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Productivity and economics of rotated culture of Nile tilapia (*Oreochromis niloticus*) fingerlings with wheat and clover under semi-intensive culture system in earthen ponds

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ABSTRACT

This study was designed to investigate the effect of rotated fish culture with field crops (wheat and clover) under semi-intensive production system in the earthen fish ponds on growth performance, water quality parameters, chemical composition of whole body, yield of clover and wheat as well as the economical profit. Experimental fish were randomly distributed in three experimental treatments with three replicates each (control, fish rotated with wheat and fish rotated with clover) reared in earthen ponds. The experimental ponds stocked with 240 Nile Tilapia (*Oreochromis niloticus*) fingerlings (4 fish/m^2) with an average initial weight of 40.21g in nine earthen ponds each of $60m^2$ ($5\times12m^2$). The study lasted from May 2014 to April 2015. Fish culture extends from May to September 2014, while crop culture extends from October 2014 to April 2015. Experimental fish fed on a commercial diet containing 30% protein and 4291Kcal /kg diet, with 3% feeding rate of total fish biomass/day for 6 days a week and the diet was introduced twice-daily at 9.00 am and 2.00 pm.

Results obtained showed no significant differences between the three treatments with respect to growth performance of the fish, while there was an increasing in soil properties after the end of fish culture as well as increase in crops productivity. Also, it was found that rotated tilapia culture with wheat was more profitable than that with clover or and is profitable than control treatment.

Key words: Productivity, economics, rotated culture, Nile tilapia, *Oreochromis niloticus,* fingerlings, wheat, clover, semi-intensive culture, earthen pond.

INTRODUCTION

Fish is one of the most important sources of animal protein available, and has been widely accepted as a good source of protein and other elements for the maintenance of a healthy body (Arannilewa *et al*., 2005). In Egypt the domestic government have seeked to increase per capita animal protein through increasing fish production with the possibility of accessibility at a price low for consumers (Hussein *et al*., 2016).

Aquaculture is the production of protein-rich foods through the controlled cultivation and harvest of aquatic animals and plants. Aquaculture is a fast growing industry, which represented one third of the world fisheries production in 2003 (Lowther, 2005). In Egypt, the fish production from aquaculture represents about 76.73% of the total fish production sources (GAFRD, 2014). In Egypt aquaculture is variable and of many methods and either monoculture or integrated either with plant and/or animal species (Salah, 2003).

Integrated fish farming can be broadly classified into two, namely: Agriculture-fish and Livestock-fish systems. Agri-based systems include rice-fish integration, horticulture-fish system, mushroom-fish system, and Seri-fish system. Livestock-fish system includes cattle-fish system, pig-fish system, poultry-fish system, duck-fish system, goat-fish system and rabbit-fish system (FAO, 2013).

Field crops-fish culture can really increase crops amounts while providing farmers with an important source of protein and additional income. Rotated fish culture showed a perfect layout for profiting maximum outputs of land, water and human power. The culture system develops the productivity of poor lands and water to produce valuable animal protein and winter field crops such as wheat and clover (El-Gendy and Shehab El-Din, 2011).

In Kafr El-Sheikh governorate, Egypt, a total area of 110413 Feddan of heavy soil are cultured with fresh water fish species like Nile tilapia, mullet species and carp species during the period from April to November annually (GAFRD, 2014). This area remained unused during the period from November to April next year which represents the winter season with cold-water temperature which is not suitable for fish growth. If this area is cultivated with winter crop like wheat and clover after the proper preparation and treatments of the pond soil, this area will produces 281553 ton of wheat yearly or will produces 4134414 ton of clover yearly which could increase the income of the fish farmer. Thus, one feddan could produce 2550 kg wheat or 37445 kg clover yearly. This system considered as an integrated use of fish earthen ponds for producing an extra crop during the period where no fish are cultured.

The aim of the present study is to give high lights on the possibility of integrating and use of fish earthen ponds after harvesting of fish to grow agriculture crops. Also, it aims to investigate the impacts of such system on the income of the fish farmer in Kafr El-Sheikh governorate, Egypt.

MATERIALS AND METHODS

Study Area:

This field experiment was conducted in a private fish farm affiliated in the area of village 6, Riyad city, Kafr El-Sheikh Governorate, Nile Delta district at the Northern side of Egypt, during the production season (2014).

layout of the Experiment:

The experimental layout was arranged according to a randomized complete block design for three treatments with three replicates, divided into two seasons during one year. The First season was fish culture for all treatments from May to September, while the second season was crop cultivation with field winter crops from October to April in the next year. The treatments with their replicates were applied in 9 rectangular earthen ponds, each of $60m^2$.

All Treatments in this study were designed as following (Table 1):

Treatment 1 (T1): (control) fish culture in season one (summer) only.

Treatment 2 (T2): fish culture in season one, and cultivated with wheat crop in winter (season 2).

Treatment 3 (T3): fish culture in season one, and cultivated with clover crop in winter (season 2)

Table (1):The experimental layout during one year (Fish culture during summer and crop production during winter).

Culture type / season	T1	T2	T3
Fish /summer	Fish	Fish	Fish
Crops / winter	-	Wheat	Clover

The experiment during the first season (fish culture)

The trial during the first season lasted for 112 days, started from 22 May, 2014 and harvested at 11September, 2014.

Experimental ponds:

The experimental ponds were designed in nine longitudinal earthen ponds of equal area (60 m^2 each). All ponds have dimensions 5x 12 m^2 x 2 m^2 average depth. The experimental ponds before begining stocked with fish were completely drained,weeded and their bottom was exposed to sun radiation for 30 days. After complete dryness, the experimental ponds were filled with water and after 7 days, the experimental fish were stocked.

Experimental ponds water supply:

The water volume in each pond was about 105 m^3 (5×12 and 1.75 m average water depth) stocked by mono-sex of Nile tilapia fingerlings. During the experimental period, water was replaced with new water at a rate 30% of the water column daily using water pumps to obtain a suitable water quality.

The farm water source :

It was mainly agricultural drainage water and that from Aldramally 3 Abu Arab drainage canal. The experimental ponds were supplied with water using pumps while drainage was maintained by gravity. All ponds were provided with an inlet and outlet water gates (pipes) covered with narrow mesh screens to prevent unwanted fish or predators to get into ponds and escaping the stocked fishes during the drainage process of water.

Seven days prior to fish stocking, ponds were filled to the level of 50 cm. Ponds water level was increased to reach the maximum target column of 175cm. After ponds dried, soil was ploughed and flatted. All ponds had a water inlet and water outlet gates through which the water level was controlled.

Experimental fish and Stocking rate (First season).

Mono sex fingerlings Nile tilapia *O. niloticus* was used and were obtained from the Egyptian Aquaculture Center for Training and Applied Research in Hamoul city, Kafr El-Sheikh in May 2014. The experimental fish were transported at early morning using a special fish transport car with aeration facilities. Fish were adapted to the experimental system condition for 7 days before starting the experiment. fingerlings were stocked at an average initial total body weight of 40.21 g/fish and an average initial total body length of 12.23 cm/fish for all treatments. Fish samples were taken weekly (10 fish per pond) and weighed to re-adjusting feeding rate according the new weights. Fish were returned back to the corresponding ponds after recording the body weight and body length. All ponds were stocked the same rate (240 fingerlings) consistent to the rate of 16800 fish/feddan.

Experimental diets and Feeding rate(First season).

Fish fed during the whole experimental period (112 days) on a commercial fish diet which was purchased from the Hendrix Misr Industrial Company located in 10^{th} Ramadan City.The experimental diets were in the form of pelleted floating diets with a diameter 3mm and containing 30.19% crude protein and 4287 Kcal/kg gross energy (Table 2).

Table (2): Proximate chemical analysis (%) of the experimental diet used in the present experiment.

Proximate analysis (% of dry weight)	
Moisture	9.48
Dry matter	90.52
Crude protein	30.19
Ether extract	3.97
Ash	8.35
Crude fiber	3.71
*Nitrogen free extract	53.78
**Gross energy (Kcal/kg)	4287.85

*Nitrogen Free Extract calculated as: 100-% (Protein + Lipid + Ash + Crude fiber).
GE (gross energy) calculated using the values 5.64, 9.44 and 4.11 Kcal GE/g DM of protein, fat and carbohydrate, respectively **(NRC, 2011).

Fish in the three treatments fed on the commercial diet six days per week at feeding rate of 3% of the fish biomass. The daily diet was given twice daily at 9.00 am and 2.00 pm during the whole experimental days.

The ingredients of the experimental diet were soybean meal 48%, wheat middling, soy oil, corn gluten meal 60%, Rice bran, Mono-calcium phosphate, corn yellow grain, salt, premix, minerals[1] and vitamins mixtures[2] .

([1]Mineral premix(as g/kg premix): $CaHPO_4.2H_2O$ =727.8 ; $MgSO_4$. H_2O =127.5 ; Kcal= 50.0 ; NaCl =60 ; Fe $SO_4.7H_2O$ = 25 ; $ZnSO_4$. $7H_2O$ =505 ; $MnSO_4.4H_2O$ =2.53 ; $CuSO_4$.=5 0785 ; $CoSO_4$.$7H_2O$ =0.4775 ; Ca LO_3. $6H_2O$ = 0.295 ; Cr CL_3. $6H_2O$ = 0.1275.

[2]Vitamins mixture contained (as g/kg premix): Thiamine =2.5 ; Riboflavin =2.5 ; pyridoxine =2.0 ; Inositol =100.0 ; Biotin =0.3 ; Pantothenic acid =100.0 ; folic acid =0.75 ; Para-aminobenzioic =2.5 ; Choline =200.0 ; Nicotinic acid =10. Cyanocobalmine =0.005 ; Tocopherol acetate =20.1 ; Ascorbic acid =50.0 ; Menadione =2.0 ; Retinol palmitate =100.0 IU ; Cholecalciferol =500.0 IU).

Water quality measurements.

During the experimental period, water was changed and renewed at a rate 30% of the water column daily to obtain the appropriate water quality using a water pump. All water samples were taken every 7 days during the experimental period from 9.00 to 10.00 am. Samples were collected from two fixed places at 30cm of water coloumn surface at each pond, then mixed together. Smples were analyzed within two hours after collection. Some parameters such as (dissolved oxygen, pH, water temperature and salinity) were measured at the field. Five milliters of chloroform were added to each bottle sample as a conserving for laboratory analysis (Ammonia, Nitrite and Nitrate).

Field analysis:

Dissolved oxygen (DO mg/L), pH values and water temperature (°C) were measured *in situ* (between 9.00 to 9.30am) twice weekly using the Orion Portable pH Meter (Thermo

Scientific Orion 5-Star Plus, Thermo Fisher Scientific Inc., Beverly, MA, USA) according to China State EPA (2002).

Salinity was measured daily by using Milwaukee Salinity Refractometer model (MR32ATC - Brix Refractometer) range from (0-32 Brix) according to Tigchelaar EC(1986).

Laboratory analysis.

A sample of water (1litre) from each pond was taken (at 9.00 to 10.00 am) weekly and transferred to the laboratory for the following measurements:

Ammonia (NH_3-N).

Ammonia was measured by using Ammonia (Low Range) Martini Instruments (Mi 407) range from (0.00 – 3.00 mg/l) according to Thompson *et al*. (1951).

Nitrite (NO_2 -N mg/L).

Nitrite was measured by (nitricol) model LP-55 code 3274 Lamotte company range from 0.2 - 0.8 ppm.

Nitrate (NO_3-N mg/L).

Nitrate-nitrogen was measured by using phenoldisulphonic acid method, using spectrophotometer (Model Milton Roy 21D), at a wavelength of 410 nm according to APHA, (1998).

Biological evaluation of fish growth performance:

Fish from each pond were measured separately for weight and length every 7 days and at the end of the 16-week trial. Final harvesting was made through draining of water-by-water pump. Besides, growth performance parameters and feed utilization for each treatment at the end of the culture period were calculated as described by Sveier *et al*. (2000) as follows:

Growth performance parameters:

Fish growth performance, weight gain, length gain, daily weight gain, specific growth rate, relative growth rate, condition factor and survival rate were determined by the following equations:

Body weight gain (BWG):

Weight gain was estimated as follows;

Body weight gain $= Wt_1 - Wt_0$

Where:-

Wt_1 = Mean final weight (g)

Wt_0 = Mean initial weight (g)

Length gain (LG):

Length gain was estimated as follows;

Length gain $= Lt_1 - Lt_0$

Where:-

Lt_1 = Mean final Length (cm)

Lt_0 = Mean initial Length (cm)

Daily weight gain DWG (g):
DWG was estimated according to Green *et al*. (2002) as follows;
DWG =Average weight gain (g) /Experimental period (day).

Specific growth rate (SGR)% growth/day:
Specific growth rate (SGR) was estimated according to Green *et al*. (2002) as follows:

$$SGR = \frac{Ln\ W_t - Ln\ W_o}{T} \times 100$$

Where:-
Ln = the natural logarithm
W_t = weight (g) at the end of the experimental period.
W_o = weight (g) at the beginning of the experimental period.
T = period of experimental (day).

Relative growth rate (RGR):

$$RGR = \frac{\text{Total weight gain (g)}}{\text{Initial weight (g)}} \times 100$$

Condition factor (k):
Condition factor was estimated according to Hung *et al*.(1993) as follows:

$$K = (W / L^3) \times 100$$

Where:-
K= Condition factor, coefficient of condition or Ponderal index.
W= total weight of fish in grams
L= total length of fish in cm.

Survival Rate (%)
It was calculated according to Harrel *et al*. (1990)

Survival Rate (%) = $N_1 / N_0 \times 100$

Where,

N_1 = Total number of fish survived in pond at end of experiments.
N_0 = Total number of fish in tank at the beginning of experiments.

Feed efficiency parameters:
Feed conversion ratio (FCR):
Was described by the equation:
FCR = total feed consumed by fish (g)/ total weight gain per fish (g)
As reported by De Silva and Anderson (1995) FCR gives the weight of food required to produce a unit of weight gain of fish.

Protein Efficiency Ratio (PER):
It was described by the equation:
PER = live weight gain / protein intake

PER indicates the weight of fish produced per unit weight of dietary protein intake as reported by De Silva and Anderson, (1995).

Protein productive value (PPV):
PPV (%) = [(PR1– PR0) / PI] 100
Where: PR1 = is the total fish body protein at the end of the experiment (on dry matter basis).
PR0 = is the total fish body protein at the start of the experiment (on dry matter basis).
PI = Protein intake.

Harvesting of fish

At the end of the experimental period, water was pumped out of the pond and all fish from all experimental ponds were harvested, weighed in kilograms and counted. The individual body weight and the total fish weight were taken. The total length of each fish was measured to the nearest mm.

Gross yield of fish (GY):
Gross yield of fish was estimated as follows:
GY = harvested fish weight (kg)/Pond .

Chemical analysis of feed and whole fish body composition.

At the starting of the experiment, the feed was exposed to the chemical analysis while at the starting and the end of the experiment, 9 fish from Nile tilapia (*O. niloticus*) were exposed to the chemical analysis of whole fish body. Dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash content of diets and fish were determined according to the methods described byAOAC (2010). Dry matter after drying in an oven at 105°C until constant weight; ash content by incineration in a muffle furnace at 600°C for 12 hrs in a muffle Furnace; crude protein (N × 6.25) by kjeldhal method after acid digestion; ether extract by petroleum ether (60-80°C) extraction ; fiber by drying and ashing after extraction with 0.5 μH_2SO_4 and 0.5 μNaOH ; nitrogen free extract (NFE) and gross energy were calculated by differences.

The second season (crops culture)

At the end of the fish culture and after harvesting of fish has been initiated in the cultivation of field crops.

Wheat crop:

Wheat cultivation lasted for 157 days started at the 15^{nd} of November 2014 and harvested at 22^{nd} April 2015. Seeding rate used in the cultivation of Wheat was (60 kg seeds/ fed).

Gross yield of wheat:
Gross yield of wheat = harvested wheat weight (kg)/Pond after estimated straw weight .

Egyptian clover crop:-

Egyptian clover cultivation lasted for173 days started at the 20^{nd} of October 2014 and harvested at 12^{nd} April 2015. Seeding rate used in the cultivation of Egyptian clover was 45 kg seeds/ fed.

Gross yield of clover:
Gross yield of clover = harvested clover weight (kg)/Pond.

Economic analysis

Economic analysis was conducted to determine economic returns. The analysis was based on market prices in Egypt for harvested fishes and all other items, which were expressed in (LE); Egyptian pound as was in season (2014). The following simple equation was used to calculate the net return according to Asaduzzaman *et al.* (2006).

R=I-(FC+VC+Ii)
Where,
R= net return,
I=income from mono sex tilapia sale,
FC=fixed common costs,
VC=variable costs and
Ii=interest on inputs

Statistical analysis.

All the data collected during the experiment were recorded and preserved in computer spread sheet.The data was statistically analyzed by one way (ANOVA) and Duncan's Multiple-range testing to compare the mean values of the factors measured using general linear models procedure adapted by SPSS Inc. (2008) version (16.0) statistical software package (SPSS , Inc ., Chicago , Illinois , USA).The differences among treatments means were significant at $P<0.05$. Statistical analysis was carried out according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Growth performance of fish:

Table (3):Least square means and standard error for the effect of artificial feeds on body weight gain, specific growth rate, relative growth rate, condition factor and survival ratio of Nile tilapia *(O. niloticus)* fingerlings.

Treatment	1	2	3	Sig
Initial weight (IW)	40.21±.00	40.21±.00	40.21±.00	NS
Final weight (FW)	345.84±.01	345.30±.01	345.14±.02	NS
Weight gain (WG)	305.63±.01	305.09±.01	304.93±.02	NS
Initial length (IL)	12.23±.00	12.23±.00	12.23±.00	NS
Final length (FL)	24.91±.01	24.89±.01	24.88±.01	NS
Length gain (LG)	12.68±.01	12.66±.01	12.65±.01	NS
Daily weight gain(DWG)	2.72±.02	2.72±.01	2.72±.02	NS
Specific growth rate (SGR)	2.55±.01	2.54±.01	2.54±.01	NS
Relative growth rate (RGR)	760.10±.04	758.75±.02	758.36±.06	NS
Condition factor (K)	2.23±.02	2.24±.02	2.24±.03	NS
Survival ratio(SR %)	100	100	100	NS
Gross yield (GY) KG/pond	83.01±.01	82.87±.01	82.83±.01	NS

T1= Fish culture, T2=Fish culture + wheat , T3= Fish culture + Egyptian clover NS= Non Significant

As shown in Table (3), the results of growth performance of Nile tilapia showed that there was no significant differences (P<0.05) of the final weight, weight gain, final length, length gain, daily weight gain, specific growth rate, relative growth rate, condition factor, survival ratio and gross yield at the end of the experimental period (16 weeks). However, the higher values was shown in T1 compared to T2 and T3. Data in Table (4) show that the average of initial weights of *O. niloticus* was 40.21 g for the three treatments, while at the end of the experiment, the average values of the body weight for *O. niloticus* were 345.84, 345.30 and 345.14 for treatments T1, T2 and T3, respectively. Moreover, the average total weight gain were 305.63, 305.09 and 304.93g respectively. These results are in agreement with that of Fath El-Bab (2014) who studied the effect of exploitation of fish ponds in the cultivation of wheat in the winter season on growth performance and total yield of *O. niloticus.* He started the experiment with initial body weight 30.49, 30.30 and 30.83g for the three treatments, artificial feeding with inorganic fertilizers (urea and Triple super phosphate) (AFI) and artificial feeding with organic fertilizer (AFO), and found that, the average of final weight values were 298.19, 319.85 and 333.22 g for three treatments, respectively, and the average total weight gain were 267.7, 289.55 and 302.61g respectively. Abdel-Hakim *et al*. (2014) studied the effect of stocking density in polyculture system on growth performance of cultured fish and productivity in earthen ponds. They started the experiment with 25g initial body weight of *O. niloticus* and they found that the average of final values of weight were 328.5, 314.0 and 283.5g, and the average total weight gain were 303.5, 289.0 and 258.0g, respectively.

The average initial length of the investigated *O. niloticus* were 12.23 cm for the three treatments , while at the end of the experiment, the average values of body length were 24.91, 24.89 and 24.88cm for treatments T1, T2 and T3, respectively (Table 3). Moreover, the average total length gain was 12.68, 12.66 and 12.65cm, respectively. These results are partly in agreement with Abdel-Hakim *et al*. (2014) who studied the effect of stocking density in polyculture system on growth performance of cultured fish and productivity in earthen ponds. They started the experiment with 12cm initial body length of *O. niloticus* and found that the average values of final weight were 30.5, 30.5 and 28.15 cm, and the average total length gain were 18.5, 18.5 and 16.15cm, respectively.

On the other hand, the daily weight gain (DWG), during the experimental period for *O. niloticus* was 2.72 g/fish/day for all treatments (Table 3). The level of protein in the food given to the fish experiment was 30%. Siddiqui *et al.* (1988) observed that the (DWG) of tilapia *O. niloticus* increased with increasing dietary protein levels up to 40% for small size of tilapia. De Silva *et al*. (1991**)** indicated that (DWG) of tilapia increased with increasing dietary protein from 25to 30%.

The values of the specific growth rate (SGR, %/d), were 2.55, 2.54 and 2.54%/d for T1, T2 and T3, respectively. While the condition factor (K) values were 2.23, 2.24 and 2.24 for T1, T2 and T3, respectively. The survival ratio (SR %) was 100% for all treatments (Table 4). These results agree with the that of Hussein *et al.* (2016) who studied the ffect of partial and total replacement of fishmeal with sand smelt (*Atherina boyeri*) meal in practical diets for mono sex Nile tilapia (*O. niloticus*) fingerlings. They found that values of the specific growth rate (SGR) were 2.59, 2.63, 2.63, 2.61 %/d and 2.59 for control , T2, T3, T4 and T5, respectively. They also found that the condition factor (K) values were 2.67, 2.65, 2.68, 2.65 and 2.74 for control, T2, T3, T4 andT5, respectively and 100% Survival ratio (SR %) for all treatments.

Results presented in Table (3) showed that values of the growth yield (GY) were 83.01, 82.87 and 82.83 kg/ pond.

Feed intake and feed utilization:

Table (4):Least square means and standard error for the feed intake and feed utilization parameters of Nile tilapia (*O. niloticus*) fingerlings.

Treatment	T1	T2	T3	sig
Feed intake (g)	360.24±.01	360.20±.01	360.05±.01	NS
Feed conversion ratio (FCR)	1.17±.01	1.18±.01	1.18±.01	NS
Protein efficiency ratio (PER)	2.81±.01	2.81±.01	2.80±.01	NS
Protein productive value (PPV)	49.43±.01	49.34±.01	49.36±.02	NS

As indicated in Table (4), there was no significant ($P<0.05$) differences of feed intake, feed conversion ratio, protein efficiency ratio, protein productive between T1, T2 and T3. The average values of feed intake were 360.24, 360.20 and 360.05g for treatments T1, T2 and T3, respectively. While, that of feed conversion ratio were 1.17, 1.18 and 1.18, respectively. Also, the average values of protein efficiency ratio were 2.81, 2.81 and 2.80, respectively. On the other hand, the averages of protein productive value were 49.43, 49.34 and 49.36% for treatments T1, T2and T, respectively. These results are partly in agreement with the that of Salah (2007) who studied the integrated aquaculture by bearing ducks on earthen fish ponds. He found that the feed conversion ratio (FCR) ranged between 1.29-3.45 , Protein efficiency ratio (PER) ranged between 1.10-4.01 and Protein productive value (PPV) ranged between 67.14-224.8%.

Water quality:

Results of water quality parameters of the experimental ponds during the experimental period (16 weeks) as average values of the weekly samples are summarized in Table (5).

Table (5): Average values of water quality parameters of all experimental ponds during the experimental period (16 week).

Parameter	Rang	Average
Dissolved oxygen (mg/l)	6.26 – 7.36	6.81
PH value degrees	7.52 – 8.34	7.93
Water temperature (°C)	25 – 29.8	27.4
Watersalinity(mg/l)	1.80 – 2.00	1.9
Ammonia(NH3) mg/l	0.16 – 0.21	0.185
Nitrite (NO2-N) mg/l	0.06 – 0.08	0.07
Nitrate (NO3-N) mg/l	0.20 – 0.22	0.21

The average values of dissolved oxygen ranged between 6.26 and 7.36 mg / l. Stickney (1979) reported that 2.3 mg DO /l is above the normal tolerance level of tilapia. In the present study, the average values of pH ranged between 7.52 and 8.34 in the all treatments. Ellis (1973) and Boyd (1998) reported that waters with a pH range was 6.5 – 9 at dawn and this is the most suitable for fish production. The investigated water temperature ranged from 25 to 29.8°C during the experiment period (22ndMay-11stSeptember). Gui *et al*. (1989) found that the average temperature of 28 °C was optimal for growth of Nile tilapia. Water salinity ranged between 1.80 to 2.00 mg/l and this result was in accordance with the findings of Boyd (1998).The values of ammonia (NH3), nitrite (NO_2-N) and nitrate (NO_3-N) ranged between 0.16 to 0.21mg/l 0.06 to 0.08 mg/l and 0.20 to 0.22 mg/l , respectively during the experimental period. These results were in accordance with the findings of Abdel-Hakim *et al*. (2014); Hussein*et al*.(2016) and Abdel-Hakim *et al*. (2013).

Chemical composition:

At the start and end of the feeding trial, proximate composition of whole fish body values for fish fed with experimental diets is given in Table (6). At the end of the experiment, no significant differences were found in the whole body dry matter (29.69-29.72 %), crude protein (56.25 -56.27 %; dry matter), ether extract (23.18-23.20 %; dry matter), ash (11.15-11.16 %; dry matter) and growth energy (5820.50-5820.80 Kcal GE/g). Moreover, the results in Table (6) show that, the proximate composition of the whole fish body values at the end of experimental period were more than that of the initial proximate composition at start of the experimental period. This increase was due to diets (Nutrition) and this result was in agreement with that given by Hussein et al. (2016) who studied the effect of partial and total replacement of fishmeal with sand smelt (*Atherina boyeri*) meal in practical diets for mono sex Nile tilapia (*O.niloticus*) fingerlings. Moreover, they found no significant differences (P<0.05) at the end of the experiment in the whole body dry matter (28.83 -29.59 %), protein (55.69 -58.06 %; dry matter), lipid (25.16 -28.67 %; dry matter), ash (14.83 -15.58 %; dry matter) and growth energy content (5699 - 5882 Kcal GE/g) for fish fed with the different experimental diets.

Table (6):Least square means and standard error for thechemical composition and energy content of whole body of Nile tilapia (*O. niloticus*) fingerlings.

Proximate composition	Initial	T1	T2	T3
Dry matter	27.53	29.72±.01	29.69±.01	29.71±.01
Crude protein	54.41	56.27±.01	56.25±.01	56.26±.01
Ether extract	20.32	23.18±.01	23.20±.01	23.20±.01
Ash	14.37	11.16±.01	11.15±.01	11.15±.01
***NFE**	10.90	9.38±.01	9.39±.01	9.40±.01
****GE (Kcal/100g)**	543.49	582.05	582.05	582.05

*Nitrogen Free Extract calculated as: 100-% (Protein + Lipid + Ash + Crude fiber).
**GE (gross energy) calculated using the values 5.64, 9.44 and 4.11 Kcal GE/g DM of protein, fat and carbohydraterespectively (NRC, 2011).

Soil properties:

The results of soil properties (Table 7) showed that there was no significant differences (P<0.05) between organic matter (OM), Nitrogen(N), Phosphors (P) and Potassium (K) for T1, T2 and T3 at the end of the fish culture. However, there was an increase in soil properties at the beginning of the experiment which may be due to fish waste.

Table (7): Soil properties before the start of the experiment and after fish culture (before crops culture).

Item	Initial (before fish culture)	T1	T2	T3
		(After fish culture)		
OM%	2.86±0.11[b]	3.47±0.02[a]	3.46±0.1[a]	3.50±0.1[a]
N(ppm)	252.0±17.23[b]	296.0±16.8[a]	292.0±17.05[a]	293.0±17.01[a]
P(ppm)	3.88±0.23[b]	5.30±0.20[a]	5.35±0.18[a]	5.32±0.16[a]
K(ppm)	558.0±11.54[a]	492.5±11.50[b]	497.0±11.52[b]	495.5±11.45[b]

Entry *et al.* (1997) reported that organic matter improves soil physical properties, such as water retention capacity, and reduced the volume of water needed for irrigation. Yuksel *et al.* (2002) studied different rates of compost (0, 40, 80, 120 and 160 ton/ha) to determine their effects on some physical properties of soils. Their results showed that, addition of waste compost to soils were more effective on soil aggregate stability than the control. Application of waste composts on soils, significantly reduced soil bulk densities. Increasing waste composts additions to soils also increased soil porosity value. At rate of 40-ton compost/ha, field capacity value was greater than the control (untreated soil).

Crops production:

Result in Table (8) indicated that the productivity of wheat yield (T2) was 2546.63 kg/fed while that of straw yield was 2680.20kg/fed. On the other hand, clover yield (T3) recorded 37445kg/fed annually.

Table (8):productivity of field crops from rotated culture.

Crops		T1	T2	T3
Wheat crop	Wheat yield(kg/fed)	-	2546.63	-
	Straw yield(kg/fed)	-	2680.20	-
Egyptian clover crop (kg/fed)		-	-	37445

Economic analysis:

Results in Table (9) showed that the total variable costs for T1, T2 and T3 were 37615.76, 39662.02, 38298.85 LE, respectively. The differences in total variable costs was due to differences in feed costs, wheat production costs and clover production costs. The total fixed costs were almost the same for all treatments, however the total variable and fixed costs had differences among treatments due to the differences in variable costs. As indicated in Table (10) the net returns recorded byT1, T2 and T3 were 19301.94, 25771.28 and 22080.25 LE, respectively. However, the net returns as percent of the smallest one (T1-100) were 133.51 and 114.39for T2 and T3, respectively.

Table (9):Effect of the experimental factors on economic efficiency (LE/Feddan).

Item	T1	T2	T3
First – Costs			
A-Variable costs (LE/Feddan)			
1-Fish production			
a-*O.niloticus* fingerlings	5040	5040	5040
b-Artificial feed	32075.76	32072.02	32058.85
c-Harvesting & other	500	500	500
2-Wheat production			
a-Wheat seed	-	350	-
b-Ploughing &Irrigation	-	500	-
c-Harvesting	-	1200	-
3- Clover production			
a- Clover seed	-	-	400
b-Ploughing &Irrigation	-	-	300
Total variable costs (LE/Feddan)	37615.76	39662.02	38298.85
B-Fixed costs (LE/Feddan)			
1- Rent (Anuval rent)	6000	6000	6000
2-Operating costs	600	600	600
3-Material & Depreciation	400	400	400
Total Fixed costs (LE/Feddan)	7000	7000	7000
Total variable and Fixed costs	44615.76	46662.02	45298.85
% of smallest value	100%	104.58	101.53
Second- Returns			
Returns from *O.niloticus*	63917.70	63809.90	63779.10
Returns from Wheat yield	-	6623.4	-
Returns from Straw yield	-	2000	-
Returns from Clover yield	-	-	3600
Total Returns(LE/Feddan)	63917.70	72433.30	67379.10
Net Returns (LE/Feddan)	19301.94	25771.28	22080.25
% of smallest value of net Returns	100%	133.51	114.39

CONCLUSION

Based on results obtained in this study and on the economical evaluation, it could be concluded that, rotated tilapia culture with wheat in fish ponds is profitable than rotated tilapia culture with Egyptian clover and profitable than control treatment.

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انتاجية واقتصاديات الاستزراع التبادلى لاصبعيات اسماك البلطي النيلي (أوريكرومس نيلوتيكس) مع القمح والبرسيم تحت نظام الاستزراع شبه المكثف في الأحواض الأرضية

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المستخلص

تم تصميم هذه الدراسة لمعرفة أثرالإستزراع التبادلى بين الأسماك ومحاصيل الحقل (القمح والبرسيم) تحت نظام إستزراع شبة مكثف في الأحواض الترابية عل أداء النمو ومعايير جودة المياه والتحليل الكيماوي للجسم ومحصول القمح ومحصول البرسيم والكفاءة الاقتصادية. وزعت اسماك التجربة عشوائيا في ثلاثة معاملات ولكل معاملة ثلاثة مكررات . تم تسكين احواض التجربة بعدد 240 إصبعية بلطينيلي بمعدل 4 سمكات /م^2 بمتوسط وزن 40.21 جم في تسعة أحواض ترابية مساحة كل حوض 60 م2 (5م×12م). أستمرت الدراسة لمدة 12 شهر من مايو2014 إلى إبريل 2015 . إستزراع الاسماك اميد من مايو2014 إلى سبتمبر2014 بينما زراعة محاصيل القمح والبرسيم أستمر من أكتوبر2014 إلى إبريل 2015. تم تغذية أسماك التجربة على عليقة صناعية 30% بروتين بمعدل 3% من وزن الجسم الحى مرتين يوميا لمدة 6 أيام في الأسبوع.

أتضح من النتائج التي تم الحصول عليها عدم وجود أي فروق معنوية بين المعاملات الثلاثة في قياسات أداء النمو بينما وجدت زيادة في خواص التربة بعد زراعة الأسماك وكذلك وجدت أيضا زيادة في إنتاج محاصيل القمح والبرسيم. كما أوضحت نتائج الدراسة ان زراعة محصول القمح تبادليا مع الأسماك في الأحواض السمكية كان أفضل من زراعة محصول البرسيم تبادليا مع الأسماك وأيضا أفضل من المعاملة الكنترول.