Effect of organic and chemical fertilization on growth performance, phytoplankton biomass and fish production in carp polyculture system

Mohsen Saleh Hussein
Department of Animal Production (Fish Production), Faculty of Agriculture,
Al-Azhar University, Egypt.

ABSTRACT

This study reports on the effect of organic (sheep and cow manure), and chemical fertilizers, on the phytoplankton, primary productivity and aquaculture production in the cultivation of carp in semi-intensive earthen ponds. The average biomass final (kg) were 1687.4, 1948.8 and 2370.6 kg / fed. in T1, T2 and T3, respectively. Treatment with chemical fertilizers was found to present the highest yield with 11.57 ± 0.67 kg/fed./day. It was followed by treatment with cow manure (9.20 ± 1.24 kg/fed./day) and sheep manure (7.79 ± 1.95 kg/fed./day). Concentrations of phytoplankton were significantly ($p<0.05$) higher in ponds fertilized with sheep and cow manures (1,824,726 and 1,416,416 cells/ml, respectively) than in ponds fertilized with chemical fertilizer (1,084,630 cells/ml). All of water quality parameters ($P>0.05$), were within the acceptable range during the present study.

In general, conditions were adequate to obtain high yields without the commercial feed, therefore organic fertilizers application can be recommended, due to its availability and low costs.

Keywords: polyculture, chemical and organic fertilizers, water quality, carp.

INTRODUCTION

Fish culture with manures as the main nutritional input is a long-time practice in China (Tang, 1970). Nevertheless the wide use of mineral fertilizers in industrialized countries; is supply limited and even expensive in many low developed nations.

Presently fish culture mainly depends on the application of organic fertilizers and to some extent on inorganic ones. Fertilization enhances phytoplankton productivity in rearing and stocking ponds (New and Fedoruk, 2003; Bhakta *et al.*, 2004, 2006). Phytoplankton and zooplankton are rich sources of protein (40-60%) on dry weight basis which is sufficient for fish growth at low stocking densities (Silva and Anderson, 1995; Tabinda and Ayub, 2009, 2010; Sun *et al.*, 2010).

Animal manures, which are generally plentiful worldwide, constitute a low- to intermediate-cost nutrient source. The study of fertilization in the carp polyculture has focused to address issues about the effect of chemical and organic fertilization on water quality and growth of carp (Vromant *et al.*, 2002; Dhawan, 2002).The water quality and fish production in ponds with or without organic fertilization (Nikolova *et al.*, 2008a and 2008b) and the effect of supplemental feeding on water quality and structure of phytoplankton in fertilized earthen ponds cultivated with Tilapia and carp (Abdel- Tawwab *et al.*, 2007).

Among the new trends in fish culture, integrated semi-intensive system seems to be the most acceptable, due to the fact that various agricultural wastes and low value feedstuff can be utilized as a cost-effective source of fish feed. Fertilizers increase the level of primary productivity, dissolved oxygen, pH and total phosphorus (Qin *et al.*,1995).They increase fish production without risk of dietary diseases and also play an important role in the formation of soil structure. The growth of fish is strongly correlated with increase of phytoplankton and zooplankton productivity as a result of fertilization. Under polyculture system, the use of organic and inorganic fertilizers provides basic nutrients and elements required for the production of phytoplankton and zooplankton which serve as a major source of food for fish (Javed *et al*., 1992).

The first link in food chains within land waters are phytoplankton and are an indicator of production level. Within these environments,fish ponds with a high abundance characterized as highly eutrophic systems primary productivity, and promote the growth of fish in a polyculture fish, particularly filter feeders. Infertilized ponds,the increase of phytoplankton is due to the intensity and type, as productivity increases with careful management, with a continuous and controlled addition of inorganic and / or organic fertilizers to produce autotrophic organisms. (Hepher and Pruginin, 1981; Hussein, 2009; Ponce Palafox, 2010).

Purpose of all these steps and precautionary measures is to enhance the present level of fish production and provide desired quality and required quantity of protein to the carcuss masses.

There have been several works research regarding the development of phyto-plankton, was described some effects of different types of fertilizers in ponds, its composition, growth, relationships between the groups and their dynamics in dailyand monthly fluctuations, indicating that they depend on various factors, including predation, the incidence light and nutrient type (Wilkins and Piedrahita, 1988; Moustaka and Nikolaidis, 1992; Vadas, 1992; Hussein, 2009; Ponce Palafox, 2010). It is important to understand diversity wealth, other characteristics of phytoplankton and the function performed by the channels trophic polyculture systems. In the present study, the effect of organic and chemical fertilizers on phytoplankton biomass and fish production was evaluated in ponds stocked with carp polyculture.

The production of fish ponds depends mainly on the vegetation, which is dependent on the nutrients in ponds. It is not possible to increase the production of cultivated fish by giving them the greater quantities of natural food directly. Organic manures and chemical fertilizers can be used to increase the planktonic biomass, on which fish mainly feeds. It stimulates the growth of natural food by providing essential elements, which are utilized by the phyto-and zooplanktons. The fertilization in fish farming is to improve water quality and to increase the variety and quantity of phytoplankton and zooplankton, which eventually leads to high fish yield and economic returns. The ultimate goal of fertilization is to achieve suitable environmental conditions for the production of natural food for fish, but in comparison with organic manure, fertilizers increase the level of primary productivity, algae abundance, dissolved oxygen, pH and total phosphates (Afzal *et al*., 2007; Hussein (2009); Jana *et al*., 2001; Ponce Palafox, 2010).

The objective of the present experiment was to evaluate the effects of fertilizer types on growth performance in terms of average body weight, specific growth rate and total fish production of common carp, grass carp, bighead carp and silver carp, water quality parameters and economic returns under polyculture in semi-intensive fish culture system at Serow Fish Farm, under different treatments.

MATERIALS AND METHODS

This work was carried out in nine earthen ponds (each of 4200 m^2 surface area) located at Serow Fish Farm, National Institute of Oceanography and Fisheries, Dakahlia Governorate, Egypt. These ponds were firstly drained and cleaned, then supplied with drainage freshwater from El-Serow drainage canal to a depth of 1.2-1.5 m. The experimental period lasted for 6 months (180 days, initiated on first of May till first of November).

Pond preparation: Before stocking, all the ponds were sun dried for fifteen days. Essential precautionary measures were taken to screen the water inlets to avoid the entry of intruders or exit of the fish from ponds. After one week of taking these steps, each pond was watered up to 1.5 m and this water level was maintained throughout the experimental period. All the ponds were fertilized with organic manure (cow manure) as a start dose to stimulate the productivity of the ponds.

Stocking of fish species in experimental ponds: Two weeks after manuring and ponds had been filled with water, each pond (with an area of one feddan), under fish polyculture system, was stocked randomly with four species of grass carp, *Ctenopharyngodon idella* (20%), silver carp, *Hypophthalmichthys molitrix* (15%), bighead carp, *Aristichthys nobilis* (15%), and common carp, *Cyprinus carpio* (50%), at one stocking rate (10,000 fishes/feddan).

The average initial body weight was recorded. There were no significant differences among treatments in the size of fish at stocking. Fingerlingscommon of carp used for the present study were collected locally from the Serow Fish Farm. Grass carp, Silver carp and bighead carp fingerlings were obtained from Abbassa Fish Hatchery belonging to the General Authority for Fish Resources Development (GAFRD), Ministry of Agriculture, Egypt.

Fertilization: The present fish ponds received sheep manure (2,6,9 ponds), cow manure (1,3,8 ponds) and mineral fertilizer (urea and triple superphosphate) (4,5,7 ponds) at twice daily intervals at 09.00 h and 14.00h,from Saturday to Thursday for a period of six months.

Approximate chemical composition of organic (cow manure and sheep manure) and inorganic (Urea and TSP) fertilizers concentrations and nutrient applications rates as kg/pond during the experimental period(% dry matter basis, Mean ± SE) used are given in Table (1), and was estimated according to AOAC (1994).

Table 1: Approximate chemical composition of organic (cow manure and sheep manure) and inorganic (Urea and TSP) fertilizers concentrations (% dry matter basis, Mean ± SE)

Treatments	Organic fertilizer		Inorganic fertilizer (Urea+TSP)
	Sheep manure	Cow manure	
	(1.6%N+0.75% P)	(1.7%N+0.45% P)	(46% N+46%P_2O_5)
Dry matter	90.21± 0.10	89.11± 0.14	-
Nitrogen (%)	1.6±0.11	1.7±0.04	46.0
Phosphorus (%)	0.75±0.02	0.45±0.01	46.0
N:P ratio	2.13±0.21	3.78±0.23	1
Kg/ fed/180 days	2520±0.22	5040±0.22	146±27

The amount of organic and inorganic fertilizers was calculated on N-P equivalence of 0.2 g N and 0.01 P/100 g wet body weight of fish (Islam, 2002; Hussein 1995). Inorganic fertilizers (Urea with 46.5% N and TSP 46% P) were used at a rate of 0.345 kg P/feddan (0.75 kg TSP/fed.) and 2.5kg N/feddan(5.3kg urea/fed.0) every two weeks, after stocking in water in plastic barrels and broadcasting this mixture over the pond water surface (Hussein,1995).Cow and sheep manures were broadcast over the ponds surface; volumes of manure used were 0.7 to 1.4 m^3/fed./day (14.0 to 28.0 kg dry matter/fed./day) (Hussein, 2009). Three treatments were randomly applied with three replicates each as follows:

T_1 (1,2,3 ponds) = organic fertilizers (sheep manure), T_2 (4,5,6 ponds) = organic fertilizers (cow manure) and T_3 (7,8,9 ponds) = inorganic fertilizers (Ch.), urea (46 %N) and triple superphosphate (46 % P_2O_5). In the present study, all the experimental ponds received the same quantity of N and P with the different sources.

Fish growth parameters: After every one month, fish sample for each weight (monthly) were 400 fish / treatment weight collectively, cultured fish species were captured randomly by using drag net from each experimental treatment and released back into their respective ponds after recording the data for wet body weight (WBW). After one month interval, on the basis of WBW, amount of organic and inorganic fertilizers added in fish ponds were determined for each treatment.

Wet body weight gain (wWG) (g) = mean final fish wWt.(g) - mean initial fish wWt.(g).

AGR (g/ day) = Final fish wt. (g) - Initial fish wt. (g)/ time (days).

Total fish production under different treatments: At the end of the experiment, total harvested fish of experimental fish species were weighed to calculate the total fish production.

Water and fish samples: The ponds were assigned to each treatment in a randomized design with three replicates per treatment. At the outlet of each pond variables of water quality and productivity were determined. Water samples were collected every 15 days from each pond from the middle of water column by a closed sample bottle and opened in the desired depth. This procedure was done in five different spots in each pond, the samples were mixed in a plastic bucket and 1 liter sample was taken as a representative water sample of each pond. These samples were taken 1 week after fertilizer application. At the time of sampling, water temperature, dissolved oxygen were measured in addition to their measurements two times weekly. Water temperature and dissolved oxygen were measured at 900 h, using dissolved oxygen meter model Orion 835 A, pH was measured by Acumen 25 meter, total alkalinity, orthophosphate (Po_4) nitrate (No_3), total ammonia nitrogen (TAN; $NH_{3/4}$) were determined according to Boyd (1990) and APHA (1985).

Primary productivity, primary gross, respiration and phytoplankton biomass were measured every 15 days, using the procedures suggested by Boyd (1990) and Arredondo-Figueroa and Ponce-Palafox (1998).

Statistical analysis: Values for fish yield and plankton biomass were determined for each pond, according to EIFAC (1980) guidelines. Analysis of variance was used to detect significant differences in biological factors between treatments (Duncan, 1955). Treatments were compared using the Tukey's test. The analyses were done using SAS (2005), (ver.9.1, SAS institute incorporation, Cary, NC27513USA for Windows package).

RESULTS AND DISCUSSION

As shown in Table (2) all of water quality parameters differ among treatments (P>0.05). All ponds were within the acceptable range of water quality parameters during the study.

As shown in Table (2), average water temperatures during the experiment ranged from 27.2±0.12 to 28.4 ±0.11 ºC. No significant differences (P≤0.05) were observed in water temperature among treatments. The highest value of water temperature in T1 (28.4±0.11) received sheep manure, may be attributed to the increase in organic matter contents of this pond that may lead to temperature increase.

This range was beneficial to fish culture and these are in agreement with results of Hussein and Abdel-Hakim(2003); Hussein (2009) and Ponce Palafox (2010).Results revealed that carp need at least 18 ºC minimum temperature for growth (Arredondo-Figueroa and Juarez, 1986), so there was no negative effect on the growth of polyculture.After temperature, dissolved oxygen concentrations of water is the most important variable in the pond culture system (Arredondo-Figueroa and Ponce-Palafox, 1998).

Table 2: Monthly average of water quality parameters and productivity data in carp polyculture in earthen ponds (in 180 days, mean ± SE).

Parameter	T1 Sheep manure	T2 Cow manure	T3 Inorganic fertilizer
Water temperature. (^{0}C)	28.4 ± 0.11[a]	27.9±0.14[a]	27.2±0.12[a]
Dissolved Oxygen (mg/L)	5.1 ±0.26[a]	5.8±0.35[a]	6.4±0.21[a]
pH	8.5±0.61[a]	8.9±0.72[a]	8.2± 0.49[a]
PO_4 (mg/L)	0.09±0.26[b]	0.04±0.56[c]	0.15±0.17[a]
Ammonium (mg/L)	0.04±0.07c	0.05±0.14b	0.09±0.11a
Primary Productivity (g C/m3/h)	1.13±0.55a	1.19±0.74a	1.05±0.70a
Gross productivity (g C/m3/h)	1.25±2.57a	1.31±2.17a	1.28±2.11a
Respiration (mg C/L/three hours)	0.53±0.22a	0.56±0.27a	0.62±0.45a

Means in the same row with different superscripts are significantly different at $p< 0.05$

The concentration of these variables wereranged between 5.1 ±0.26 - 6.4±0.21mg/ L throughout the culture (Table 2) , and were within the optimum range and higher than 5 mg/ L which reported by Boyd (1998) as the minimum desirable DO level in fish ponds. These are in agreement with results obtained byHussein (2009) and Ponce Palafox (2010). Concentrationsof dissolved oxygen in water was found above the minimum reported for these species (3.25 mg/L) in the region by Gonzalez *et al*. (2002), without affecting the growth of carp.

pH values ranged between 8.2± 0.49 (T3) and 8.9±0.61 (T2) and were insignificantly ($P\leq0.05$) influenced by the experimental treatments and this is in agreement with Boyd (1998) and Hussein (2009). Boyd (1990) reported that the application of ammonium and urea-based fertilizers can cause acidification of pond water because of nitrification, which produces two hydrogen ions from each ammonium ion. The orthophosphours (PO_4 -mg P/l) concentrations were fluctuated between 0.04±0.56 and 0.15±0.17 mg/l and were significantly ($P\leq0.05$) influenced by the experimental treatments. Ammonia concentrations (NH_4-mgN/l) were insignificantly ($P\leq0.05$) influenced by the experimental treatments and they ranged between 0.04±0.07 and 0.09±0.14 mg/l. These results show a slight increase in ammonia concentration with the increase of pH, which were in agreement with Hussein (2009). He reported ammonia concentrations of (0.22-0.30 mg/ L) in ponds fertilized with cow manure and inorganic fertilizers. Low concentrations of ammonia may be attributed to ammonia utilization by phytoplankton (Boyd, 1998) or oxidation of ammonia nitrite especially in high dissolved oxygen level conditions (Boyd, 2000). Total ammonia nitrogen fluctuated throughout the experiment but remained below 1 mg/ L at the pH levels observed. Unionized ammonia probably did not adversely affect fish performance. Major water quality parameters measured during the present study remained in the favorable range for fish culture Boyd (1990) suggested that fish growth performance was not limited by any of water quality parameters. Comparable results were obtained by Hussein (2009). Even though the values of physico-chemical characteristics of water ponds during the experimental period were within the acceptable limits for carps as indicated by Miranda-filho *et al*., (1996).

The phytoplankton, productivity and respiration were representative for the open waters of the whole ponds. Chlorophytes were the dominant phytoplankton group in the culture ponds throughout the experiment. They were followed by the Bacillariophytes and Cianophytes (Table 3). Padmavathi and Prasad (2009); Hussein

(2009) and Ponce Palafox (2010) in carp ponds found that the major groups of phytoplankton present were also those reported in this study. There was high concentration of *Cianophytes*, *Chlorophytes*, *Euglenophytes* and *Bacilariophytes* in cow manure, and *Chlorophytes* in sheep manure and mineral fertilizer. Phytoplankton was represented by 40 genera, 16 of which were found more frequently in the system. Debeljak and Adamek (1994) and Ponce Palafox (2010) found that the structure of phytoplankton in fish ponds with the poultry fertilizer made up 131 species, and in the fish ponds treated with the mineral fertilizer 105 species. Relative abundance of plankton was changed with time. *Chlorophytes* being the most dominant species in the cold season and *Bacil ariophytes* and *Cianophytes* in the warm season. The dominant species was *Chlorophytes* with significant difference ($p< 0.05$).

The Use of inorganic and organic fertilizers improved water quality through stimulation of natural food, mainly phytoplankton and zooplankton, suitable for the filter feeding carp species. Organic fertilizers act as an energy source for bacterial growth, but the aerobic decomposition of organic matter by bacteria was an important drain of oxygen supplies in ponds (Boyd, 1982). Both phytoplankton and zooplankton biomass were significantly higher in ponds with improved fertilization compared to ponds with poor nutrition. Total ammonia nitrogen varied throughout experiment but remained below 1 mg/ L at the pH levels observed. Major water quality parameters measured during the study remained in the favorable range for fish culture (Boyd, 1990), suggesting that cultured fish growth performance was not limited by any of the water quality parameters. Comparable results were obtained by Lawson (1995); Hussein (2009) and Ponce Palafox (2010).

Table 3: Phytoplankton groups (cells/mL) on carp ponds.

Group	T1 Sheep manure	T2 Cow manure	T3 Mineral fertilizer
Cianophytes	$288{,}730^{b}$	$395{,}590^{a}$	$252{,}470^{c}$
Chlorophytes	$987{,}570^{a}$	$445{,}986^{b}$	$394{,}230^{c}$
Euglenophytes	$89{,}110^{c}$	$175{,}050^{a}$	$154{,}650^{b}$
Bacilariophytes	$459{,}316^{a}$	$399{,}790^{b}$	$283{,}280^{c}$
Total	$1{,}824{,}726^{a}$	$1{,}416{,}416^{b}$	$1{,}084{,}630^{c}$

Means in the same row with different superscripts are significantly different at $p< 0.05$

These conditions seem to be good for the growth of fish species, especially for the filter-feeding ones. It was found that in ponds fertilized with sheep and cow manures higher concentrations of phytoplankton were shown (1,824,726 and 1,416,416 cells/ml, respectively) that are significantly ($p <0.05$) higher than in ponds where chemical fertilizer was applied (1,084,630 cells/ml). These concentrations of phytoplankton are higher than those reported by Molina-Astudillo *et al*. (2003) and Ponce Palafox (2010) in carp ponds fertilized with cow manure (17,008 to 630,731 cells/ml and 1,157,706, 945,940 and 744,560 cells/ml). Noriege-Curtis (1979) reported that fish production in intensively manured ponds was not exclusively due to primary production, but also to heterotrophic production.Net primary productivity in organic fertilized ponds in Hondoras was significantly greater than in inorganic fertilized ponds (Green *et al*.,1989a & b and 1990a and Ponce Palafox, 2010).

Respiration was evaluated by means of light and dark bottles, with an average value from 0.53 to 0.62 mg C/L/three hours (25% gross photosynthesis). Respiration had a similar trend in animal manure treatments .Gross photosynthesis maintained an increasing tendency of 0.95 to 1.0 mgC/L /three hours and primary productivity with values fluectuated between 1.05 and 1.19 mgC/L/three hours. Primary productivity revealed a differential pattern between organic manures and mineral fertilizers. These are in agreement with results of Ponce Palafox (2010).

In the present study, the final average biomass (kg) yield of carp was significantly ($p < 0.05$) more in mineral fertilizer ponds (2370.6 kg/fed.) than in cow (1948.8 kg/fed.) and sheep (1687.4 kg/fed.) manure ponds (Table 4).

Table 4: Production, yield and survival data in carp polyculture.

Parameter	T1 Sheep manure	T2 Cow manure	T3 Mineral fertilizer
Surface area (m^2)	4200±170a	4200±210a	4200 ±180a
Number of fish / pond	10,000	10,000	10,000
Av. Biomass initial (kg):	285.3±1.82a	292.6±1.44a	287.2 ±1.3a
Grass carp (20%)	34.2x2000=68.4	33.6x2000=67.2	34.4x2000=68.8
Silver carp (15%)	28.1x1500=42.15	27.9x1500=41.85	28.7x1500=43.05
Bighead carp (15%)	24.5x1500=36.75	26.7x1500=40.05	27.2x1500=40.8
Common carp (50%)	27.6 x5000 =138	28.7x5000=143.5	26.9x5000=134.5
Av. Biomass final (kg)	1687.4±133.3c	1948.8±193.4b	2370.6±85.7a
Av. Fish yield (kg/fed./day)	7.79 ± 1.95a	9.20 ±1.24b	11.57 ± 0.67a

Means in the same row with different superscripts are significantly different at $p < 0.05$

Data showed that the different fish species cultured in polyculture system performed better in treatment 3 (inorganic fertilization) followed by treatment 2 (cow manure), while lowest growth was observed in treatment 1 (sheep manure). Similar observations were detected by Ponce Palafox (2010). Pond fertilization plays an important role in meeting nutrient deficiency as well as stimulating plankton production and functioning through autotrophic and heterotrophic pathways (Bhakta *et al*., 2004; Sahu *et al.,* 2007; Hussein, 2009 and Ponce Palafox, 2010).

Results revealed that the total average fish yield (kg/fed./day) gains of carps in three treatments were 7.79, 9.20 and 11.57 kg/ fed./ day, respectively. This revealed that the total weight gain of carp was greater in T3 and T2 followed by T1. Lower value was found in T1, which was different from the three treatments.

In general, the final biomass obtained from 1687.4 to 2370.6 kg / fed. was within that reported by Gonzalez *et al*. (2002) Hussein (2009) and Ponce Palafox (2010) for carp polyculture without supplemental feed

Added manure or fertilizer had a positive effect (Vromant *et al*., 2002) on the dissolved oxygen, phytoplankton and primary productivity. All the treatments did not degrade the physico-chemical properties of water (Ponce-Palafox *et al*., 1994). The sheep and cow manures cause wide fluctuations in the water quality, mainly dissolved oxygen concentration which is shown in the largest standard deviations of 5.8 and 6.4 (mg/L) for sheep and cow fertilizers, respectively, and lower in the mineral fertilizer (5.1 mg/L). The ammonium was significantly higher in the mineral fertilizer (0.09 mg/L). Information about the potential production level of a fertilized fishpond is indispensable for its rational management. From the data collected by Barbe *et al*. (1999) statistical treatment evidenced relationships between phytoplankton types, chlorophyll a densities and fish production levels. Combining both five typical groups of phytoplankton and five different concentrations of chlorophyll a arranged into a grid, it was possible to determine the potential fish production of the ponds (up to over 2000 kg/fed.).

In general, an inverse relationship was found between the abundance of phytoplankton and fish yield and a direct relationship appeared between yield and concentrations of dissolved oxygen in pond water. The general conditions were adequate to obtain high yields without commercial feeds (2.0 ton/fed.), higher than those found in temperate regions (0.72 ton/Ha) of Europe (Nikolova *et al*., 2008a&b) and the application of organic manures can be recommended because of their availability and low cost.

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Arabic Summary

تأثير التسميد العضوى والكيماوى على أداء النمو , العوالق النباتية , وأنتاج الأسماك فى نظام الأستزراع متعدد الأنواع للمبروك (الشبوطيات)

محسن صالح حسين
قسم الأنتاج الحيوانى (شعبة أنتاج الأسماك) بكلية الزراعة - جامعة الأزهر - مصر.

تهدف هذه الدراسة الى بيان آثار كل من الأسمدة العضوية (روث الغنم وروث البقر)،والأسمدة الكيماوية على العوالق النباتية،و الأنتاجية الابتدائية وإنتاج تربية الأحياء المائية في أستزراع شبه مكثف لسمك المبروك في الأحواض الأرضية. و قد أوضحت النتائج أن المتوسط النهائي للكتلة الحية (كجم) 1687.4، 1948.8 و 2370.6 كجم / فدان، على التوالي في المعاملات T1،T2وT3.وتم الحصول على أعلى محصول من الأسماك مع المعاملة بالأسمدة الكيماوية 11.57 كجم / فدان / يوم ،تليها المعاملة مع روث البقر (9.20 كجم / فدان / يوم) وروث الأغنام (7.79 كجم / فدان / يوم). ووجد أيضا أن التركيزات من العوالق النباتية كانت معنويا (P<0.05) أعلى في ألأحواض المخصبة مع الأغنام وروث البقر (1824726 و 1416416 خلية / مل،على التوالي) مما كانت عليه في الأحواض التي استخدمت فيها الأسمدة كيميائية (1084630 خلية / مل). وكانت جودة المياه تختلف بين المعاملآت (P>0.05). وكانت جميع الأحواض ضمن نطاق مقبول من معاييرجودة المياه خلال هذه الدراسة.

بشكل عام، كانت الظروف ملائمة للحصول على عوائد عالية دون استخدام التغذية التجارية، وعليه يمكن أن أوصى الدراسة باستخدام الأسمدة العضوية بسبب توافرها وتكلفتها المنخفضة.