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Sustainable Impact from Using Drainage Water of Fish Farms in Irrigation of Groundnut

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ABSTRACT

Now, Egypt is facing a lot of challenges such as the limited resources of water. There are many new sources of water, which are not well exploited in agriculture. Drainage water of fish farms is one of these important sources. The aim of this study is maximizing benefits from drainage water of fish farms in irrigation of groundnut crop and using it as a bio-source for fertilizing. Two field experiments were carried out during growing seasons 2013 and 2014, it executed in research farm of National Research Center (NRC) in Nubaryia district, Egypt to study the effect of fertigation rates and using drainage water of fish farms in irrigation of groundnut crop. Study factor was fertigation rate "FR" 0%, 20%, 40%, 60%, 80% and 100% recommended dose from mineral fertilization from N and compared with sustainable method (integrated method of fertilization through to take advantage of dissolved elements and vital component in drainage water of fish farms to supplement the fertilizer needs with minimum amount from mineral fertilizers). The following parameters were studied to evaluate the effect of study factors :(1) Calculating the total amount of drainage water of fish farm per season (2) Chemical and biological description of drainage water of fish farms. (3) Fertilizing stress of groundnut crop "- kg N" (4) Yield and yield component of groundnut. (5) Some of quality traits of groundnut. Statistical analysis of the effect of the different methods of fertigation indicated that, maximum values were obtained under FR100% N, also indicated that, there were no significant differences under FR100% N > FR80%N > FR60%N this means that, using drainage water of fish farms as a bio-source for fertilizing will save at least 40% from minerals fertilizers under sprinkler irrigation system.

Key words: Drainage water of fish ponds, Fertigation rates, Groundnut crop and Sustainable Fertilization Technology.

Introduction

Now, Egypt is facing a lot of challenges such as the limited resources of water . In the near future and after building El-NAHDA Dam in Ethiopia, Egypt will suffer from a severe aqueous shortage. This will be a natural result of the growing population and the lack of water sources. To alleviate the severe suffering from shortage of water sources, the suggested solutions should be innovative and sustainable. There are many new sources of water, which are not well exploited in agriculture. One of these sources is drainage water of fish farms. Reuse drainage water of fish farming which rich with organic matter for agriculture use can improve soil quality and crops productivity (Elnwishy *et al*., 2006), reduce the total costs since it decreases the fertilizers quantity use, which demand became affected by the prices and the framer's education (Ebong and Ebong, 2006). Meanwhile, organic matter content of drainage water of fish supports the cation exchange process in soils, which is important to the nutrition of plants (Altaf *et al.,* 2000). Fish feed provides most of the nutrients required for plant growth. As the aquaculture effluent flows through the hydroponic component of the recirculating system, fish waste metabolites such as ammonia is removed by nitrification and direct uptake by the plants, thereby treating the water, which flows back to the fish-rearing component for reuse. Plants grow rapidly with dissolved nutrients that are excreted directly by fish or generated from the microbial breakdown of fish wastes. In closed recirculating systems with very little daily water exchange (less than 2 percent), dissolved nutrients accumulate in concentrations similar to those in hydroponic nutrient solutions. Dissolved nitrogen, in particular, can occur at very high levels in recirculating systems. Fish excrete waste nitrogen, in the form of ammonia, directly into the water through their gills. Bacteria convert ammonia to nitrite and then to nitrate by nitrification process. Aquaponic systems offer several benefits, however, dissolved waste nutrients are recovered by the plants, reducing discharge to the environment and extending water use (i.e., by removing dissolved nutrients through plant uptake, the water exchange rate can be reduced). Minimizing water exchange reduces the costs of operating aquaponic systems in arid climates and heated greenhouses where water or heated water is a significant expense. Having a secondary plant crop that receives most of its required nutrients at no cost

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improves a system's profit potential. The daily application of fish feed provides a steady supply of nutrients to plants and thereby eliminates the need to discharge and replace depleted nutrient solutions or adjust nutrient solutions as in hydroponics. The plants remove nutrients from the culture water and eliminate the need for separate and expensive bio-filters. An aquaponic system in a tightly enclosed greenhouse is ideal because CO_2 is constantly vented from the culture water. There is a growing body of evidence that healthy plant development relies on a wide range of organic compounds in the root environment. These compounds, generated by complex biological processes involving microbial decomposition of organic matter, include vitamins, auxins, gibberellins, antibiotics, enzymes, coenzymes, amino acids, organic acids, hormones and other metabolites. Directly absorbed and assimilated by plants, these compounds stimulate growth, enhance yields, increase vitamin and mineral content, improve fruit flavor and hinder the development of pathogens. Various fractions of dissolved organic matter (e.g., humic acid) form organo-metallic complexes with Fe, Mn and Zn, thereby increasing the availability of these micronutrients to plants. (James, *et al*. 2006). Two field experiments were carried out during growing seasons 2011 and 2012. It was executed in research farm of National Research Center in Nubaryia region, Egypt to study the effect of irrigation systems, fertigation rates by using the wastewater of fish farms "WWFF" in irrigation of potato. Study factors were irrigation systems (sprinkler irrigation system "SIS" and trickle irrigation system "TIS"), water quality (traditional irrigation water "TIW" and WWFF) and fertigation rates "FR" (20%, 40%, 60%, 80% and 100% NPK). The following parameters were studied to evaluate the effect of study factors: 1) Calculating the total amount of WWFF per season; 2) Chemical and biological description of WWFF; 3) Clogging ratio of emitters; 4) Yield of potato; 5) Irrigation water use efficiency of potato "IWUEpotato". Statistical analysis indicated that, maximum values were obtained of yield under SIS × FR100% NPK × WWFF, also, there were no significant differences for yield values under the following conditions: SIS × FR100% NPK × WWFF > SIS × FR80% NPK × WWFF > SIS× FR60% NPK × WWFF > TIS × FR100% NPK × TIW. This means that, using WWFF in the irrigation can save at least 40% from mineral fertilizers and 100% from irrigation water under sprinkler irrigation system. (Abdelraouf, *et al*., 2014).

The objective of this study was maximizing utility from drainage water of fish ponds in groundnut cultivation and using it as a bio-source for fertilizing under sprinkler irrigation system.

Material and Methods

Site description

Field experiments were conducted during two ground nut seasons from May to September of 2013–2014 at the experimental farm of National Research Center, El-Nubaria region, Egypt (latitude 30.8667N, and longitude 31.1667E, and mean altitude 21 m above sea level). The experimental area has an arid climate with cool winters and hot dry summers prevailing in the experimental area.

Experimental Design

Experimental design based on random block design. Study factor was fertigation rate "FR" 0%, 20%, 40%, 60%, 80% and 100% recommended dose from N mineral fertilization as shown as in figure (1). Phosphorus fertilizer, as calcium superphosphate, 15 % P_2O_5 was added during the seed bed preparation at 300 kg P_2O_5/fad. Potassium fertilizer as potassium sulfate, 48 % K_2O was added at 24 kg applied after one month from sowing, while nitrogen fertilizer was added as ammonium sulfate, 20.6 % was added at 60 kg.

The Total Amount of drainage water of Fish Farm Per Season

The total amount of wastewater of fish farm in Nubaria farm experiment, there are 12 basin in the fish farm, the dimensions of each basin are 5 m * 5 m * 2 m, however the depth of the actual exchange is 1.5 m and therefore the size of the outgoing water per week = 5 * 5 * 1.5 * 12 basin = 450 m^3 of water weekly as shown in fig. (2).

Total nitrogen and algae in drainage water of fish farm during cultivation season of groundnut

The data mentioned in table (3) above showed quantitative fertigation capacity of the drainage water of fish farm under study to be used as irrigation water and there are many of types of algae found in the drainage water of fish ponds such as *Chlorella sp*, *Nostoc sp*, *Oscillatoria sp* and *Pediastrum sp* as shown in fig. (3). Drainage water for fish farm samples were collected at the outlet of water basin used for fish breeding and production. All microorganisms were counted on their specific count media and incubation temperature of 30 ºC

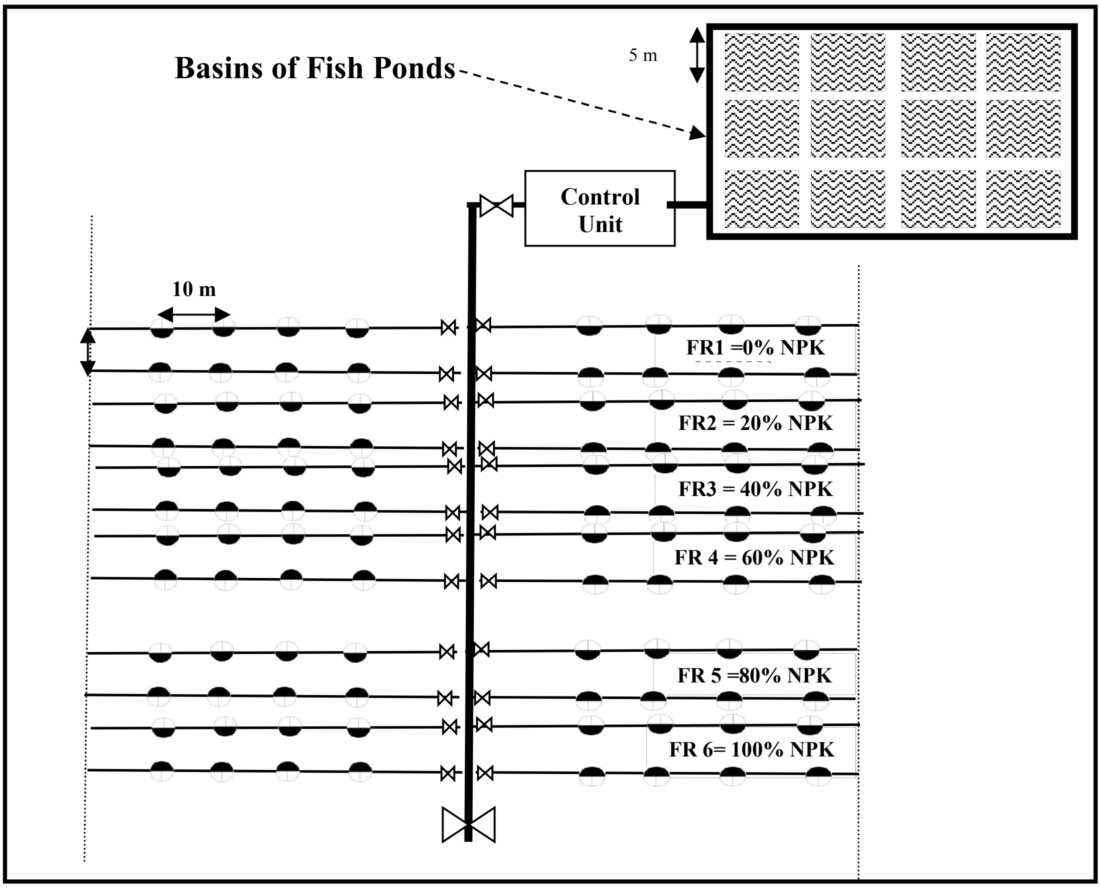


Fig. 1. Layout of Experimental Design

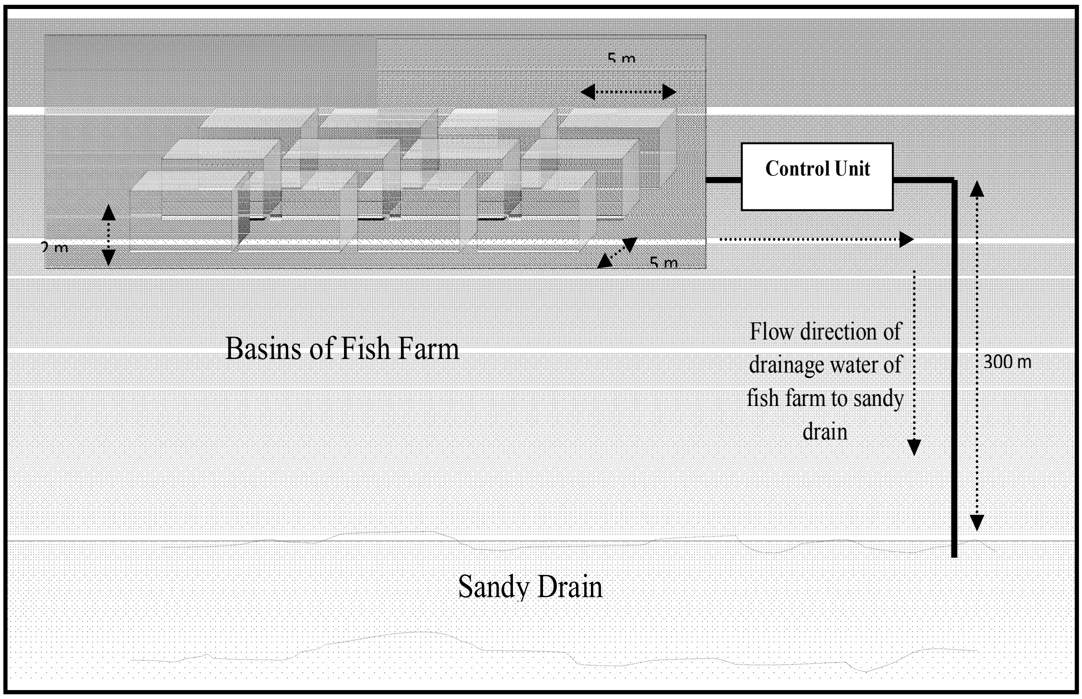


Fig 2. Loss of drainage water of fish farm

except faecal coliform group that was incubated on 44 ºC. Total Viable Count of Bacteria (TVCB) was determined using the standard plate count method and nutrient agar culture medium according to APHA (1998). Total count of fungi was determined using the standard plate count method and Rose-bengal agar culture medium according to Taso, (1970). Faecal coliform bacteria were counted using MacConkey broth and incubated at 44 ºC (Atlas 2005) using most probable number method (Munoz and Silverman,1979). Total counts of free N_2 fixers using Ashby's medium (Kizilkaya, 2009). Algae enumeration: The grouping of green algae and blue-green algae were accomplished and counted depending on morphological shape under light microscope using the Sedgwick-Rafter (S-R) cell count chamber according to APHA, (1998) and then calculated algae counts from the following equation.

$$No./mL= (C*1000\ mm^3) / (L*D*W*S)$$

Where: C = number of organisms counted, L = length of each strip (S-R cell length), mm, D = depth of a strip (S-R cell depth), mm, W = width of a strip (Whipple grid image width), mm, and S = number of strips counted.

Table 3: Some physical and chemical and biological determinations of drainage water of fish farm under search.

Physical Determinant		Value
EC		1.82 dsm^{-1}
pH		7.02
Chemical elements:		
Chromium	Cr	0.0 ppm
Copper	Cu	0.33 ppm
Nickel	Ni	0.0 ppm
Zinc	Zn	1.1 ppm
Nitrogen	N	4.79 ppm
Phosphorus	P	10.2 ppm
Potassium	K	35 ppm
Sodium	Na	205 ppm

Biological Determinant	Counts as CFU/ml
Total counts of bacteria	$1.5X10^4$
Total count of faecal coliform	$3X10^2$
Total counts of fungi	500
Total counts of free N_2 fixers	600
Green algae:	
Chlorella sp. Count	400
Scenedesmus sp. Count	150
Pediastrum sp. Count	120
Cyanobacteria:	
Oscillatoria sp. Count	100
Nostoc sp. Count	50

Seasonal irrigation water for groundnut

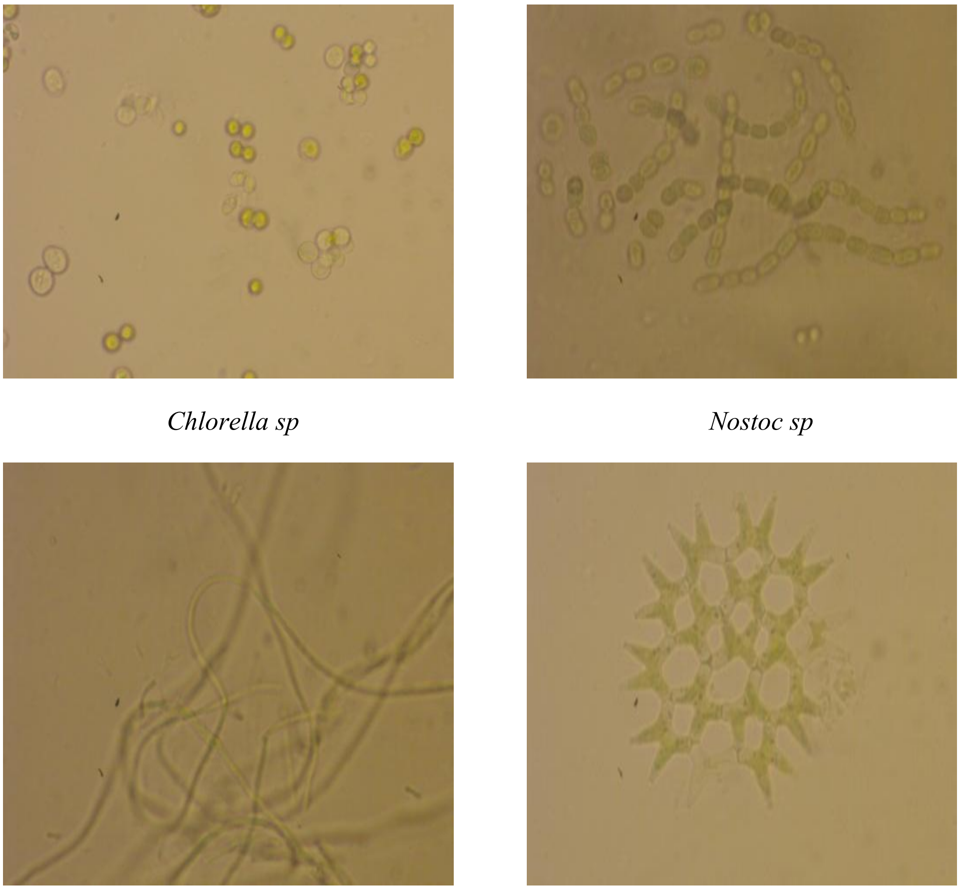
Seasonal irrigation water was estimated according to the meteorological data of the Central Laboratory for Agricultural Climate (CLAC) depending on Penman-Monteith equation. The seasonal irrigation water applied was found to be 2370 m^3/fed./season for sprinkler irrigation system.

Some physical and chemical properties of soil and irrigation water

Some properties of soil and drainage water of fish farms for experimental site are presented in (tables 1,2,3).

Sprinkler Irrigation System

Irrigation system components consisted of a control head and a pumping unit. It consisted of centrifugal pump with 45 m^3/h discharge driven by electrical engine back flow prevention device, pressure regulator, pressure gauges, flow-meter and control valves. Main line was of PVC pipes with 110 mm in diameter (OD) to convey the water from the source to the main control points in the field. Sub-main lines were of PVC pipes with 75 mm diameter (OD) connected to the main line. Manifold lines: PE pipes was of 63 mm in diameter (OD) were connected to the sub main line through control valve 2`` and discharge gauge. Sprinkler is a metal impact sprinkler 3/4" diameter with a discharge of 1.17 m^3h^{-1}, wetted radius of 12 m, and working pressure of 250 kPa and the source of drainage water of fish farm collected from 12 basin (5m *5m *2m depth).



Chlorella sp *Nostoc sp*

Oscillatoria sp *Pediastrum sp*

Fig 3. Types of algae found in the drainage water of fish ponds.

Table 1. Some chemical and mechanical analyses of soil under search.

Character	Chemical analysis (%)			Mechanical analysis				Texture
Soil depth	OM (%)	pH (1:2.5)	EC (dSm^{-1})	$CaCO_3$ (%)	Course sand	Fine sand	Clay + Silt	
00 - 20 cm	0.65	8.70	0.35	7.02	47.76	49.75	2.49	sandy
20 - 40 cm	0.40	8.80	0.32	2.34	56.72	39.56	3.72	
40 - 60 cm	0.25	9.30	0.44	4.68	36.76	59.40	3.84	

OM: Organic Matter

Table 2. Characteristics of soil under search.

Depth	SP (%)	F.C (%)	W.P (%)	A.W (%)	Hydraulic conductivity (cm/hr)
0-20	21.0	10.1	4.7	5.4	22.5
20-40	19.0	13.5	5.6	7.9	19.0
40-60	22.0	12.5	4.6	7.9	21.0

S.P. = saturation point, F.C. = field capacity, W.P. = wilting point and A.W. = available water.

Data recorded

Yield and yield component

At harvest, a random sample of 10 plants was taken from each plot to determine number and weight of pods/plant, number and weight of seeds/plant, 100-seed weight, 100-pod weight. Plants in the whole plots were harvested and their pods were air dried and threshed to calculate seed yield/ha.

Fertilizing stress of groundnut crop

Fertilizing stress means the shortage of fertilizers which less than the recommended dose for plant requirements.

Irrigation water-use efficiency (IWUE) value was calculated according to Howell *et al.* (1990).

$$IWUE = (\frac{E_y}{I_r}) \times 100$$

Where IWUE is the irrigation water use efficiency (kg $_{seed}$/m^3$_{water}$), Ey is the economical yield (kg $_{seed}$/ha), I_r is the amount of applied irrigation water (m^3 $_{water}$ ha^{-1}/season).

Chemical traits

Oil % and N in seed was determined according to the method described by A.O.A.C. (1990) and the seed protein content was calculated by multiplying total nitrogen concentration by 6.25. Oil and protein yields/ha were calculated by multiplying seed yield by seed oil and protein percentage.

Statistical analysis

The obtained data were statistically analyzed according to Gomez and Gomez (1984) and the combined analysis of two seasons was done according to Steel and Torrie (1980) while, the values of least significant differences (L.S.D. at 5 % level) were calculated to compare the means of different treatments.

Results

Fertilizing stress:

Fertilizing stress decreased by increasing of amount of nitrogen and minimum stress occurred at FR4 = 60 % N and no stress at FR5 and FR6 as shown table (4).

Table 4: Effect of fertigation rates on the fertilizing stress of groundnut

Character / Treatment	Bio-source	Supplemental amount from mineral fertilizers	Total N applied from both source	Fertilizing stress of groundnut
	(kg N)	(kg N)	(kg N)	(- kg N)
FR1 = 0%N	13.07	0	13.07	-46.93
FR2 = 20%N	13.07	12	25.07	-34.93
FR3 = 40%N	13.07	24	37.07	-22.93
FR4 = 60%N	13.07	36	49.07	-10.93
FR5 = 80%N	13.07	48	61.07	1.07
FR6 = 100%N	13.07	60	73.07	13.07

In this table and the following one, FR: Fertigation Rate, N : nitrogen

Yield and yield components:

Combined data in table (5) Showed that, the yield and all yield component of groundnut increased by increasing fertigation rate and maximum yield occurred under FR6 and there were no significant deference between FR6, FR5 and FR4.

Table 5. Effect of fertigation rates on seed yield and yield components (combined data of two seasons)

Character / Treatment	Pods/plant		Seeds/plant		100-pod weight (g)	100-seed weight (g)	Seed yield (ton/fed.)
	numbers	weight (g)	numbers	weight (g)			
FR1= 00 % N	10.47	11.09	18.42	10.22	41.38	22.73	0.43
FR2= 20 % N	14.61	15.48	25.71	14.26	57.74	31.71	0.6
FR3= 40 % N	18.26	19.35	32.13	17.83	72.18	39.64	0.75
FR4= 60 % N	28.05	29.67	49.27	27.34	110.67	60.78	1.15
FR5= 80 % N	32.55	33.32	53.06	30.15	112.46	62.3	1.17
FR6= 100 % N	33.67	36.15	55.39	32.12	115.54	63.06	1.19
$LSD_{5\%}$	0.39	0.36	0.21	0.33	0.75	0.36	0.05

Oil and Protein percentage and yield

Oil and protein percentage and yield of Groundnut increased by increasing fertigation rate and maximum Oil and Protein Yield occurred under FR6 and there were no significant deference among FR6 and FR5, FR4 as shown as in table (6).

Irrigation water Use Efficiency (IWUE)

IWUE groundnut increased by increasing fertigation rate and maximum $IWUE_{Groundnut}$ occurred under FR6 and there were no significant deference among FR6, FR5 and FR4 as shown as in table (6).

Table 6: Effect fertigation rates on oil and protein yield and irrigation water use efficiency "$IWUE_{Groundnut}$" (combined data of two seasons)

Character / Treatment	Oil		Protein		IWUE Groundnut (kg seed/m^3 water)
	(%)	Yield (kg/fed)	(%)	Yield (kg/fed)	
FR1 = 00%N	20.60	88.58	14.80	63.64	0.18
FR2 = 20%N	21.90	131.40	15.60	93.60	0.25
FR3 = 40%N	25.40	190.50	19.00	142.50	0.32
FR4 = 60%N	35.40	407.10	20.10	231.15	0.49
FR5 = 80%N	38.80	453.96	23.40	273.78	0.49
FR6 = 100%N	40.10	477.19	25.60	304.64	0.50
$LSD_{5\%}$	0.52	11.97	0.32	6.19	0.04

Discussion

To calculate the total amount of drainage water of fish farm in Nubaria farm experiment, the volume of water discharged per week should be calculated as follow: There are 12 basin in the fish farm, the dimensions of each basin are 5 m * 5 m * 2 m, however the depth of the actual exchange is 1.5 m and therefore the size of the outgoing water per week = 5 * 5 * 1.5 * 12 basin = 450 m^3 of water weekly. The total volume of drainage water of the fish farm under search during the groundnut growing season (17 week) = 17 * 450 = 7650 m^3 /season of water as shown in fig. (2) that represents about 280.2% of groundnut necessary irrigation water per season and total nitrogen in drainage water of fish farm during cultivation season of groundnut can be calculated from the data mentioned in table (3) above showed quantitative fertigation capacity of the drainage water of fish farm under study to be used as irrigation water. Drainage water of fish farm could supply the soil seasonally with 13.07 kg of nitrogen/fed of the whole quantities of irrigation water used by sprinkling method, that are equivalent to 80.65 kg of ammonium sulphate fertilizer (21% N) according to the following equation: Total N dissolved in DW of fish farm = 4.79 x 2730/1000 = 13.07 kg.

Seed, irrigation water use efficiency oil, protein yield of groundnut increased by increasing fertigation rate and maximum seed, oil, protein yield and $IWUE_{Groundnut}$ occurred under FR6 and there were no significant deference between FR6 and FR5, FR4 as shown as in tables (4,5 and 6) and figs.(5, 6 and 7) respectively this may be due to drainage water of fish farming is rich with organic matter for agriculture use and it can improve soil quality and crops productivity where, organic matter content of drainage water of fish supports the cation exchange process in soils, which is important to the nutrition of plants this is agreement with (Altaf *et al.,* 2000). (Elnwishy *et al*., 2006) and (Ebong and Ebong, 2006).

In conclusion, Using drainage water of fish farms in cultivation of groundnut will save at least 40% from mineral fertilizers of nitrogen and this due to increasing of Total N dissolved in DW of fish farm in addition to organic matter and converting bacteria and fungi green algae to nitrogen in the soil.

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