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Towards the Integrated Agri-aquaculture in the Desert Using Groundwater Reservoirs for Nile Tilapia Farming "Evaluating Study in Upper Egypt".

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ABSTRACT

The present study was carried out to evaluate the integrated fish farm and plants using groundwater reservoirs in the desert of upper Egypt to spotlight the importance of aquaculture and its radical efficacy on the national income. The study was conducted on a private farm in Qena valley in the governerate of Qena, Egypt. The water reservoir as a fish pond (30*40*3m) was provided by a water source from the well enhanced with an underground machine. The suitability of water conditions for fish farming, particularly for tilapia, was checked. The fish pond was supported with 25,000 fry mono sex Nile tilapia fed on fish diets of 30- 25% protein. The second category (two plant crops of squash and tomato) was treated with the water of the fish pond that contains, conceivably, natural fertilizers. An experiment was organized to compare the results of using chemical fertilizers, natural fertlizers and zero fertilizers. The water quality, growth performance, hematology and biochemistry of fishes were in normal ranges during the experiment with a satisfied growth rate to marketable size. Moreover, compared to the riginal water, the use of fish pond water succeeded to increase the production of crops in both with/ without fertilizers. The increase of the crops production of squash and tomato reached 24.4 and 30.52% , respectively at group A, while both crops increased by 58.83 and 59.83%, respectively at group B. The present work aimed to introduce the advantages of the integrated aqua- agriculture system in the desert of Egypt to guarantee fish and plant products, with the good utilization of water resources, with high quality and quantity, in addition to the reduction of fertilizers' cost. Thus, it is recommended to draw the attention towards the desert of Egypt, enhance the aquaculture awareness in Upper Egypt to create new fields of industries and ensure new job opportunities for young people in those areas.

INTRODUCTION

Globally, the agriculture and aquaculture are very important sources for food support. Recently, the limited water resources are the main constraint for aquaculture in arid/semi-arid regions. Hence, the global efforts encourage the integrated agri-aquaculture system. In Egypt, groundwater or surface water is now separately used for agriculture or aquaculture and other industries including human consumption. The government has tended to exploit the desert areas to maintain sustainable development and guarantee work chances for the youth. Since the only water source in the desert is the underground water, farm owners usually build surface reservoir to facilitate water utilization needed to grow vegetables though it varies in salinity, ranging from 0.5 to 26 g/liter, and in temperature varying from 22 to 26 °C **(Sadek, 2011)**. Such a water source may be used also in aquaculture as an integrated system. This system helps to produce highly priced off-season fish, vegetables and fruits granted with good quality all the year around **(Corner *et al*., 2010)**. However, it needs modifications to become a promising production system **(Sadek, 2011),** and a good preparation supported with the suitable conditions for sustainable and profitable factors without causing disturbances to the ecosystem **(Chidambaram, 2016)**. Egypt, having vast resources of groundwater, posseses the suitable natural conditions for desert aquaculture **(Allam *et al*. 2003)**. Fresh groundwater resources in Egypt consists of 20% of the total potential water resources. The water of many locations in the west desert like Oasis, Bahariya, Farafra, Dakhla, Kharga, and Siwa, comes from the underground natural wells and springs **(Heijden *et al*., 2014)**.

By time, the Egyptian desert comprises more than 100 tilapia farms and 20 commercial aquaculture farms scattered throughout seven different provinces. They are capable of producing up to 6 000 MT/year, whereas the remaining 7 000 MT/year are produced in ~100 rural farms **(GAFRD, 2018).** Since 2010, the use of non-conventional water sources have become more economically developed through government and private- backed ventures. Production from IAA farms increased from 700 tonnes in 2010 to 2200 tonnes in 2017 **(Corner *et al*., 2010).** The reported 100 commercial aquaculture desert farms of Egypt are predominantly located in ten governorates within the broader of the Nile delta, high Egypt near the Nile valley and Sinai Peninsula (**Corner *et al*., 2010).** The Nile tilapia (*O. niloticus*) was estimated to represent 90 percent of the desert-based aquaculture production, beside red tilapia (*O. mossambicus* x *O. niloticus*) and other finfish species reaching eight species **(Corner *et al*., 2010).** During the survey (2017-2019) held on the desert farms in Egypt **(Corner *et al*., 2010),** most commercial farms have adopted a certain protocol; to feed livestock through aquaculture for vegetable crops production, while some IAA farms have introduced biogas production, using fish farm particulate wastes and vegetable matter to generate gas for domestic heating and cooking. The Egyptian desert covers an area of approximately 1 million km^2, and is divided into three regions. While 99 percent of Egypt's population are living on just five percent of its land area, concentrated along the valley of the Nile and the northern Nile delta **(Sadek, 2011)**. Upper Egypt suffers from insufficient aquaculture activities in spite of the presence of a lot of desert areas within the sustainable developmental plan of Egypt. Very few desert farms have been mentioned in the report of **Corner *et al*. (2010)** in Upper Egypt until Sohag province. The present study was presented to apply and evaluate the integrated aquaculture-agriculture system in the desert of Qena valley, Egypt in a scientific form (including growth performance, healthy status of fish and vegetables' economically status) to asses the benefits of the integrated agri- aquculture in the desert, compared to the desert agriculture, to increase the awareness of aquaculture in Upper Egypt.

MATERIALS AND METHODS

Experimental Design.

The present study was carried out on private agriculture farm in the desert of Qena valley, Qena Governorate, Egypt (26º 540′ 58″ N; 32º 770′ 227″ E) (Figure 1). It is supported by water pond (reservoir) to secure the water needs for plants. This pond (30*40*5 meters) is lined with plastic layer of 1mm thickness, provided by water from an underground water well (Figure 1) that is supplied by machine. Its water quality was analyzed to check its suitability for fish farming and agriculture according to American Public Health Association **(APHA, 1995)** and the decisions of the Ministry of Health and Ministry of Environment **(No 92 - low 66 year 2013)**. Parameters included ammonia, dissolved oxygen, total hardness, salinity, phosphate, sodium, chloride, potassium, alkalinity, fluorine, sulphate, iron, pH values and temperature. About a sum of 25,000 fry of fish mono-sex Nile tilapia was bought from the private hatchery in Kafr El-Sheikh and transported under suitable conditions at night to secure its transportation during the long distance with the consideration of 10-20% loss. In the farm, the fish fry has been checked again and acclimated before being released to fish pond water.

Figure 1. Map shows the location of the fish farm in the Agriculture farm in the desert lined with plastic layer of 1mm thickness provided by water from underground water well to secure the water for plants.

Fish fry were fed on the commercial extruded floating fish diet (30% and 25% crude protein) six days per week at a daily feeding rate of 10% for the younger stages to 3% for the older stages of the estimated fish-weight of the total biomass of the fish according to **Siddiqui *et al*. (1997)** with twice daily feeding at 9.00am and 2.00pm. Feed quantity was adjusted according to the average body weight of the sample. The amount of feed was changed to the new fish biomass. The composition and chemical analysis (% on dry matter basis) of the experimental diets are shown Table (1).

Experimental analyses:

Fish samples were netted from pond for growth performance and feed utilization including weight gain (WG, g = FW – IW (g / fish), specific growth rate (SGR, %/day= = 100 × [(ln final fish weight) - (ln initial fish weight)] / experimental days), feed conversion ratio (FCR= feed fed (g) (dry weight)/weight gain (g)) and protein efficiency ratio (PER). Then samples were pooled and homogenized for a proximate composition. Moisture, total protein, lipid and ash contents were all determined by Standard Association of Official Analytical Chemist methodology **(A.O.A.C. 2000)**

For haematological measurements, the blood samples of fish individuals were collected twice during the study period; after 5 months (in August) and at the end of the experiment at the age of 10 months (in January). The blood samples were collected from the cardiac puncture as described by **Osman *et al*. (2011).** The hematological parameters, including hemoglobin concentration (Hb), hematocrit value (Hct), red blood cells count (RBCs), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated according to **Dacie and Lewis (2002)**.

Table 1. The composition and chemical analysis (% on dry matter basis) of the experimental diets**.**

Ingredients	Diet composition/kg. (30%)	Diet composition/kg. (25%)
Fish meal (65% CP)1	150	100
Soybean meal	350	300
Yellow corn	75	200
Rice bran	100	50
Wheat flour	75	200
White bran	200	100
plant oil	20	20
Premix2	30	30
Total	1000	1000
Chemical composition %		
Dry matter (DM)	94.5	94.5
Crude protein (CP)	30.1	25.4
Ether extract	6.2	6.2
Crude fibre	5.07	5.07
Ash	10.9	10.9
Nitrogen free extract (NFE)3	52.43	52.43
Gross energy (KJ/g DM)4	17.46	17.46

1Danish 999 LT fish meal (68.9% protein & 8.1% lipid). 2Vit. /min. Premix (mg kg_1); p-amino benzoic acid (9.48); D-Biotin (0.38); Inositol (379.20); Niacin (37.92); Ca-pantothenate (56.88); Pyridoxine-HCl (11.38); Riboflavin (7.58); Thiamine-HCl (3.79); L-ascorbyl-2-phosphate Mg (APM) (296.00); Folic acid (0.76); Cyanocobalamin (0.08); Menadione (3.80), Vitamin A-palmitate (17.85); a-tocopherol (18.96); Calciferol (1.14). K2PO4 (2.011); Ca3 (PO4)2(2.736); Mg SO4 7H2O (3.058); NaH2PO4 2H2O (0.795). [3]Nitrogen-free extract (NFE) = 100 - [% Ash +% lipid +% protein +% Fiber]. [4]GE (kJ/g) = (protein content × 23.6) + (Lipid content × 39.5) + carbohydrate content × 17.2). (NRC 1993).

The blood biochemistry was performed using spectrophotometer (Jasco-V530) with the absorbency at wave length ranging from 340 to 546 nm; total protein (g/dl), Creatinine and Urea (mg/dl) were estimated according to **Henry (1964)**. Cholesterol (mg/dl) and Triglycerides (mg/dl) were analyzed based on **Thomas (1992)** and **Friedewald *et al.* (1972)** respectively**.** Glucose (mg/dl) was reported in accordance with **Trinder (1969)**. While, aspartate aminotransferase (AST, U/I) and alanine aminotransferase (ALT, U/I) were determined calorimetrically according to **Reitman and Frankel (1975).**

Agriculture design system.

The agriculture design system was conducted to complete the integrated agri-aquaculture purposes through the utilization of the resulted fertilized fish farm water for plant supplementation during a season. Productivity of the two crops (Squash plant "*Cucurbita Pepo*" and Tomato "*Solanum Lycopersicum L.*") was evaluated under both of natural fertilized pond water and the use of some chemical fertilizers' treatments.

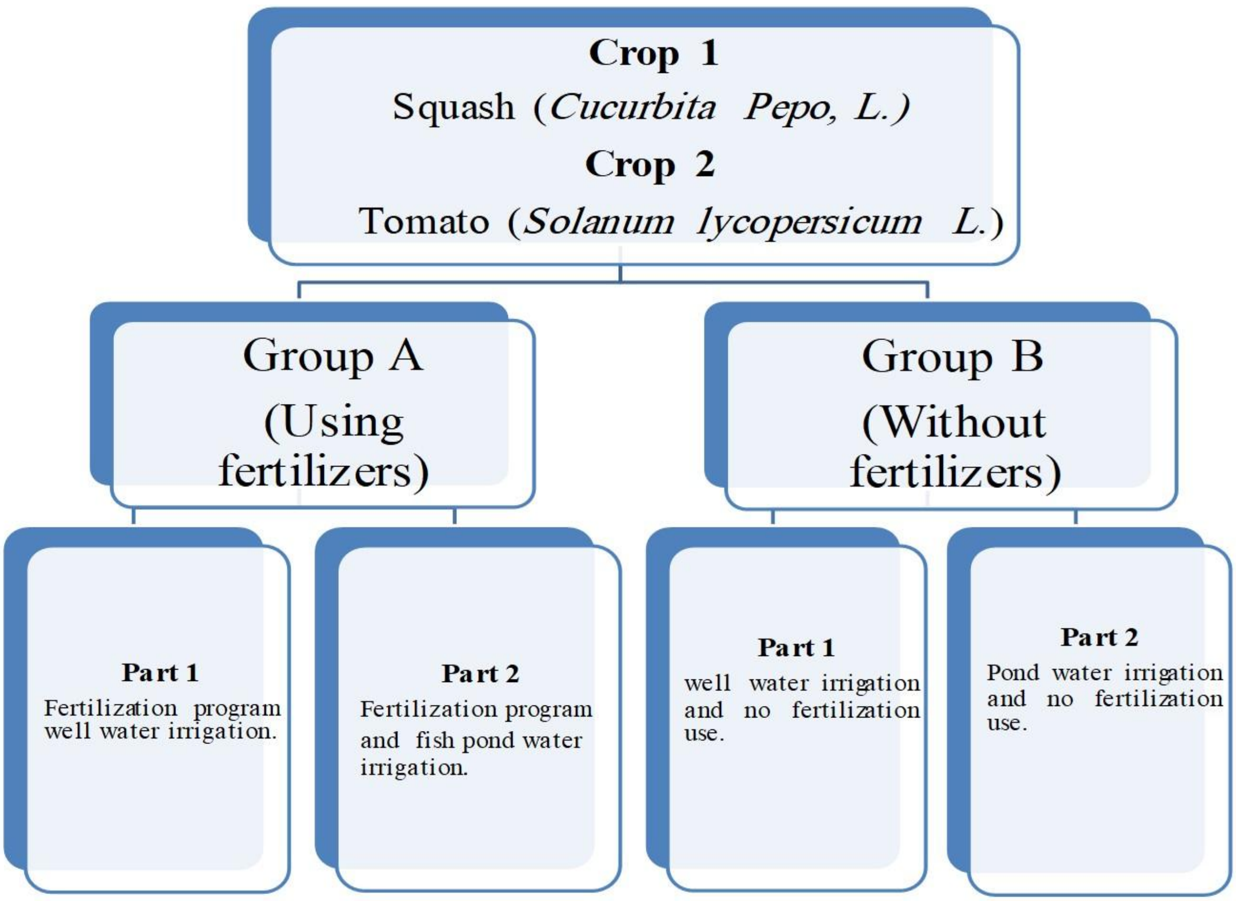

Figure 2. Diagrammatic plan of plant crops in various applications in the desert farm**.**

Different small lands were prepared to apply the required comparison between water supplementation of natural fertilized water (fish farm water) and well water (underground water without fish fertilizers) on productivity of two chosen crops (Figure 1). Moreover, this comparison was applied in two ways (by using chemical fertilizers and without such fertilizers) to give a satisfied picture for the evaluation as shown in the the diagrammatic designs (Figure 2). The small lands were investigated for crop (1), while the crop (2) (Toamto) was investigated in large scale using several feddans to confirm the results of agri-aquaculture effect on the commercial scales. The program of chemical fertilizers used (2kgN + 2kg ammonium sulfate + 2kg humic acid + 2kg Ammonium nitrate +2kg potassium and 2kg calcium) was irrigated by well water or fish pond water and applied for two crops.

Statistical Analysis

The collected data were subjected to statistical analysis using general linear model's procedure adapted by SPSS, Versions16, (1997). With a one-way ANOVA. Means were statistically compared for the significance ($p \leq 0.05$) using multiple range test spss16.

RESULTS

The present results of the integrated agri-aquaculture in the desert of Upper Egypt were introduced in two sections (Fish pond and plant harvest) as follows.

Part I: Fish farm investigation

Physico-chemical parameters.

The water quality of the fish pond during the experimental period was evaluated in three phases. 1) The suitability of the well's water for fish aquaculture, the suitable parameters were presented previously in the part of methodology; they were in a suitable range to culture *O. niloticus*. These parameters were as follows: pH value was 8.1 mg/, dissolved oxygen (DO) was 4 mg DO/L; Total Hardness was 128 mg/l, Alkalinity was 170 mg/l and total dissolved salts (TDS) was 1509 mg/l, and water temperature ranged between 16.7 C° and 24.3 C° during day time with an average of 20.8 ±3.5 C°. In general, the dissolved oxygen in the well as a source of water during the experiment ranged between 4.1 and 4.5 mg/l, with an average of 4.3±0.2 mg/l.Then, the physico-chemical parameters, during the experimental period, showed that water temperature reached its maximum values during July; while it scored its minimum during December. The pH ranged between 7.5 and 7.8, recording the highest value (7.8) during June, and minimum value (7.5) during October, with an average of 7.6±0.2. The dissolved oxygen ranged between 4.8 mg/l and 6.1 mg/l with an average of 5.3±0.3 mg/l. It had the highest value in August, while the minimum value was recorded in May. Total Hardness of the fish pond water ranged between 118 and 125 mg/l with an average of 122.1±2.9 mg/l.

The second and third phases were operated to monitor the parameters resulted from fish pond and required for plants. They were investigated twice (in August and January) and shown in Table (2). During August, the ionized ammonia (NH4) was recorded to be 5.5 mg/l, the unionized ammonia (NH^{3}) was recorded to be 2.8 mg/l, phosphate (PO^{4}) 1.2 mg/l, DO 5.8 mg/l, phosphorus (P) 0.3, iron (Fe) 0.4 mg/l, sodium (Na) 150 mg/l and potassium (K) 90 mg/l. These parameters were higher than those measured in the well's water. Whereas, the following parameters; F (0.1 mg/l), pH (7.4), total hardness (120 mg/l), tot. $Mgco^{3}$ (40 mg/l) and alkalinity (160 mg/l) were lower than those measured for well water.

During January, the NH^{4} was recorded to be 3.6 mg/l, the NH^{3} was recorded to be 2 mg/l, PO^{4} was 1.3 mg/l, DO= 5.9 mg/l, P= 0.4, Fe= 0.4 mg/l, Na= 157 mg/l and K= 93 mg/l. These parameters were higher than those measured for well water. While, the following parameters; F (0.1 mg/l), PH (7.6), total hardness (123 mg/l), tot.$Mgco^{3}$ (42 mg/l) and alkalinity (162 mg/l) were lower than those of well water

Table 2. Parameters of water quality of the well water and fish pond water used in the experimental study and collected in August and January.

Parameter	Well water	Pond water (August)	Pond water (January)	(MH and ME,2013))
S	10	500	644	10mg/l
F	0.2	0.1	0.1	1mg/l
NH4	NIL	5.5	3.6	NIL
NH3	1.1	2.8	2	2.4 mg/l
PH	8.1	7.4	7.6	6.5-9mg/l
TDS	1509	1530	1513	0-4000 mg/l
PO4	NIL	1.2	1.3	0.06 mg/l
DO	4	5.8	5.9	Min 4 mg/l
BOD	55	56	56	60 mg/l
P	NIL	0.3	0.4	NIL
NO3	NIL	NIL	0.1	45mg/l
Total Hardness	129	120	123	30-180 mg/l
Tot.CaCo3	81	80	81	63 - 250 mg/l
Tot.Mgco3	48	40	42	150 mg/l
Fe	0.2	0.4	0.4	0.01 mg/l
Mn	0.3	0.3	0.3	0-0.01 mg/l
CL	439	440	441	500 mg/l
Na	126	150	157	200 mg/l
K	73	90	93	150 mg/l
ALK.	170	160	162	50-300 mg L-1.

S Sulfur; F Fluorine; NH4 Ammonium; NH3 Ammonia; Fe Iron; Mn Manganese; K Potassium; N Nitrogen; Na Sodium; P Phosphorus; NO3 Nitrate; BOD Biochemical Oxygen Demand; TSS Total suspended solids; Phosphate PO4; TDS Total dissolved solid

***Growth performance*.**

The growth performance was investigated bimonthly. The progressive increase in fish growth was observed through the experiment considering the following items.

Final weight gain

The weight gain of investigated mono sex *O. niloticus* is presented in Table (3). At the start of the experiment (April), the average of initial weight of fish larvae was 0.5± 0. 1g. After two months of the experiment (End May), the average of body weight was found to be 11.3±1.6g. Remarkedly, after four months age (July), the average of FBW was 26.7±2.3. While at the end of the experiment (January)as shown in Figure (3), the averages of body weight was 212.5±29.8g. Concerning the results of weight gain (WG), the averages of WG during the first two months was found to be 10.8 g. This value increased by time, giving the highest averages WG in December 66.5 (g/fish) followed by a decrease showing the decline in value to 37.3 (g/fish) at the end of experiment (January). Specific growth rates (SGR) exhibited clear fluctuations ranging from 3.97 (%/day) at the end of first months (April to May) to increase by the time giving the highest value of SGR in November to December (7.23 %/day). It decreased to give the lowest value (3.31%/day) at the end of experiment (January) as shown in Table (3). The feed intake (FI) during the present experiment ranged from 12 to 112.5 (g/fish). The minimum value was recorded after the first months (April– May). Then it increased by time reaching maximum value (112.5 (g/fish) in December. Afterwards, the value of FI decreased to reach 15 (g/fish) during

January (At the end of the experiment). The value of FCR was 1.93 at the end of first month (April). Then, it showed some disturbances and declines. The FCR elevated again gradually by the time and attention to water quality and feeding behaviour reached the maximum value during November-December (1.94). At the end of the experiment (January), this value decreased recording a value of 1.43 after the decline in the temperature.

Table 3. Growth and feed utilization indices of farmed fish during the experiment.

Month	April	June	August	October	December	January
IBW (g/fish)	0.5±0. 2	11.3±1.6	26.7±2.3	59.6±4.0	108.7±3.5	175.2±5.5
FBW (g/fish)	11.3±1.6	26.7±2.3	59.6±4.0	108.7±6.5	175.2±15.5	212.5±29.8
WG (g/fish)	10.8±0.0	15.4±0.0	32.9±0.2	49.1±0.1	66.5±0.8	37.3±2.1
SGR (%/day)	3.97	4.56	5.82	6.11	7.23	3.31
FI (g/fish)	12	14	32	50	112.5	15
FCR	1.93	0.90	1.21	1.69	1.94	1.43

Figure 3. harvesting and production of the fish pond.

Biochemical composition of fish

The body composition of the present farmed fish, at the initial phase of experiment (April), during August and the end of the experimental period (January), are presented in Table (4). Moisture contents showed a decline during the experimental period (81.81±0.19; 77.26±0.59 and 75.43±0.24) for a start, in August and January, respectively. Crude protein (CP) showed a slightly increase from the very beginning to the end. It constituted 13.56±0.64; 13.90±0.87 and 14.56±0.92 during the start, in August and January, respectively. Ash contents illustrated a decline towards the end, it constituted 3.38±0.13; 3.05±0.46 and 2.84±0.32, respectively.

Regarding the ether extract (EE), it showed an increase from the start till the end. It constituted 2.28±0.42; 5.58±0.54 and 7.66±0.33 during the start, in August and January respectively.

Table 4. Biochemical composition of fish feeding trial (dry matter weight basis %).

Treatments	Initial (April)	August	January
Moisture	81.81±0.19	77.26±0.59	75.43±0.24
Crude protein	13.56±0.64	13.90±0.87	14.56±0.92
Ether extract	2.28±0.42	5.58±0.54	7.66±0.33
Ash	3.38±0.13	3.05±0.46	2.84±0.32

Haematological measurements

The blood parameters of *O. niloticus* were investigated twice during the experiment (in August and January) and are presented in Table (5). The red blood cells count (RBCs) at the end of the experiment in January 3±0.2 ($\times 10^6$µl) was higher than that obtained during August 2.2±0.46 ($\times 10^6$µl). Also, hemoglobin (Hb) at the end of the experiment in January (9.7±0.6 g/dl) was higher than that obtained during August (7.73±0.45 g/dl). Mean cell hemoglobin (MCH) decreased from 43.63±4.28 (Pg) during August to 36.4±1.25 (Pg) during January. While the mean cell hemoglobin concentration (MCHC), mean cell volume (MCV), hematocrit Hct (%) and white blood cells count (WBCs) showed an inverse trend where they increased towards the January.

Table 5. Hematological parameters of monosex *O. niloticus* during August and January (Mean ± SD).

Parameter	August	January
Hb (g/dl)	7.73±0.45*	9.7±0.6*
RBCs ($\times 10^6$µl)	2.2±0.46*	3±0.2 *
MCH (pg)	43.63±4.28*	36.4±1.25*
MCHC(g/dl)	28.47±1.2	30.2±0.458
Hct (%)	33±3.60	41±10.58
MCV (fL)	147.33±14.7	118.33±3.51
WBCs ($\times 10^3$µl)	24.63±1.27*	27.2±0.9*
Lymphocytes (%)	57.33±4.16	57.33±2.52
Neutrophils (%)	31.33± 2.08	29.3± 2.13
Eosinophils (%)	9±1.1	12.33±2.5
Monocytes (%)	2.66 ±0.57	3.1±0.9

Blood biochemical parameters

General blood biochemical variables are presented in Table (6). Most parameters increased during August till the end of experiment in January, except GL (mg/dl) and Tg (mg/dl), both showed a decrease in their values from August to January.

Table 6. Biochemical parameters of monosex *O. niloticus* during August and January (Mean ± SD).

Parameter	August (5 months)	January (10 months)
T.P (mg/dl)	2.35±0.44	3.4±0.72
GL (mg/dl)	52.7± 9.0*	31.67± 8.0*
Chol (mg/dl)	59.33± 14.84	74± 9
Tg (mg/dl)	140.77± 17.0	134± 18.520
Ur (mg/dl)	19.83± 4.27	20.2± 1.78
Crt (mg/dl)	1.63±0.26	1.97±0.15
ALT (U/I)	19.4±1.0816	21.63±1.23
AST (U/I)	21.3±1.179	28.93±6.574

T.P Total protein; GL Blood glucose; Chol Cholesterol; Tg Triglyceride; Ur Urea; Crt Creatinine; ALT Alanine aminotransferase ; AST Aspartate aminotransferase.

Part II: Agriculture investigation (Plant crops).

The second category of the integrated system is the plant crops that were gathered from each treatment (50 days after sowing plants) and continued harvesting for a month to record the yield. The analysis of variance showed the presence of significant differences among two treatments (with/ without fertilizers) in the two groups for two crops. For crop (1) (S. *Cucurbita pepo L.*), the yield for twelve harvesting kg/ plot ranged from 8.07 to 12.90 kg/plot in Group A for part (1) of well water with fertilizers, reaching an average of 10.50±1.56 kg/plot, while it ranged from 10.27 to 16.23 kg/plot in Group A part (2) of fish pond water with fertilizers recording an average of 13.87±1.58 kg/plot in group A

For group B (without fertilizers), the yield ranged from 1.00 to 3.83 kg/plot for part (1) of well water, with a mean of 2.06±0.83 kg/plot, while it increased from 2.97 to 6.03 kg/plot for part (2) of fish pond water with a mean of 5.01±0.94 kg/plot in group B. Therefore, it was noted that the use of fish pond water with natural fertilizers caused an increase in the plant yield for the two groups (with/ without chemical ferilizers) as it recorded 24.33 and 58.93 %, respectively. It is worth-mentioning that, the sum of production yielded from using pond water with fertilizers (166.5 kg) was more than that without fertilizers (60.07 kg) which, in return, serves as a commercial benefit.

For crop 2, tomato (*S. lycopersicum* L.), the analysis of variance showed significant differences among the two treatments in the two groups same as in crop 1. The data indicated that, in group A part (1), irrigated by well water with applied fertilizers, the yield ranged from 966.7 to 1350 kg/Fed, recording an average of 1138.78±117.18 kg/ Fed. While the fertilization in group A part (2) exhibited the yield that ranged from 1458 to 1805 kg/ Fed, with an average of 1638.8±112.836 kg/ Fed. The results showed an increase in the total production; from 17081.67 to 24582.32 kg for part (1) and part (2) respectively. Table (7) shows that, the yield average ranged from 153.3 to 323.3 kg/ Fed, with an average of 221.3 kg/ Fed.

For group B part (1), (irrigated by well water and no fertilizers were applied), and group B part (2) (irrigated by pond water and no fertilizers were applied), the yield average ranged from 153.3 to 323.3 kg/ acre, with an average of 221.33±50.63 kg/ Fed. Whereas, in group B, part (2) (irrigated by well water and no fertilizers were applied), the yield average ranged from 433.3 to 681.7 kg/ Fed, with an average value of 546.93±78.30 kg/ Fed. The results revealed an increase in the total production from 24.67 kg to 60.07 for part (1) and part (2) respectively. The same trend was reported from part (1) (3319.87) to part(2) (8203.96), with an increasing rate of 59.53 %. Generally, the use of fish pond water increased the production of crops in both with/ without fertilizers when compared to the original water. The production increased by 24.33 and 30.51% for squash and tomato crops, respectively at group A (with fertilizers), while they increased by 58.83 and 59.83% for both crops, respectively at group B.

Table 7. Total production for each part for crop (1) squash (*C. pepo* L.) and crop (2) Tomato (*S. lycopersicum* L.) plant/kg.

Crops	Group	Group A (With fertilizers)			Group B (Without fertilizers)		
	Treatments	Well water + fertilizers	pond water + fertilizers	Incre (%)	Well water	Pond water	Incre (%)
***(Cucurbita pepo* L.)**	Sum of production (kg)	125.97	166.5	24.33	24.67	60.07	58.93
	Av. ± SD	10.50 ± 1.56	13.87 ± 1.58		2.06 ± 0.83	5.01 ± 0.94	
	Min.- Max	8.07- 12.9	10.27- 16.23		1- 3.83	2.97 – 6.03	
. Tomato (*S. lycopersicum* L.) /kg	Sum of production (kg)	17081.67	24582.32	30.51	3319.87	8203.96	59.53
	Av. ± SD	1138.78±117.18	1638.8±112.836		221.33±50.63	546.93±78.30	
	Min. Max	966.7- 1350	1458 - 1805		153.3 – 323.3	433.3 – 681.7	

Figure 4. Crop (1) squash (*C. pepo* L.) plant showing farming and yield.

Figure 5. Crop (2) Tomato (*S. lycopersicum* L.) plant.showing farming and yield.

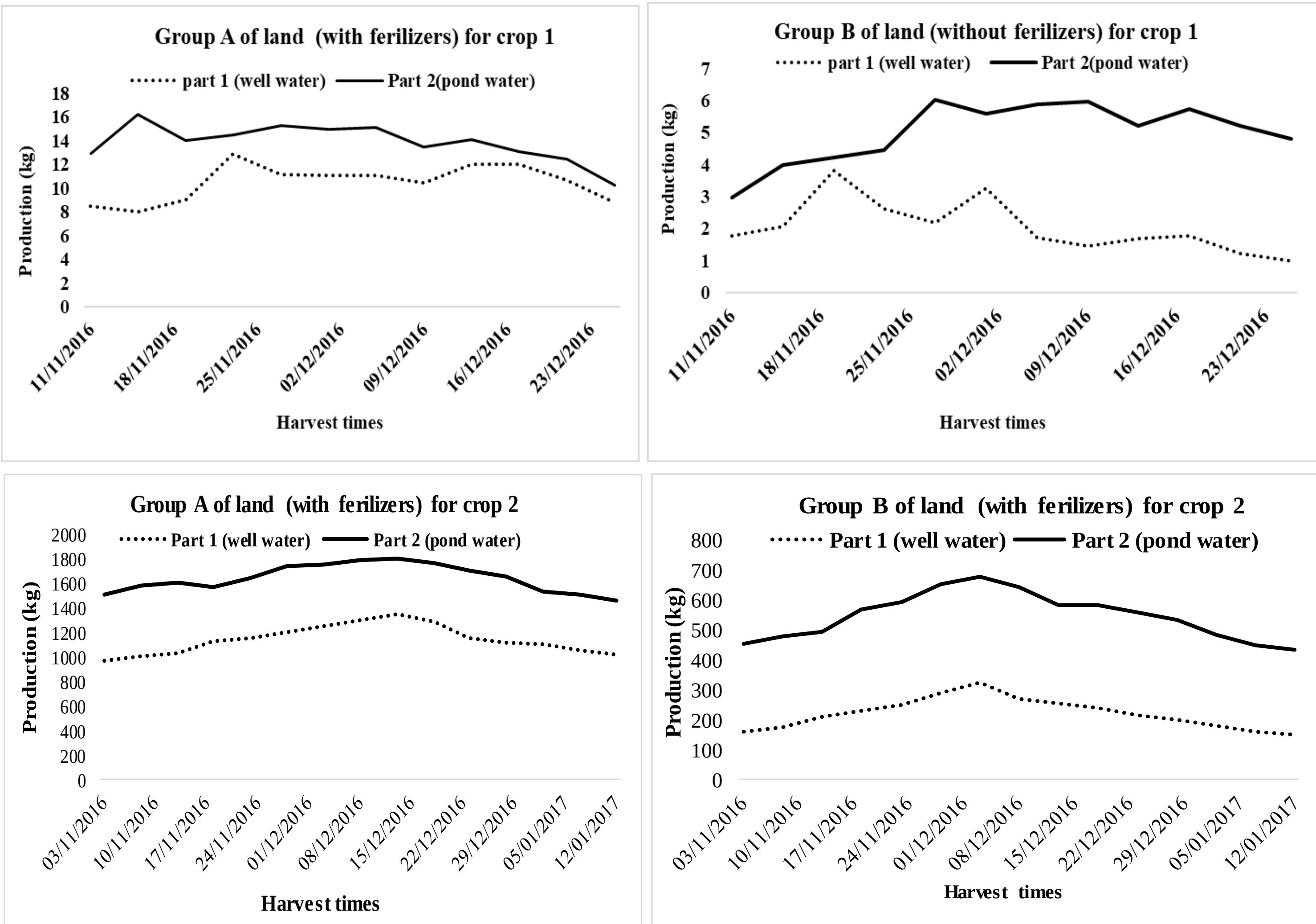

Figure 6. production for each part for crop (1) squash (*C. pepo* L.) plant and crop (2) Tomato (*S. lycopersicum* L.) plant.

DISCUSSION

The present work introduces the evaluation of the agri-aquaculture system using the underground water in the fish farming integrating with the agriculture applications in the desert, Upper Egypt. The present study is among the few works on the desert aquaculture in Egypt and may be the first documented in the Upper Egypt in a scientific form. Farmers in the desert usually construct a surface pond reservoir to facilitate the water pumping to plants in lower coast from a deep well. This water source system may be suitable for fish culture in a progress step to maximize the water use and enhance the quality of plants via using the fish water wastes that contain valuable fertilizers. The present fish pond criteria included suitable parameters for fish farming, particularly the tilapia species that are suitabile as reported in some studies **(Bhatnagar *et al*., 2004; Lazur, 2007; Bhatnagar & Singh, 2010; Linke *et al*., 2011)**. During the experimental period, water quality was checked for suitability for fish health as well as to make sure that it contained the main fertilizers that plants need.

The growth performance and feed utilization efficiency of *O. niloticus* could be affected by different environmental factors such as water quality parameters including; water temperature, pH, nitrogen waste, and dissolved oxygen concentration **(Abdel-Tawwab *et al,*. 2010)**. The present water quality parameters recorded during the experiment were within the suitable range for the normal growth performance of *O. niloticus*. In this work, the applied diets were commercial as the two dietary protein levels were 30 % and 25 % CP. Although for tilapias, there is a wide range of variations in the data available about the optimum protein that ranges between 20 % and 40 % crude protein (**Siddiqui *et al.*, 1988; Newman *et al*., 1997; El-Sagheer, 2001)** . Nevertheless, the practical diets, as low as 24 % protein, was successfully used for rearing mono-sex tilapia **(Clarck *et al*., 1990)**. It is worthmentioning that the quality of the diet and feeding management adopted by producers can significantly affect growth, survival and feed conversion of culture tilapia **(Wang *et al*., 2007)**. Feed is delivered in equal amounts throughout the day **(Tacon & De Silva, 1997).** However, as a cold-blooded animal, fish appetite varies throughout the day, mainly with the effect of water temperature. Up to a certain degree, an increase is expected in fish feed intake as water temperature rises during the day **(Sanches & Hayashi, 2001; Riche *et al.*, 2004; and Handeland *et al.*, 2008)**.

In the present work, the evaluation of growth performance of the farmed fish *O. niloticus* that lives in underground water and fed on the commercial fish diet (25 and 30 %) was illustrated, recording the average of FBW at the end of the experiment at a value of 212.5±29.8g. Thus, it is somewhat considered a marketable fish as it reached a weight of 252.3g. This trend of growth was in agreement with **Hrubec *et al.* (2000)**, **Toutou *et al*. (2016)**, **Badry *et al.* (2019)**, and **Badry *et al*. (2021)**.

Knowledge of the hematological characteristics is important as an effective and sensitive index to monitor healthy status in fishes **(Hrubec *et al*., 2000; Vázquez & Guerrero, 2007).** Fish blood hematological and biochemical parameters could be influenced by several factors such as species, sex, stress, environmental conditions and physiological nutritional status **(Najim & Poznyak, 2014).** The present hematological and blood biochemical variables of farmed mono-sex Nile tilapia observed were located within the normal range especially the results of WBC that coincide with those described by **Bittencourt *et al*. (2003)**, **Toutou *et al.* (2016)** and **Badry *et al*. (2019)** indicating that the fish was healthy**.** the blood variables were most consistently influenced by diet, the RBCs, total protein and glucose levels (**Ologhobo & Fetuga 1986; Toutou *et al*., 2016; Badry *et al.*, 2019)**. The significant reduction in the leukocytes number was below the normal range and could be harmful to fish, **(Dalmo *et al.*, 1997)**. Moreover, this could be an indication of allergic condition, anaphylactic shock, and certain parasitism **(Ahamefule *et al.*, 2008)**, which is not the case in the current study.

Lymphocytes represented the highest proportion of the WBCs in the blood of fish in this study. Neutrophils were in the second level representing around 30% of the total WBCs count in the blood of Nile tilapia fed on both diets. The range of monocytes of Nile tilapia in this study was within the normal range. This was in accordance with **Kelly (1979)** who reported that monocytes comprise less than 10 % of the total WBCs production in animals of all species. The present results regarded growth performance and blood parameters which, in turn, reflected the success of fish farmed in underwater ground in the desert. Biochemistry may vary among species and can be influenced by many biotic and abiotic factors such as; water temperature, seasonal pattern, food, age and sex of the fish **(Jawad *et al.*, 2004)**. The concentration of blood plasma protein is an indicator of general health condition of fish. Furthermore, the total protein, in this study, was within the normal range according to **Hrubec and Smith (1999)** where they recorded the total protein level with a value of 3.1g/dl. In the present study, it was 2.35±0.44mg/dl in August and 3.4±0.72mg/dl at the end of the experiment (January).

The blood glucose levels have long been used as indicators of stress in fish **(Abdel-Baky, 2001)**. These stressors may be changed with degrees of temperature. Glucose also can be affected by the season and time passed from last time feeding **(Pavlidis *et al.*, 1999).** As pointed by **Chavin and Young (1970)**, temperature affects the blood sugar levels, but the pattern is inconsistent where glucose mean level at August was 52.7 mg/dl, which was higher than that obtained in January (31.67 mg/dl). The present decline of glucose may be related to the decline of temperature due to the seasonal variation from August to January at the end of experiment

Cholesterol is a chemical compound that is naturally produced by the body, in a combination of lipid (fat) and steroid. Cholesterol is a building block for cell membranes and for sex hormones like estrogen and testosterone. Its concentration increases as the fish size increase **(Hill, 1982)**. In this study cholesterol concentration levels increased during August (after 5 months) from 59.33± 14.84mg/dl to 74± 9 mg/dl at the end in January (after 10 months). Triglycerides concentration in this study was within the normal range according to **Hrubec & Smith (1999)** where it was during August 140.77± 17.0mg/dl and 134± 18.520 mg/dl at the end of the experiment (January). Releasing creatinine and urea is a function of kidney (**Abdel-Tawwab & Wafeek, 2014)**. The present values of urea and creatinine were in the normal range for fishes, a result that is in conjunction with that of **Hrubec *et al.* (2000)**. In addition, the liver functions were measured to record 28.93 U/I for AST, and 21.63 U/I for ALT by the end of the experiment. Both were in the normal ranges and agreed with the findings of **Hrubec *et al.* (2000).** Those enzymes belong to the plasma nonfunctional enzymes which are normally localized within the cells of liver, heart, gills, kidneys, muscle and other organs. Those enzymes are important to assess the state of the liver and some other organs **(Verma & Penniston 1981)**. Thus, concerning the growth performance and healthy status of the reared fish in the water reservoir, this activity proved its successful impact as a commercial scale, though it still needs more trials and investigations to develop and exploit the underwater ground in the desert.

Regarding the second sector of agriculture (plant crops), the variables were distributed randomly in four replicates, in accordance with the importance of each variable in a split-plot design. The design included the chemical ferilizers utilizations together with both pure well water and after fish rearing. Also, a no addition of fertilizers was exhibited, depending merely on the natural fertilizers that result from fish rearing, to give a complete picture for the investigations. The trend obtained with early yield might be due to the positive effect of treatment on plant growth and mean fruit weight. The obtained results of total yield were in good accordance with the analysis of some researchers **(Aly, 1992; Mibus & Tatlioglu, 2004; Glala *et al.*, 2010)**. The production increased by 24.33 and 30.51% for squash and tomato crops, respectively, at group A, while they increased by 58.93 and 59.53% for both crops, respectively, at group B. This result indicates that fish agriculture farming in such areas should be used to maximize the utilization of ground water reservoirs, and hence, reduce the cost of production.

The fruit yield of tomato plants grown on the effluent fish farms at the end of the growing period was in good condition. The results indicate that the fruit yield increases with irrigation using pond water and fertilizers, where it was 24.582 kg /acre, a result that agrees with that of **Shedeed *et al.* (2009)** where they recorded 23.7 ton/ acre. On the other hand, farming of fish increased effluent nutrient (N.P.K.) levels in most cases as shown in Table (2), and the effluent was subsequently used to irrigate crops and orchards and may be able to reduce the required amounts of fertilizers for agriculture. Moreover, this may reduce the operation cost in conjunction with the increase of both the quality and the cost of agriculture products. Supporting agricultural products by natural fertilizers taken from the fish rearing activity may positively affect the yield, as these fertilizers contain a main component of different enzymes, such as glutathione peroxidase and thioredoxin and reductase that play an important role in the antioxidant protection of cells as supported by **Ferrarese *et al.* (2012).** The obtained results of total yield are in good condition in accordance with those of **Mibus and Tatlioglu (2004)** and **Glala *et al*. (2010)**. Therefore, the present investigation of this applied experiment reflected the positive outcome of the agri-aquaculture integrated system including fish products, agriculture products, low cost fertilizers and good quality of products. This would draw the attention to the integrated systems that could be used in the deserts and in other aquaculture systems like aquaponics.

CONCLUSION

In conclusion, farming of fish increased effluent nutrient (N.P.K.) levels in most cases, and the effluent was subsequently used to irrigate crops and orchards. Moreover, it could reduce the required amounts of fertilizers in agriculture, and improve the quality and quantity of plant crops. Consequently, it is recommended to enlarge the investigation in the desert of Egypt, and enhance the aquaculture awareness of Upper Egypt to create new fields of industries to assess new job opportunities for the youth. This, in turn, would maximize the benefits of farms, particularly those in the desert, through the integrated agri-quaculture system to attain various products. It is recommended to better utilize water resources to supply the market with free-chemical fertilizers crops (semi- organic or organic plants), and thus, establish the sustanaible developmental plan of the country.

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