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IMPROVEMENT OF FISH PRODUCTION AND WATER QUALITY IN TILAPIA CULTURED PONDS BY USING DIFFERENT TYPES OF ARTIFICIAL DIETS AND ORGANIC FERTILIZERS

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SUMMARY

Feeding trials were conducted to evaluate the influences of the supplementary diets and organic fertilizers on fish production and water quality in tilapia cultured ponds. Tilapia species (*Oreochromis niloticus*) fingerlings with an initial weight ranged from 16.36 to 16.79 gm was reared in earthen ponds (3 feddans each) at a rate of 6300 fish / fed. (1.5 fish/m^2) during a period of 214 days. The cultured fish were fed on three artificial diets (25.0-30.0 % protein) composed of different feed ingredients. Ponds 2,3 were fertilized with two levels (low, high) of organic fertilizers (manure).

The experiment indicated that, the daily weight gain reached its highest value (1.69 gm/fish) in pond 1 (fed only on diet 1) and total fish production was 2.209 tons/feddan (5.256 tons /hectar) for fish fed on the same diet. These values slightly decreased to 0.77 gm / fish/day and 2.370 tons / ha in pond 3 (fed on diets 3 with high level of fertilization). Meanwhile the profit index has its maximum value (2.00%) for fish reared in pond 2 (fed diet 2 with low level of fertilization). Food conversion ratio has the values of 2.11, 2.25 and 2.42 at the three treatments respectively. With respect to fish body composition, the maximum value of crude protein (70.21 %) was observed in fish fed diet 1, ether extract was not affected in the three treatments. While ash content and dry matter reached its highest values (26.95% and 29.66%) in fish of pond 3. In case of water quality, it was noticed that the water temperature, pH value and salinity throughout the rearing period

increased gradually from pond 1 to pond 3 in which these values are 31.9°C, 8.6 and 11.8 ppt., while the dissolved oxygen has its maximum value (9.2 mg/L) in pond 1 (feeding only without fertilization).

INTRODUCTION

Fish production is considered as one of the main sources of animal protein in developing countries including Egypt. Tilapias surpass other species for culture because of their higher tolerance to adverse environmental conditions and they can breed more than one time in the year (Green et al., 1990). Nile tilapia (*Oreochromis niloticus*) is a popular food fish in many tropical areas due to its fast growth under a wide variety of ecological conditions (Brummett and Alon, 1994). Increasing intensification of culture methods for tilapia species in recent years depend to a large extent on supplementary feeding. Fish as well as other animals require balanced diets containing certain levels of protein, fats, carbohydrate, vitamins and minerals (Sweilum, 1998).

The dietary protein requirements of several species of tilapia have been estimated to range between 20 % and 56 % (Al-Hafedh, 1999). In addition, the same author mentioned that the formulation of tilapia diets containing different protein levels depend mostly on the principle feed ingredients as fish meal, soybean meal, meat and bone meal. While, Bureau et al., (1999) reported that the use of these ingredients which are usually limited, or even avoided for various reasons such as poor digestibility and quality variability. Therefore, better manufacturing practices appear to be currently in use and recent studies have shown that feather meal, meat and bone meal are relatively digestible in rainbow trout (Bureau et al., 2000).

On the other hand, addition of organic fertilizers (animal manures) to tilapia cultured ponds stimulate the heterotrophic production, thus increasing the growth rate and fish production in tilapia ponds (Green et al., 1989). Similarly, Njoku (1997) found that poultry droppings applied to fish ponds at a rate of 5000 kg / hectar / year gave best yield for *O. niloticus* and optimum tolerance levels of physico-chemical parameters of water for fish growth. Green et al., (2002) studied evaluation of Nile tilapia ponds by using manures and chemical fertilizers with artificial diets and noticed that, Nile tilapia yields, with organic fertilization plus formulated feed treatments, were significantly greater than the yield from formulated feed or fertilization alone. The purpose of the present study was to evaluate the influences using supplementary diets and manures in the Nile tilapia ponds on fish production and water quality in these ponds.

MATERIALS AND METHODS

Site of work and fish used .

The experimental work was conducted in a private fish farm near Shakshouk Research Station

El-Fayoum. The fish farm included 4 earthen ponds, the first pond has a surface area of one feddan and served for nursery and storage of the small fish, while the other 3 ponds (rearing ponds) have an area of 3 feddans for each and these ponds contained a clay bottom. In these ponds, water was maintained at 1.5 meters depth and the water column was drained / pond at a rate of 1/24. The rearing fish (*O. niloticus*) with an initial size of 9.7 cm total length and 16.5 gm body weight were stocked in ponds at a density of 6300 fish / feddan (1.5 fish / m2).

Feed supply and fertilization .

The reared fish were fed on three different artificial diets formulated from different feed ingredients as shown in table (1). The experimental diets were supplied to the fish ponds as pellets using California Pellet Meal (CPM) machine. The fish in pond 1 fed on the 1st diet (containing fish meal, meat meal and soybean) fish in pond 2 fed on the 2nd diet (composed of corn gluten, molass and soybean meal); and fish in pond 3 fed on the 3rd diet (formulated from sorghum grains, bread by-product and soybean). Ponds 2, 3 were fertilized with a mixture of poultry and cows manure (2:1) at two different levels (1.5 m^3 and $3m^3$ / fed./month). The experimental treatments were; in pond 1, the fish fed on 30 % dietary protein level without fertilization, in pond 2 fed on 25 % dietary protein with low level of fertilization, while those in pond 3, were fed on 25 % protein level with high rate of fertilization. The supplementary food was added to the rearing ponds 29 days per month at a level of 3 % of fish body weight, twice per day (9 am and 3 pm).

Sample collection and chemical analysis .

Water quality was measured from the experimental ponds during the rearing period (from 1st April to end of October, 2002) as follows; water temperature was measured daily using simple thermometer. Dissolved oxygen was monitored also daily by using oxygen meter Cole Parmer Model 5946; pH value was estimated daily using Orian digital pH meter model 201. The total salinity was determined as a part per thousand (ppt) from the rearing ponds biweekly using Orion 105 salinometer.

The chemical analysis of fish bodies, supplementary diets and organic manures were carried out according to AOAC (1984) methods. The measured growth parameters included percentage weight gain (PWG) and specific growth rate (SGR). Net fish production (NFP) and food conversion ratio (FCR) were calculated according to the following equations;

PWG = Final weight - Initial weight / Initial weight.

SGR = Ln final weight - Ln initial weight / Period x 100.

NFP = Fish weight at harvesting / fed. - Fish weight at the start/fed.

FCR = Feed intake / Weight gain.

Economic efficiency and statistical analysis .

The final cost and profitability of rearing fish (*O. niloticus*) in each pond were determined according to the method described by Mohamed (1998) as follows:

Profit index = Price of fish produced per pond / Feed cost per pond.

The means of experimental results were statistically analysed using T. test and F.test of significance as mentioned by Berlly and Lindgren (1990) with applying the following equations;

$$T. \text{ Calculated value} = \bar{X}_1 - \bar{X}_2 / \frac{SD_1}{\sqrt{n_1}} + \frac{SD_2}{\sqrt{n_2}}$$

F. calculated value = Mean square to treatment / Mean square to error.

RESULTS AND DISCUSSION

Water quality in this experiment was assessed by using four parameters; water temperature, dissolved oxygen, pH value and total salinity which are considered as the usual limiting factors in local fish ponds and gave different values with experimental treatments (Table 2).

The present measures indicated that, water temperature was increased from 23.3°C in pond 1 (Feeding only without fertilization) to 25.3°C in pond 3 (feeding on diet 3 with high level of fertilization) at the same time. Similarly, pH value and total salinity reached its highest values (8.6 and 11.8 ppt) in pond 3 (feeding with high fertilization) and these values decreased in ponds 1, 2 (feeding only or feed with low fertilization). In contrast, the dissolved oxygen was decreased in the case of feeding with high rate of fertilization (pond 3) while its values increased to 9.2 and 8.8 mg/L in ponds 1, 2. Bombeo-Tuburan et al. (1989) studied the evaluation of organic and inorganic fertilizers in milkfish ponds and found that, the ponds applied with chicken manures at a high concentration showed depletion of dissolved oxygen and increasing of temperature, pH and salinity. Further, Shevgoor et al. (1994) mentioned that dissolved oxygen concentrations declined to neer 0 mg/L at higher manure loading rates. Similarly, Njoku (1997) reported that at rearing *O. niloticus* when the ponds were supplied with pelleted feed and fertilized by high rate of poultry droppings (7500 kg/ha/year), the values of dissolved oxygen were significantly decreased. On the other hand, at low rate of fertilization (2500 kg/ ha/year) the dissolved oxygen were gradually increased.

As shown in table (3), the maximum values of percentage weight gain (21.57%) and specific growth rate (1.48%) of *O. niloticus* were obtained from fish reared in pond 1 (feeding only on diet 1 without fertilization) . While the minimum values (9.72 , 1.12% for PWG and SGR) were recorded in pond 3 (feeding on diet 3 with high level of manure). However in pond 2 (feeding on

Table (1): Composition of the experimental diets containing different feed ingredients and fed to Nile tilapia in the rearing ponds.

Ingredients	Diet 1		Ingredients	Diet 2		Ingredients	Diet 3	
	Wt (gm %)	Pro. (%)		Wt (gm %)	Pro. (%)		Wt (gm %)	Pro. (%)
Fish meal	12	7.9	Corn gluten	5	1.1	Sorghum grains	18	1.6
Meat meal	12	7.4	Molass can	5	-	Bread by-product	2	0.2
Soybean meal	20	9.2	Soybean meal	42	19.4	Soybean meal	42	19.4
Yellow corn	25	2.2	Yellow corn	20	1.8	Yellow corn	10	9.0
Wheat bran	11	1.3	Wheat bran	10	1.2	Wheat bran	10	1.2
Rice bran	12	2.0	Rice bran	10	1.7	Rice bran	10	1.7
Fish oil	2	-	Fish oil	2	-	Fish oil	2	-
Di-ca-phosphate	2	-	Di-ca-phosphate	2	-	Di-ca-phosphate	2	-
Ca-carbonate	1	-	Ca-carbonate	1	-	Ca-carbonate	1	-
Vit & Min premix*	3	-	Vit & Min premix	3	-	Vit & Min premix	3	-
Total	100	30.0	Total	100	25.0	Total	100	25.0

*** One Kg of premix contained.**

Vitamins: 48 x 10^4 IU vit. A, 8 x 10^5 IU vit. D_3, 144mg vit, E, 400mg vit B1 1600mg vit. B_1, 1600mg vit B_2, 600mg vit. B_6, 4mg vit B_{12}. 20mg Biotin, 400 mg Folic acid and 400mg Niacin.

Minerals: 12000mg Iron, 16000mg Manganese, 1200mg Copper, 120mg Iodine, 16000mg Zinc, 80mg Cobalt and 40 mg Selenium.

Table (2): Average values of water quality measures in the three treatments during the rearing period from 1st April to the end of October, 2002 (Ponds 2,3 were fertilized)

Items		April	May	June	July	August	September	October
Water temperature (°C)	Pond 1	23.3	27.8	28.1	30.2	31.0	29.5	28.7
	Pond 2	23.6	28.4	28.3	30.3	31.1	29.7	28.9
	Pond 3	25.3	29.0	28.4	30.7	31.5	29.7	29.2
Dissolved oxygen (mg/L)	Pond 1	5.9	6.2	6.9	6.6	6.0	9.2	8.9
	Pond 2	5.6	6.2	6.8	6.9	6.2	8.5	8.8
	Pond 3	5.3	6.5	6.6	6.2	5.2	8.4	7.9
pH value	Pond 1	7.9	8.2	8.1	8.3	8.5	7.9	7.8
	Pond 2	8.1	8.3	8.2	8.3	8.5	7.9	7.9
	Pond 3	8.3	8.6	8.3	8.3	8.6	8.0	7.9
Total salinity (ppt)	Pond 1	5.6	7.1	8.8	9.9	9.4	7.4	4.7
	Pond 2	5.4	6.9	9.1	10.9	10.6	7.6	5.3
	Pond 3	6.6	7.6	11.4	11.8	10.8	8.6	5.3

Table (3): Growth performance and body composition of *Oreochromis niloticus* in the three ponds after a period of 214 days (7 months).

Items	Pond 1 fed on diet 1 (Without fertilization rate)		Pond 2 fed on diet 2 (Low fertilization rate)		Pond 3 fed on diet 3 (High fertilization rate)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Initial weight/fish (gm)	16.00-16.80	16.40±0.57	16.10-16.60	16.35±0.35	16.30-17.20	16.75±0.64
Final weigh/fish (gm)	3250-417.0	371.0±65.7	220.0-265.0	242.5±31.8	155.0-200.0	177.5±31.8
Gain in weight/fish (gm)	308.90-400.20	354.6±64.5	203.9-248.4	226.2±31.5	138.7-182.8	160.8±31.2
Daily weight gain/fish (gm)	1.47-1.91	1.69±0.31	0.97-1.18	1.08±0.15	0.66-0.87	0.77±0.15
Percentage weight gain, PWG	19.31-23.82	21.57±3.19	12.66-14.96	13.81±1.63	8.81-10.62	9.72±1.28
Specific growth rate, SGR	1.43-1.53	1.48±0.07	1.24-1.32	1.28±0.06	1.07-1.17	1.12±0.07
Grude protein, CP (%)	69.22-71.20	70.21±1.40	70.16-70.20	70.18±0.03	63.30-63.80	63.55±0.35
Ether extract, EE (%)	8.40-10.60	9.30±1.56	9.20-9.40	9.30±0.14	9.20-9.80	9.40±0.42
Ash content, AC (%)	20.18-20.40	20.29±0.16	20.44-20.60	20.52±0.11	26.40-27.50	26.95±0.78
Dry matter, DM (%)	24.30-24.71	24.51±0.29	24.60-24.70	24.60±0.07	29.20-30.12	29.66±0.65

Comparison between means of the previous results using t. test

Items	Calculated values						Degree of freedom	Tabulated values		
	Pound 1 with pond 2		Pound 1 with pond 3		Pound 2 with pond 3					
	Value	Sign.	Value	Sign.	Value	Sign.		0.05	0.01	0.001
PWG	4.26	**	7.01	***	3.72	***	n+n2-2	2.18	3.06	4.32
SGR	4.00	**	9.00	***	3.20	***	= 7+7-2			
CP	0.06	*	10.09	***	47.36	***	= 12			
EE	0.31	*	0.13	*	0.48	*				

* Insignificant ** Significant *** Highly significant

Table (4): Total production, survival rate and profitabilityof ***Oreochromis niloticus*** in the three ponds after a period of 214 days (7 months).

Items	Pond 1 fed on diet 1 (Without fertilization rate)	Pond 2 fed on diet 2 (Low fertilization rate)	Pond 3 fed on diet 3 (High fertilization rate)
Gain in weight/ fish (gm)	354.60	226.15	160.75
Total gain in weight/pond (ton)	6.627	4.220	2.987
Number of fish/pond	18900	18900	18900
Number of fish survive	18690	18660	18580
Survival rate (%)	98.89	98.73	98.31
Total production, T.P/hectar (ton)	5.256	3.349	2.370
Production/feddan (ton)	2.209	1.407	0.996
Harvest/m^2 (kg)	0.526	0.335	0.237
Total food given/pond (ton)	13.971	9.486	7.230
Food conversion ratio	2.11**	2.25**	2.42**
Profit index (P.I)	1.71**	2.00**	1.86**

F. test of significant between differences of the results.

Source of variation	Pound 1 with pond 2		Pound 1 with pond 3		Calculated values		F. values			
							Calculated		Tabulated	
	T.P	P.I	T.P	P.I	T.P	P.I	T.P	P.I	T.P	P.I
Treatment	2	2	28.40	2.10	14.20	1.05				
Error	18	18	0.38	0.49	0.02	0.03	7.10	35.0	3.55	6.01
Total	20	20	28.78	2.59	1.44	0.13				

* Price of one Kg fish was 4.5 L. E. and one Kg pelleted feed was 1.25 L.E diet 1 and 1.00 L. E. for diets 2, 3.

diet 2 with low level of organic fertilization) showed an optimum values for these growth responses. This may be attributed to that, in pond containing high level of manure, the dissolved oxygen decreased to 5.3 mg/L and pH value increased to 8.3, consequently the growth rates of rearing fish decreased (Bombeo-Tuburan et al., 1989). The same observations were also detected by Shevgoor et al. (1994), Njoku (1997) and El-Shandweily (1999) in their studies on the effect of different levels of poultry manures on growth performance of *O. niloticus*. Table (3) indicated also that, the means of PWG and SGR in the three ponds (treatments) were statistical analysed by T. test and showed significant differences ($P < 0.01$) between them.

With respect to the body composition of reared fish, it was noticed that the maximum value of crude protein (70.21 %) was recorded in fish reared in pond 1 (feeding only on diet 1) and the minimum value (63.55%) was observed in pond 3 (feeding on diet 3 with high level of fertilization). While other body components (ether extract, ash content and dry matter) reached its highest values (9.40%, 26.95% and 29.66 %) in pond 3 (pelleted feed with organic fertilization). The comparison between means of these components by T. test showed that, the differences of ether extract (EE) between the three treatments were insignificant differences ($P > 0.05$). While crude protein (CP) cleared insignificant difference ($P > 0.05$) between pond 1, pond 2 and highly significant ($P < 0.001$) of other differences. These differences were mostly due to the types of feed ingredients (dietary protein levels) and different rates of organic fertilization. Osman (1991) using different dietary protein levels (20, 25 and 30 %) with different carbohydrate levels (48, 55 and 62 %) from several types of food ingredients for rearing tilapia species and found that, body protein increased by increasing dietary protein level and decreasing carbohydrate level. Eid (1995) mentioned that, body fat was higher with wheat and bread meals and lower with corn starch, while body protein was not affected with different these ingredients.

On the other hand, Table (4) indicated that the total fish production (production / fed. and harvest / m2) reached its highest values (2.209 tons /fed. and 0.526 kg/m2) for fish reared in pond 1 (feeding only on diet 1). While, its lowest values (0.996 ton/fed. and 0.237 kg/m2) were observed in pond 3 (feeding on diets 3 with high level of organic fertilization). The values of total production (T.P.) were comparable and varied significantly ($P < 0.01$) in different treatments. These results coincide with that postulated by Green et al. (1989) and (1990) when used chicken litter as organic fertilizer in *O. niloticus* ponds. Similarly Green (1992) who used pelleted feed only (23% CP) and pelleted feed with high level of organic manure (1000 kg/ha/week) and noticed that the fish net yield / ha decreased to 3654 kg (3.65 tons) in the second treatment.

In contrast, Njoku (1997) and El-Shandweily (1999) mentioned that in ponds supplied with pelleted feed and optimum rate of organic fertilizer (poultry manures) the net yield of rearing fish reached its highest values. Green et al. (2002) also reported that, Nile tilapia (*O. niloticus*) yields in organic fertilization plus formulated feed supplementation were significantly greater than the yield obtained from the other treatments (feeding only or fertilization only).

In case of the profitability of fish farm, table (4) showed that the profit index (a relation between price of fish produced and feed cost) reached its highest value (2.00%) in pond 2 (feeding on diet 2 with low level of fertilization), while its lowest value (1.71%) was recorded in pond 1 (feeding only without fertilization), these values varied significantly ($P < 0.01$) from pond to other in the fish farm. The previous values of profitability were obtained by considering the average price of one kg fish was 4.5 L.E. and the cost of one kg pelleted feed was 1.25 L.E. for diet 1 and 1.00 L.E. for diets 2, 3. Such costs and profitability of rearing ponds were closely near to that obtained by AOAC (1995), Njoku(1997) and El-Shandweily (1999) in their studies on economic efficiency of *O. niloticus* in earthen ponds.

In conclusion, rearing of Nile tilapia (*O. niloticus*) in earthen ponds (fish farm) at a density of 15000 fish /ha and fed on pelleted diets (25 % protein level) with low level (1.5m3/fed./ month) of organic fertilization (mixture of poultry and cows manures) gave the best growth rate and optimum fish production with high level of profitability.

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