11[b]	1.72±0.5[a]	2.46±0.5[a]	1.58±0.01	0.00±0.00
P	263.5±52[a]	630.7±0.0	7055.0±16.1[a]	1.38±0.5[b]	3.01±0.6[b]	1.61±0.01	1.71±0.00

Mean having different letters within column for the same factor are significantly different (P<0.05)

Total yield (tons/feddan):

Results of the present study for total yield (TY) for Nile tilapia produced, regardless of fertilization and culture system, revealed that TY decreased significantly (P<0.05) from clayey to sandy soil. Accordingly, TY of grey mullet showed a similar but insignificant pattern for treatments of the 3 soil types. However, polyculture treatment species (Nile tilapia and Grey mullet) in fertilized treated ponds were found to have a significantly (P<0.05) higher TY than that of unfertilized pond treatments. Whereas, TY of *O. niloticus* was not effect significantly by culture systems, but the gross yield of both species combined in polyculture system was significantly higher than that of monoculture system. Thus, the revenue of the polyculture system was more profitable than that of monoculture system for the three soil types.

Discussion

Physico-chemical parameters (pH and temperature) did not fluctuate significantly during the study. This is indicative of a relatively stable ecosystem with the right conditions for fish productivity and could be considered an advantage for the ponds with respect to their management. The amount of DO, temperature and the pH are the most important physical-chemical features of the pond. (Ntengwe, 2008). Data collected for water temperature along the period of the study indicate that, different treatments, type of soil and adding fertilizers was within the considered range for fish growth. Boyd (1990) reported that water temperatures in ponds are related to solar radiation and air temperatures. Therefore, water temperatures generally are quite predictable by season and location. This explains the reason for the slight variations observed in water temperature was not a limiting factor throughout the experimental period of the present study. Although, DO throughout the present study was not affected by different treatments which ranged between 5.55 and 6.95 mg/l indicating that DO was not a critical variable in this experiment. The DO in the present study were above the normal tolerance of tilapia (>2.3 mg/L) is above the normal tolerance of tilapia. Diana *et al*.(1994) reported that events of low DO (less than 1 mg/L) were not correlated to total inputs in ponds (total amount of fertilizer and feed added) or to phytoplankton biomass, but rather occurred sporadically in ponds spanning the range of lowest to highest feeding rates. Also, Gray mullet can raise DO (Katz, 2002). The drop of DO to less than 4 mg/l might have a stressful effect on fish triggering problems as poor growth. Reproduction decreases and increases the susceptibility to diseases. Correspondingly, pH values were not affected by different treatments, which ranged between 7 and 9.2. This result may be attributed to the values of soil pH that did not differ significantly by locations. Similar results were obtained by Moustafa (2005) who stated that pH ranged between 8.05-8.6 with chicken litter treatment, while using organic fertilizer could help to stabilize water quality (Wurts, 2004). However, (TDS) in the present study with no significant differences between treatments for monoculture system illustrating the absence of bottom feeders (*M. cephalus*) achieved a higher TDS values. This finding could be explained by the increases of chlorophyll”A” and zooplankton population. This coincide with what El-Tawil (2006) found that TDS increased in fertilized ponds with increasing fish rearing rate. With respect to total alkalinity which was directly proportion to the clayey content of the soil was insignificantly different among treatments. This agree with what Boyd (1998) reported that with the increase of total alkalinity the natural fertility of pond water increases. On the other hand, Ntengwe (2008) disclosed that slightly alkaline ponds might be suitable for fish cropping particularly tilapia. Although, total hardness in the present study are showed the same trend as total alkalinity with no significant difference. Boyd (1990) indicated that hard water which had total alkalinity higher than 40 mg/L are generally more productive than soft water, which has total alkalinity less than40 mg/L. Thus, the high levels of alkalinity and hardness herein explains the stability of pH during the grow-out period all over the study. Also, alkalinity concentration is considered as evidence of inorganic carbon availability in fish pond waters which are important for photosynthesis. However, there were significantly differences in total ammonia and unionized ammonia in the present study; they were within the safe tolerable range. While Fromm (1970) declared that ammonia of 3 mg/L for trout became hyper-excitable, and at 8 mg/l is considered an LC_{50} for trout. The proportion of unionized ammonia is regulated by the pH and temperature of the water. Nevertheless, nitrate and nitrite concentrations showed insignificant differences among treatments. The highest values were recorded in clayey soil followed by loamy then the lowest were for sandy soil, and it was higher in fertilized pond and monocuture system than in unfertilized ponds or polyculture system. This result might be ascribed to variation in soil contents, also fertilizer process. The nitrate concentrations in the present study were similar to those reported by Ahmed et al. (2013) for monosex Nile tilapia ponds feed homemade feed in earthen mini ponds. Soil type and fertilized treatments had a positive effect on total phosphorus. It increased significantly for clayey soil than sandy. These finding was due to differences among soil in TP at different soil types. Diana and Lin (1998) found that total phosphorus concentrations ranged between 0.29 and 0.53 mg/l in ponds fertilized by chicken manure, urea and triple super phosphate with N: P ratio of 4: 1 by weight like the ratio used in the present study. That finding may be assigned to the presence of grey mullet which can consume phosphorus from sediment.(Lupatsch,2003).Orthophosphate concentration showed the same profile of total phosphorus. With regard to water visibility, chlorophyll a and number of zooplankton in the present study, results showed that, Secchi disk readings affected significantly by soil type, fertilization and culture systems treatments. The lowest SD visibility was noticed in clayey soil, and highest was for sandy soils and that demonstrates the increased density for chlorophyll a and zooplankton this treatments. These results may be ascribed to the variation among soil contents in basic nutrients used by phyto and zooplankton. Secchi disk visibility increased significantly with monoculture system however, chlorophyll a and number of zooplankton decreased. Thus, the presence of grey mullet in polyculture system which consume large amount of phyto and zooplankton (Katz et al., 2002). FBW for Nile tilapia and Grey mullet increased significantly with increasing clayey component of soil, implication of fertilization and with polyculture system. These may be attributed to variations in soil structural content disclosing an alteration between phyto and zooplankton in water among soil type. The present study findings corresponds with what Amer (2000) investigated for the effect of different polyculture ratios of striped mullet (*M. cephalus*) and Nile tilapia (*O. niloticus*) under the polyculture system in net enclosure. The author indicated that, with increasing the rate of mullet in the polyculture ratio, final body weight and weight gain of both striped mullet and Nile tilapia fingerlings decreased due to the inter specific competition between mullet and tilapia for food. Moreover, the increase in mullet ration affects its growth due the intra specific competition between mullet fingerlings. Amer (2000) found that the best mixture for high production was 70% tilapia and 30% mullet, which coordinates with the ratio of Grey mullet of the present study (≈30 %). Hickling (1996) reported that the pond bottom plays an important and indeed vital role in the production of fish. FCR and PER improved significantly with increasing clayey component of soil and with presence of fertilization and polyculture system. The findings herein might be endorsed to increasing natural food with increasing clay content of the soil. Similar findings were observed by El- Sayed (2006) where FCR improved better with polyculture than with monoculture system. On the other hand, Shrestha and Lin (1996) found that maximum net fish yield 4.2 g/m^2/day was obtained at a soluble reactive phosphorus concentration of 0.3 mg/L, higher concentration rates did not increase fish yield. Vererica *et al.* (2000) reported that maximum gross fish yield was obtained at soluble reactive phosphorus 1.2 and 1.3 mg/L in cool and warm season, respectively. Therefore, phosphorus must be applied in fertilizers to maintain productivity (Boyd, 1998).

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