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Effect of stocking density and feeding rate of *Oreochromis niloticus* on water quality and abundance of phytoplankton in aquaculture earthen ponds

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ABSTRACT

The present work aimed to study the effect of stocking density and feeding rates of *Oreochromis niloticus* on water quality and abundance of phytoplankton in earthen ponds. This experiment was conducted in 12 earthen ponds at Parsik Culture, Idko, Behira Governorate, Egypt. The ponds have the same area of about 2 feddan with an approximately average depth of 1m. Monosex fries of *Oreochromis niloticus* reared for 214 days with different stocking densities and feeding rates (**T_1**: stocking density of 6 fish/m^3 with feeding rate of 2.5%; **T_2**: stocking density of 6 fish/m^3 with feeding rate of 3.5%; **T_3**: stocking density of 8 fish/ m^3 with feeding rate of 2.5% and **T_4**: stocking density of 8 fish/ m^3 with feeding rate of 3.5%), each treatment had three replicates.

Results showed that the highest average values of salinity(‰), total dissolved solids (mg/l), hydrogen ion concentration, total hardness (mg/l) and total nitrite (mg/l) were recorded in **T_1** and **T_2** (low stocking fish densities); while their lowest values were recorded in **T_3** and **T_4** (high stocking fish density). On the other hand, the highest average values of chlorophyll a (µg/l) were recorded in **T_3** and **T_4** and their lowest values were recorded in **T_1** and **T_2**. The highest average value of dissolved oxygen content (mg/l) was recorded in **T_2** and **T_4** (high feeding rate), while the lowest average was recorded in **T_1** and **T_3** (low feeding rate). Total nitrate (mg/l) and orthophosphate had the reverse trend of these results. The maximum average value in abundance of phytoplankton specimens was recorded in **T_4** (222728667±37584559 organism/l) and the lowest occurred in **T_2** (156813467±22022381 organism/l). The variations in phytoplankton abundance were generally non-significant between the different experimental treatments. Four divisions of phytoplankton were recorded in the experimental fish ponds; Chlorophyceae, Cyanophyceae, Bacillorophyceae and Euglinophyceae. The most abundant division in all experimental fish ponds was Chlorophyceae (42.46%); followed by Euglinophyceae (33.85%).The variations in abundance of these phytoplankton divisions were statistically significant.The phytoplankton abundance was greatly varied in each treatment ponds during different months of the experiment. Generally, it reached the highest averages during the period of September-November in all treatments, and the lowest averages were recorded during June. The results concluded that the highest stocking density (8fish/m^3) with low feeding rate (2.5%) was positively correlated with best water quality and high abundance of phytoplankton in earthen ponds of *Oreochromis niloticus*.

INTRODUCTION

The aquaculture industry accounted for over 45% of all sea food consumed. That will have been projected to increase to 75% over the next years (FTU, 2007).

In Egypt, the total fish production in 2016 was estimated at 1706273 tons, of which 80% from aquaculture and 20% from natural fisheries. The production of Nile Tilapia, *Oreochromis niloticus* forms 68.6% from the total aquaculture and natural production in Egypt (GAFRD, 2016). Fish importance as the food source of animal protein was increased with the increases in demands (Azab *et al*., 2005). A great attention has been paid to establishment of fish farms. These farms could contribute partially in producing the demanded on animal protein sources consumed by human (Ashour *et al*., 2018).

Tilapia is an ideal candidate for worm water aquaculture. They received considerable attention in many countries because of their good aquaculture potential; they are widely distributed in the world. The importance of *Oreochromis niloticus* stems from biological reasons (fast growth, short food chain, high food conversion ratio, readily accepting the artificial feeds, ease of breeding in captivity, disease resistance, high fecundity), social reasons (good table food quality, good market price) and physical reasons (tolerant to a wide range of environmental conditions). These attributes, along with relatively low input costs have made tilapia widely cultured freshwater fish in tropical and subtropical countries (Soliman, 2015; Samir *et al*., 2017and Abdel-Naby *et al*., 2017).

However, the determination of stocking density for cultured tilapia is essential for the maximization of its production, profitability and sustainability. This is because stocking density is one of the factors that could potentially affect fish survival (Houde, 1977) and production performance (Luz &Zanibonifilho, 2002), so it must be considered when determining the economic profitability of production systems (Gomes *et al*., 2000). Furthermore, the use of the appropriate density is a commercially beneficial operation, focusing on maximizing the utilization of the rearing system, water and financial resources (Fairchild & Howell, 2001). The growth and production of fish depend on regulating the quantity of feeds required to produce the maximum growth and this can be achieved by variations in the feeding rates (Kheir & Mohammed, 2001).

Management procedures (stocking densities, feeding rate, sediment removal, fertilizing) of fish ponds are the key to sustainable fish production and directly affect the ecological processes developing in the water column. The water quality management in the fish pond shows a direct influence on planktonic population, since fish ponds are shallow and constantly receive large nutrient loads (feed and fish waste) which contribute towards algal growth. Excessive phytoplankton growth could be avoided by limiting nutrients to plankton growth through fish feed deprivation periods. The length of the latter may be sufficient so that phosphorus and nitrogen may be depleted and phytoplankton abundance decreased (Turano *et al*., 2008 and Soltan *et al.*, 2016).

In aquaculture, fish productivity mainly depends on aquaculture ecosystems, especially water quality. Poor water quality causes decrease of fish productivity, increase of production costs and risk of diseases. In addition, it has negative effects on the environment, human health, laborers and consumers. *O. niloticus* is one of the most important cultured freshwater fish over the world. *O. niloticus* can tolerate a wider range of environmental conditions such as DO, pH, NO_3, NO_2 and ammonia levels. Therefore, this fish can easily culture and adaptable to a wide range of environmental conditions (El-Sayed, 2006 and Ashour *et al*., 2018).

In the case of aquaculture, the maintenance of good water quality is of primary importance, so that excellent culture environment, adequate feed for optimal fish yield potential, and increase in plankton population may be achieved. Therefore, the present investigation aimed to analyze the effect of stocking density and feeding rates of *Oreochromis niloticus* on water quality and abundance of phytoplankton in aquaculture earthen ponds.

MATERIALS AND METHODS

Fish and experiment design:

This experiment was conducted in twelve aquaculture earthen ponds at Parsik Culture, Idko, Behira Governorate, Egypt. The ponds have the same area of about 2 feddan with an approximately average depth of 1m and filled in through agriculture drainage water from El Khairy drainage. Monosex fries of Nile Tilapia, *Oreochromis niloticus* (initial length= 2.45± 0.07 & initial weight= 0.45± 0.06), reared for 7 months extended from May to November, 2016 (for 214 days) with different stocking densities and feeding rates {(**T_1**): stocking density of 6 fish/m^3 (25000 fry/ feddan) with feeding rate of 2.5%; (**T_2**): stocking density of 6 fish/m^3 (25000 fry/ feddan) with feeding rate of 3.5%; (**T_3**): stocking density of 8 fish/ m^3 (33000 fry/ feddan) with feeding rate of 2.5% and (**T_4**): stocking density of 8 fish/ m^3 (33000 fry/ feddan) with feeding rate of 3.5%}, each treatment had three replications. Fish were fed twice daily, six days a week on diet containing 18% protein. All treatment fish were fed at feeding rate of 10%, 7%, 5% and 4% of fish biomass during May, June, July and August respectively. The rates of feeding were changes to 2.5% of biomass in treatments **T_1&T_3** or 3.5% of biomass in treatments **T_2&T_4** during September, October and November respectively. The feeding rate adjusted at monthly intervals, where the fish were randomly selected by dragging a net in the ponds, weighed; and the average fish weight was obtained and the monthly feed intake (g feed / fish /month) was calculated for each bond. Half of the water volume, for all earthen ponds, was weekly replaced.

Water analysis:

Water samples were taken by a vertical PVC water sampler at depth of a half meter from the water surface. Samples at each pond of each treatment were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle and transferred to the laboratory for analysis.

Water quality of the ponds was checked every month to determine salinity, total dissolved salts (TDS), hydrogen ion concentration (pH), dissolved oxygen (DO) and temperature (°C) were measured in the ponds at the time of collection water sample. The alkalinity, total hardness (mg/l as $CaCO_3$), nitrite (NO_2-N), nitrate (NO_3-N)}, orthophosphate and chlorophyll a content (µg/l) were carried out in the Limnology and Plankton Laboratories of the Central Laboratory for Aquaculture Research (CLAR).

Total dissolved salts (TDS) were determined using a salinity-conductivity meter (model, YSI EC 300). Hydrogen ion concentration was measured with a pH meter (Model 25, Fisher Scientific). Temperature ($T^{°C}$) and dissolved oxygen (DO, mg/l) were measured by using a digital oxygen meter (Model YSI 55). The concentration of alkalinity (mg/l), total hardness (mg/l as $CaCO_3$) (APHA, 1992), total nitrite (NO_2-N, mg/l), nitrate (NO_3-N, mg/l), orthophosphate (mg/l) and chlorophyll a content (µg/l) were measured by methods described in Boyd & Tucker (1992).

Phytoplankton (%):

One liter of water was monthly collected from each experimental fish pond in polyethylene bottles. Phytoplankton in the sample was concentrated by settling 1000 ml sample in a volumetric cylinder for about 24 hours after being preserved in lugols̉ solution (APHA, 1992). One ml of sample was transferred into Sedgwick-Rafter cell and microscopically counted. Three replicates of each sample were investigated.

All phytoplankton organisms were counted to genus level and estimated as organisms per cubic meter, according to the following formula: N= n (v/V) * 1000

Where, N: Total number of phytoplankton per cubic meter, n: Average number of phytoplankton in 1 ml of the sample, v: Volume of phytoplankton concentrates (ml). V: Volume of total water filtered (L).

Different phytoplankton genus was identified according to Bellinger and Sigee (2010). Phytoplankton species were belonging to four divisions, which are: green algae (Chlorophyceae), blue-green algae (Cyanophyceae), diatoms (Bacillari-ophyceae), and Euglena (Euglinophyceae) and different genus were identified and counted. All colonial, filamentous or unicellular organisms were counted as one unit (organism).

Statistical analysis:

Data of different phytoplankton divisions in different experimental groups were analyzed by using the All Pairwise Multiple Comparison Procedures by Holm-Sidak Method (Holm, 1979) at 95% confidence. Also, these data were analyzed by grouping information using the Tukey Pairwise Comparison Method (Tukey, 1949) at 95% confidence of data was conducted by using Microsoft Excel and SPSS under windows programs.

RESULTS

Water quality:

Results of water quality of *Oreochromis niloticus* fry, reared in 12 earthen ponds for seven months with different stocking densities and feeding rates were given in Table (1).

Data in Table (1) showed that, the highest average value of salinity (2.10 ± 0.87 ‰) was recorded at $\mathbf{T_1}$. It gradually decreased (1.77 ± 0.46 ‰) at $\mathbf{T_2}$ and reached to its lowest values (1.634 ± 0.359 ‰) at $\mathbf{T_3}$ and (1.629 ± 0.386 ‰) at $\mathbf{T_4}$.The highest average value of total dissolved solids (4.24 ± 1.73mg/l) was recorded at $\mathbf{T_1}$. It gradually decreased in bonds of $\mathbf{T_2}$ (3.62 ± 0.91 mg/l), followed by bonds of $\mathbf{T_3}$ (3.44± 0.70 mg/l) and reached to its lowest value (3.32 ± 0.70 mg/l) in bonds of $\mathbf{T_4}$.

Data in Table (1) showed that, the highest average values of hydrogen ion concentration (8.39 ± 0.21 & 8.39 ± 0.16) were recorded at $\mathbf{T_1}$ and $\mathbf{T_2}$ respectively, while, the lowest average values of pH were conducted at $\mathbf{T_3}$ (8.30 ± 0.19) and $\mathbf{T_4}$ (8.30 ± 0.21) respectively. The average values of dissolved oxygen content ranged between 6.20 ± 1.14 mg/l at $\mathbf{T_1}$ to 7.61 ± 2.47 mg/l at $\mathbf{T_4}$. The average values of water temperature ranged between 19.46 °C and 30.73 °C in all treatments.

Results in Table (1) showed that, the average values of total alkalinity ranged between 281.94±52.54 to 312.77 ± 29.34 mg/l at $\mathbf{T_3}$ and $\mathbf{T_4}$ respectively**.** The highest average value of total hardness (1634.76 ± 387.09 mg/l) was recorded at $\mathbf{T_1}$. It gradually decreased to 1154.72± 390.36 and 1117.22± 442.16 mg/l at $\mathbf{T_2}$ and $\mathbf{T_3}$**,** and reached to its lowest value (1096.11 ± 459.73mg/l) at $\mathbf{T_4}$.

Data in Table (1) showed that, the highest average value of total nitrite was 0.09 ± 0.07mg/l at **T_1** and the lowest average value was 0.076 ± 0.064 mg/l at **T_4.** The highest average value of total nitrate (0.36 ± 0.29mg/l) was recorded at **T_3** and the lowest average value (0.29 ± 0.18 mg/l) was recorded at **T_2**.

Data in Table (1) showed that, the highest average value of Orthophosphate (0.25 ± 0.10mg/l) was recorded at **T_3** and the lowest average value (0.22 ± 0.11 mg/l) occurred at **T_4**. The highest average value of Chlorophyll (232.45 ± 143.05 µg/l) was recorded at **T_4** and the lowest average value (174.56 ± 36.10 µg/l) occurred at **T_2**.

Table 1: Variations of water quality (Mean± SD) of *Oreochromis niloticus* fry, reared in earthen ponds for seven months with different stocking densities and feeding rates

Water quality Parameters		**Low stocking density**		**High stocking density**	
		Low feeding rate	**High feeding rate**	**Low feeding rate**	**High feeding rate**
		T1	**T2**	**T3**	**T4**
Salinity, S (‰)	**Range**	1.30 – 3.60	1.40 – 2.56	1.26 – 2.30	1.23 – 2.36
	Mean± SD	2.103 ± 0.871	1.773 ± 0.462	1.634 ± 0.359	1.629 ± 0.386
Total dissolved solids (mg/l)	**Range**	2.66 – 7.26	2.9 – 5.13	2.56 – 4.66	2.53 – 4.83
	Mean± SD	4.24 ± 1.73	3.62 ± 0.91	3.44± 0.70	3.32 ± 0.70
Hydrogen ion concentration	**Range**	8.2 – 8.46	8.23 – 8.63	8.03 – 8.56	8.03 – 8.70
	Mean± SD	8.39 ± 0.21	8.39 ± 0.16	8.30± 0.19	8.30 ± 0.21
Dissolved Oxygen content, (mg/l)	**Range**	5 – 8.33	4.7 – 9.66	4.5 – 9.13	4.9 – 11.16
	Mean± SD	6.20 ± 1.14	7.44 ± 2.18	6.65±2.01	7.61 ± 2.47
Temperature (°C)	**Range**	19.66 – 30.73	19.46 – 30.3	19.8 – 30.06	19.83 – 29.70
	Mean± SD	25.77 ± 4.36	25.68 ± 4.29	25.64 ± 4.23	25.45 ± 4.22
Total alkalinity (mg/l)	**Range**	268.33 – 358.33	215 – 375	225 - 350	286.7 – 356.66
	Mean± SD	311.1 ± 37.66	293.19 ± 63.25	281.9± 52.54	312.8 ± 29.34
Total hardness (mg/l)	**Range**	1166.6 – 2333.33	900 – 1933.33	800 – 1966.66	803.3 – 2000
	Mean± SD	1634.76 ± 387.09	1154.7± 390.36	1117.2± 442.16	1096.1 ± 459.73
Total nitrite (mg/l)	**Range**	0.028 – 0.214	0.035 – 0.23	0.028 – 0.164	0.029 – 0.19
	Mean± SD	0.09 ± 0.07	0.088 ± 0.074	0.08 ± 0.05	0.076 ± 0.064
Total nitrate (mg/l)	**Range**	0.106 – 0.637	0.102 – 0.571	0.095 – 0.884	0.079 – 0.567
	Mean± SD	0.34 ± 0.18	0.29 ± 0.18	0.36 ± 0.29	0.33 ± 0.27
Orthophosphate (mg/l)	**Range**	0.101 – 0.345	0.088 – 0.451	0.075 – 0.379	0.102 – 0.354
	Mean± SD	0.24 ± 0.09	0.23 ± 0.18	0.25 ± 0.10	0.22± 0.11
Chlorophyll (µg/l)	**Range**	154.43 – 281.52	133.98 – 228.83	143.82 – 337.03	125.26 – 513.19
	Mean± SD	204.81± 47.74	174.56 ± 36.10	220.81± 68.27	232.45 ± 143.05

Phytoplankton analyses:

Abundance of phytoplankton:

The average number of the total phytoplankton was $590.98*10^6 \pm 94.394*10^6$ organism/l. The maximum average number of phytoplankton ($222.7*10^6 \pm 37.58*10^6$ organism/l) was recorded in the ponds of **T_4**. This average decreased in ponds of **T_3** ($221.4*10^6 \pm 16.80*10^6$ organism/l), and **T_1** ($187.0*10^6 \pm 17.4*10^6$ organism/l), and reached to its minimum value ($156.8*10^6 \pm 22.02*10^6$ organism/l) in ponds of **T_2**. The variations in phytoplankton abundance were generally non-significant between the different experimental treatments (Table 2 and Fig. 1).

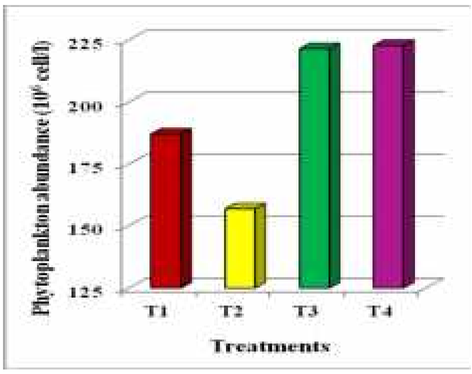

Fig. 1: Average phytoplankton abundance (10^6 organism/l) in different treatment ponds during the period of experiment.

Table 2: Total phytoplankton count x10^6 and abundance of phytoplankton taxa (% of total number), in earthen ponds of different treatments, during the experiment period.

Division	Genus		Treatments				Whole ponds
			T_1	T_2	T_3	T_4	
Chlorophyceae	*Chlorella*		4.0	3.67	5.38	3.79	4.26
	Crucigenia		3.59	3.55	3.38	3.62	3.53
	Scenedesmus		4.62	4.41	3.64	4.05	4.14
	Kirchneriella		2.77	1.60	2.25	1.81	2.12
	Pediastrum		0.92	0.98	2.17	1.72	1.51
	Closterium		2.26	1.96	2.69	2.67	2.44
	Cosmarium		3.08	0.73	1.99	0.60	1.61
	Chlamdomonas		4.62	5.88	4.86	4.65	4.95
	Staurastrum		1.25	1.95	2.17	2.07	1.88
	Tetradroen		1.85	2.07	2.08	2.33	2.09
	Protococcus		3.90	3.92	3.56	3.28	3.63
	Tetrastrum		1.54	1.22	0.95	1.21	1.22
	Schroederia		5.75	7.04	5.77	7.07	6.38
	Microspora		3.28	2.37	3.21	1.90	2.69
	Total (%)	**Average**	**43.1 A**	**41.5 A**	**44.0 A**	**41.3 A**	**42.46 A**
		SD	**5.64**	**4.72**	**2.14**	**6.91**	
Cyanophyceae	*Anabaena*		4.93	1.76	1.13	1.64	2.30
	Merisomopedia		2.36	2.94	3.64	3.53	3.17
	Gleocapsa		4.52	4.53	4.16	3.53	4.14
	Microcystes		2.46	2.33	2.95	1.81	2.39
	Total (%)	**Average**	**14.3 B**	**11.8 B**	**11.8 B**	**10.7 B**	**12.00 B**
		SD	**1.47**	**2.90**	**0.90**	**1.75**	
Bacillorophyceae	*Cyclotella*		6.77	7.06	8.98	11.81	8.87
	Synedra		2.87	1.10	2.95	1.90	2.27
	Tabellaria		0.51	0.73	0.35	0.43	0.49
	Diatoma		0.10	0.12	0.00	0.09	0.07
	Total (%)	**Average**	**10.2 B**	**9.0 B**	**12.2 B**	**13,6 B**	**11.70 B**
		SD	**4.66**	**0.13**	**1.66**	**6.08**	
Euglinophyceae	*Euglena*		15.9	22.28	16.39	18.66	17.90
	Phacus		8.83	9.18	6.85	6.64	7.72
	Trachelomonas		5.23	3.67	4.77	6.99	5.29
	Lepocinclis		2.87	2.94	3.73	2.19	2.93
	Total (%)	**Average**	**32.4**	**37.7 C**	**31.9 C**	**34.4 C**	**33.85 C**
		SD	**7.69 C**	**4.69**	**3.99**	**2.78**	
Totals organism*10^6/ l		**Average**	**187.0 NS**	**156.8 NS**	**221.4 NS**	**222.7 NS**	**590.98**
		SD	**17.4**	**22.02**	**16.80**	**37.58**	**94.394**

Averages that do not share a letter, are significantly varied; NS: non-significant, SD: standard deviation.

Four divisions of phytoplankton were recorded in the experimental fish ponds, which are: Chlorophyceae, Cyanophyceae, Bacillorophyceae and Euglinophyceae. The most abundant division in all experimental fish ponds was Chlorophyceae (with whole average of 42.46% of the total number of phytoplankton specimens); followed by Euglinophyceae, with whole average of 33.85% of the total number of phytoplankton specimens. The variations in abundance were statistically significant between different phytoplankton divisions (Table 2 and Fig. 2).

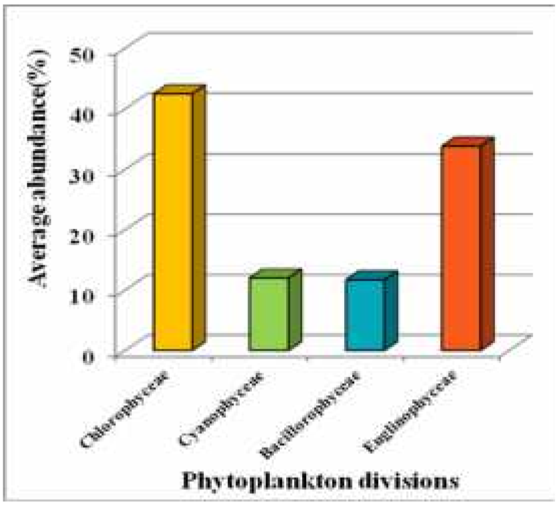

Fig. 2: Average abundance (% of the total phytoplankton number of whole experimental ponds) of different phytoplankton divisions, during the period of experiment.

Data in Table (2) showed that *Schroederia* and *Chlamdomonas* were the most abundant taxa of Chlorophyceae, representing 6.38% and 4.95% of the total number of phytoplankton specimens, respectively. *Tetrastrum* and *Cosmarium* were the minor component of Chlorophyceae**.**

The highest average value of Chlorophyceae abundance (% of the total number of phytoplankton specimens in the treatment ponds) was recorded in $\mathbf{T_3}$ (44.0±2.14 %), followed by $\mathbf{T_1}$ (43.1±5.64%) and reached to its lowest values (41.5±4.72 % and 41.3±6.91 %) in $\mathbf{T_2}$ and $\mathbf{T_4}$, respectively (Table 2 and Fig. 3).

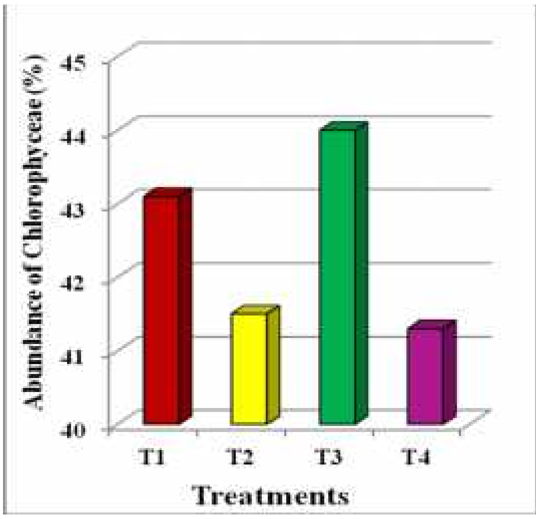

Fig. 3: Average Chlorophyceae abundance (as % of the total number of phytoplankton in each treatment) during the period of experiment

Data in Table (2) showed that *Gleocapsa* was the most abundant component of Cyanophyceae, representing 4.14% of the total number of phytoplankton specimens. *Anabaena* was the minor component of Cyanophyceae. The maximum average value of Cyanophyceae abundance (% of the total number of phytoplankton specimens in the treatment ponds) was recorded in $\mathbf{T_1}$ (14.3±1.47 %) and the minimum average (10.7±1.75 %) occurred in $\mathbf{T_4}$**.**

Data in Table (2) showed that *Cyclotella* was the most dominant taxa of Bacillorophyceae, representing 8.87% of the total number of phytoplankton specimens. *Diatoma* was the minor taxa of Bacillorophyceae (0.07%).The highest average value in Bacillorophyceae abundance (% of the total number of phytoplankton specimens in the treatment ponds) was recorded in $\mathbf{T_4}$ (13.6±6.08 %). This value gradually decreased to 12.2±1.66 % and 10.20±4.66% in $\mathbf{T_3}$ and $\mathbf{T_1}$ respectively. The lowest value (9±0.13 %) was recorded in $\mathbf{T_2}$.

Euglena was the main taxa, representing 17.9 % of the total number of phytoplankton specimens. *Lepocinclis* was the minor one of Euglinophyceae (2.93 %).The highest average value of Euglinophyceae abundance (% of the total number of phytoplankton specimens in the treatment ponds) was recorded in $\mathbf{T_2}$ (37.7±4.69 %). It gradually decreased to 34.4±2.78 % and 32.4±7.69 %in$\mathbf{T_4}$, and $\mathbf{T_1}$, respectively. It reached to its minimum abundant value (31.9±3.99 %) in $\mathbf{T_3}$ (Table 2 and Fig. 4).

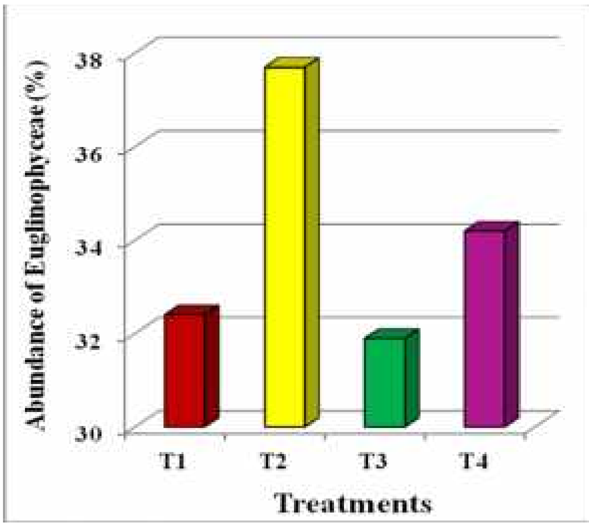

Fig. 4: Average Euglinophyceae abundance (as % of the total number of phytoplankton in each treatment) during the period of experiment

Monthly variation in abundance of phytoplankton:

The highest average value in monthly abundance of all phytoplankton groups ($37.1*10^6 \pm 27.41*10^6$ organism/l) was recorded in $\mathbf{T_4}$. It gradually decreased to $36.9*10^6 \pm 18.33*10^6$ organism/l and $31.2*10^6 \pm 16.47*10^6$ organism/l in $\mathbf{T_3}$ and $\mathbf{T_1}$, respectively. It reached to its lowest value ($26.1*10^6 \pm 23.73*10^6$ organism/l) in $\mathbf{T_2}$.The phytoplankton abundance was greatly varied in each treatment ponds during different months of the experiment. Generally, it reached the highest averages during the period of September-November in all treatments, and the lowest averages were recorded during June (Table 3 and Fig. 5).

The highest average value in monthly abundance of Chlorophyceae (41.8±15.82 %) was recorded in $\mathbf{T_1}$. It gradually decreased (39.1±17.27 %) in $\mathbf{T_3}$, followed by $\mathbf{T_4}$ (35.9±17.65 %) and reached to its lowest value of 32.7±26.20 % in $\mathbf{T_2}$. Monthly variation in abundance of phytoplankton groups showed that Chlorophyceae was more abundant in September and less abundant in July. It was entirely absent in$\mathbf{T_2}$at July and August (Table 3).

Results showed that, the maximum average value in monthly abundance of Cyanophyta (16.5±10.76 %) was recorded in T_1 and the minimum value (7.4±5.98 %) occurred in $\mathbf{T_4}$. Monthly variation in abundance of phytoplankton groups showed that Cyanophyceae was more abundant in July and less abundant in June. It was entirely absent in $\mathbf{T_2}$ at June and July and in $\mathbf{T_4}$ at June and August (Table 3).

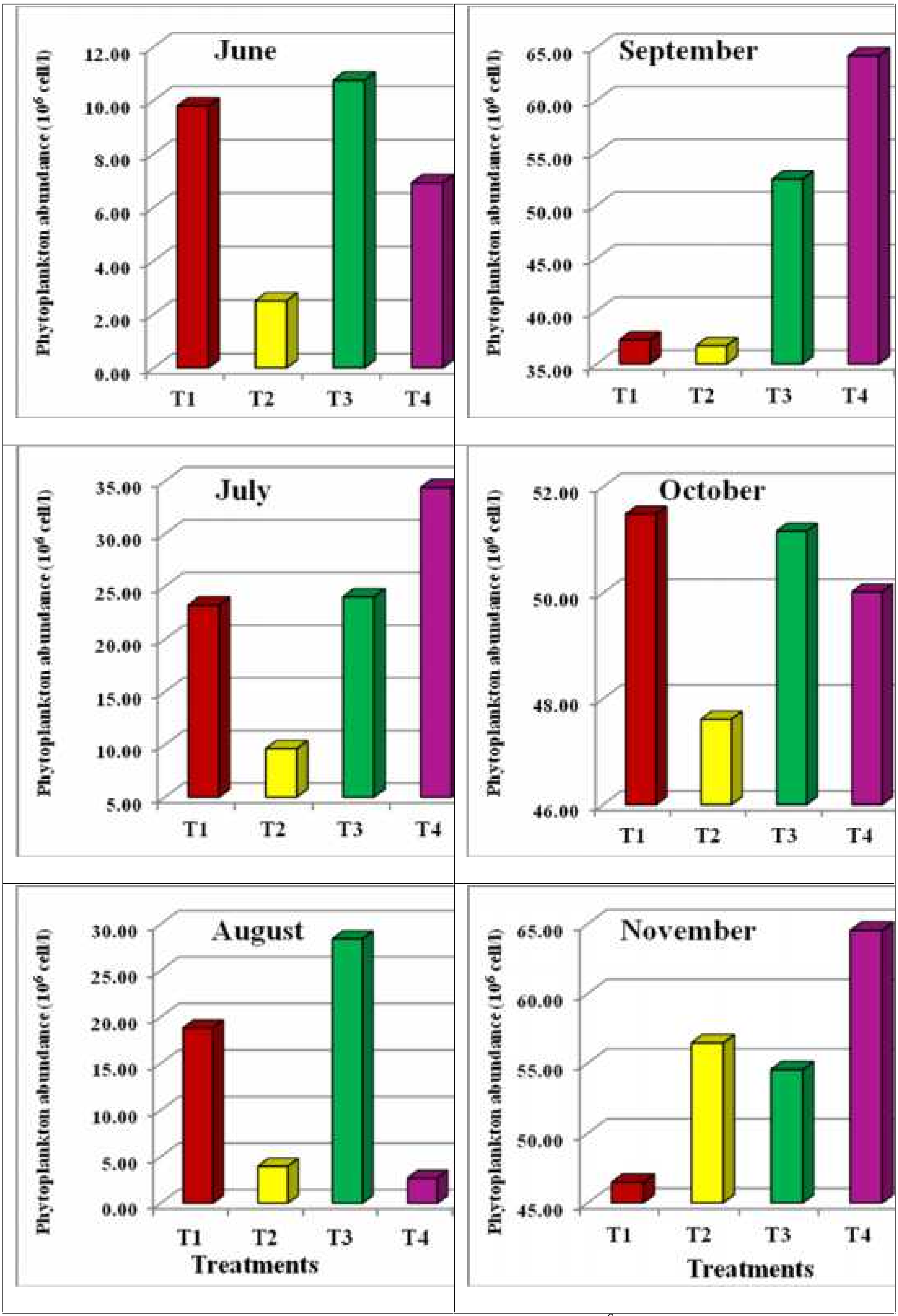

Fig. 5: Monthly variation in the average phytoplankton abundance (10^6 organism/l) in each treatment, during the period of experiment

Table 3: Monthly variation in total phytoplankton count x10^6 and abundance of phytoplankton groups (% of total number), in earthen ponds of different treatments

Division	Month		Treatments			
			T_1	**T_2**	**T_3**	**T_4**
Chlorophyceae	**June**		50.98	61.54	25.00	30.56
	July		9.92	0.00	10.40	4.47
	August		43.88	0.00	51.35	35.71
	September		50.00	43.82	51.92	55.32
	October		48.17	47.58	47.84	47.22
	November		47.94	43.54	47.89	41.95
	Total (average ± SD)		**41.8±15.82**	**32.7±26.20**	**39.1±17.27**	**35.9±17.65**
Cyanophyceae	**June**		25.49	0.00	8.93	0.00
	July		33.88	0.00	8.80	10.61
	August		6.12	33.89	9.46	0.00
	September		10.31	13.79	11.70	10.47
	October		11.93	10.89	13.13	14.20
	November		11.16	11.56	14.08	9.22
	Total (average ± SD)		**16.5±10.76**	**11.7±12.42**	**11.0±2.28**	**7.4±5.98**
Bacillorophyceae	**June**		23.53	0.00	39.29	61.11
	July		11.57	28.00	27.20	46.93
	August		29.59	66.11	27.03	64.29
	September		5.67	6.28	5.67	6.28
	October		6.71	6.05	4.50	4.61
	November		6.61	6.46	6.34	5.06
	Total (average ± SD)		**13.9±10.17**	**18.8±25.09**	**18.3±14.76**	**31.4±29.15**
Euglinophyceae	**June**		0.00	38.46	26.79	61.11
	July		44.63	72.00	53.60	46.93
	August		20.41	0.00	12.16	64.29
	September		34.02	36.11	30.71	6.28
	October		33.18	35.48	34.52	4.61
	November		34.30	38.44	31.69	5.06
	Total (average ± SD)		**27.8±15.62**	**36.8±22.81**	**31.6±13.37**	**25.3±17.39**
All phytoplankton (organism*10^6/l)	**June**		**9.79**	**2.50**	**10.75**	**6.91**
	July		**23.23**	**9.60**	**24.00**	**34.37**
	August		**18.82**	**3.96**	**28.42**	**2.69**
	September		**37.25**	**36.69**	**52.51**	**64.21**
	October		**51.49**	**47.62**	**51.17**	**50.02**
	November		**46.47**	**56.45**	**54.53**	**64.54**
	Total	**Average**	**187.0**	**156.8**	**221.4**	**222.7**
		SD	**±17.40**	**±22.02**	**±16.80**	**±37.58**
	Monthly	**Average**	**31.2**	**26.1**	**36.9**	**37.1**
		SD	**±16.47**	**±23.73**	**±18.33**	**±27.41**

Data in Table (3) showed that, the highest average value in monthly abundance of Bacillorophyceae (31.4±29.15 %) was recorded in**T_4**and the lowest value (13.9±10.17 %) occurred in **T_1**. Monthly variation in abundance of phytoplankton groups showed that Bacillorophyceae was more abundant in August and less abundant in September and October. It was entirely absent in**T_2** at June.

Results in Table (3) showed that, the maximum average value in monthly abundance of Euglinophyceae (36.8±22.81 %) was recorded in **T_2**. It gradually decreased to 31.6±13.37 % in **T_3**, followed by 25.3±17.39 % in**T_4**and reached to its minimum value (27.8±15.62 %) in **T_1**. Monthly variation in abundance of phytoplankton groups showed that Euglinophyceae was more abundant in July and less abundant in August. It was entirely absent inT_1 at June and in T_2 at August.

DISCUSSION

The aquaculture production is directly affected by aquaculture ecosystems. Nutrient availability, water quality, soil grain size analysis, and plankton (community, productivity and nutritional composition) are the main ecosystem components affecting the cultured fish in earthen ponds (Ssanyu *et al*., 2011).

In the present study, the lowest average values of salinity and total dissolved solids (1.629 ± 0.386‰ and 3.32 ± 0.70 mg/l, respectively) were recorded at T_4 (high stocking density with high feeding rate). While, the highest average values of salinity and total dissolved solids (2.103 ± 0.871‰ and 4.24 ± 1.73 mg/l, respectively) were recorded at T_1 (low stocking density with low feeding rate). These results were in the optimum range in salinity needed for cultured *O. niloticus* (El-Sayed, 2006 and Ashour *et al*., 2018).

In the present study, the lowest average value of hydrogen ion concentration (8.30) was recorded in T_3 and T_4 (high stocking density of 8 fish/ m^3) and its highest average value (8.39) was recorded in T_1 and T_2 (low stocking density of 6 fish/ m^3). Boyd (1982) reported that the phytoplankton consumed CO_2 and decrease of pH with highly stocking density. The tolerance of pH ranged from 5 to 11, but optimal results can usually be obtained only between pH 6 and 9.

In the present study, the lowest average values of dissolved oxygen concentration were recorded inT_1 and T_3 (low feeding rate of 2.5%), being 6.20 ± 1.14 mg/l & 6.65 ± 2.01 mg/l, respectively. The highest average values of dissolved oxygen concentration were recorded at T_2 and T_4 (high feeding rate of 3.5%), being7.44 ± 2.18 mg/l & 7.61 ± 2.47 mg/l, respectively. This result more or less similar to the result was obtained by Sultana *et al.* (2017). The fluctuation in oxygen concentrations might be attributed to photosynthetic activity and the variation of oxygen consumption by fish and other organisms (Afia *et al.*, 2018). Abdel-Tawwab *et al.* (2007) found that the concentration of dissolved oxygen was positively correlated with feeding rates. Generally, it could be noted that the average dissolved oxygen at different treatments lies within the permissible limits (Abdel-Tawwab *et al.*, 2014).

The variation in water temperature influences the solubility of gases, pH, conductivity and phytoplankton distribution. In the present study, the average value of water temperature ranged between 19 – 30°C in all treatments. This result is matching with Sifa *et al.* (2002). They mentioned that Tilapias are thermophilic fish and known to tolerate a wide range of water temperatures. The temperature range for the normal development, reproduction and growth was fluctuated between 20 and 35°C, depending on fish species, with an optimum range of about 25–30°C**.**

The highest average value of total hardness (1634.76 ± 387.09 mg\l) was recorded at T_1 (low stocking density and low feeding rate) and the lowest value (1096.11 ± 459.73 mg\l) was recorded at T_4 (high stocking density and high feeding rate). This mainly due to increase in photosynthesis activity in T_4, which leads to the consumption of carbon dioxide (Co_2) and hydrolysis of bicarbonate (HCo_3) (Boyd, 1990). On the other hand, Pote *et al.* (1990) mentioned that the increasing the ratio of hardness to alkalinity, pH fluctuation would be moderate and the maximum daily pH would be reduced.

High nitrate concentration directly affected plankton densities. In the present study, the average value of total nitrate (mg/l) was higher in $\mathbf{T_3}$ and $\mathbf{T_4}$ (high stocking density) than that in $\mathbf{T_1}$ and $\mathbf{T_2}$ (low stocking density). It may be attributed to high densities of phytoplankton in $\mathbf{T_3}$ and $\mathbf{T_4}$. This might be due to the fact that increase in nitrogen inflow stimulates the plankton community (Mischke and Zimba, 2004). On the other hand, the values of NO_3 were fluctuated from 0.12 to 0.78 in irrigation water of El- Salam and El- Mahmoudia canals (Ashour *et al*., 2018).

In the present study, the highest average value of Orthophosphate was recorded at $\mathbf{T_3}$ and $\mathbf{T_1}$ (low feeding rate) and the lowest occurred at $\mathbf{T_4}$ and $\mathbf{T_2}$ (high feeding rate). The lowest of Orthophosphate value in $\mathbf{T_4}$, may be due to increase of phytoplankton in these treatments which uses in photosynthesis. This result was disagreement the results of El-Dahhar *et al.* (2006) who found that the total phosphorus level was increased in direct proportion with feeding rate. As well as Abdel-Tawwab *et al*. (2007) reported that phosphate concentration also increased significantly with the increase in feeding rate of Tilapia, silver carp and common carp under poly-culture systems.

Ssanyu *et al.* (2011) concluded that the relative status of plankton gives an indicator of water quality parameter and the possible success or failure of the aquaculture system of *O. niloticus*. Quantification of phytoplankton as a primary production in terms of chlorophyll-*a* is alternative, easy and quick to measure phytoplankton biomass in aquaculture (Ashour *et al*., 2018). In the present study, the highest average values (232.45 ± 143.05 µg/l and 220.81± 68.27 µg/l) of Chlorophyll a were recorded with high stocking density at $\mathbf{T_4}$ and $\mathbf{T_3}$ respectively, while the lowest values (204.81± 47.74 and 174.56 ± 36.10 µg\l) were recorded with low stocking density at $\mathbf{T_1}$and $\mathbf{T_2}$ respectively. This result may be due to the abundance of phytoplankton in these treatments. Chlorophyll *a* was increased with increasing in stocking density, may be due to uses fish feces in photosynthesis. In contrast, this result is differing with the result detected by Teichert-Coddington (1996) who noticed that the total nitrogen and chlorophyll *a* decreased linearly as rate of stocked tilapia increased, because of grazing by tilapia on phytoplankton.

Concerning the stocking density variations, the maximum values of all physico-chemical parameters of water were observed with low stocking density, except dissolved oxygen and nitrogenous compounds with high stocking density. This could be attributed to increase of phytoplankton abundance in these treatments. Tilapia ecosystems and productivities are indirectly affected by the changes of water quality conditions, which can regulate the plankton productivity, biochemical composition and community in such tilapia earthen ponds. These conditions fundamentally change due to the availability of nutrient concentrations (El-Otify, 2015).

Plankton was required as the first food for many cultured fish. They are valuable natural sources of protein, amino acids, lipids, fatty acids, minerals and enzymes required for effective growth of fish (Ajah, 2017). In the present study, the high concentrations of nutrients coinciding with higher abundance of phytoplankton (organism/l) in earthen ponds of $\mathbf{T_4}$ and $\mathbf{T_3}$ (high stocking density). Mou *et al.* (2018) mentioned that the phytoplankton abundance was higher with low stocking density of fry and fingerlings of *Mystus vittatus*. It seems likely that in the ponds where stocking density is high, consumption of plankton by fishes is also high. These results were in agreement with Khattaby *et al*., 2010, they found that Nile Tilapia reared in agriculture daring water grow up higher than Nile Tilapia reared in fresh water, because agricultural drainage water contains high concentration of natural food (phytoplankton). The increase of plankton abundance can significantly increase fish production in ponds (Geiger and Parker, 1985).

In the present study, Chlorophyta is more abundant in September and less abundant in July. The most abundant taxa captured of chlorophyceae were *Schroederia* and *Chlamdomonas*, which peaked during September. Cyanophyta is more abundant in July and less abundant in June. The most abundant taxa among cyanophyceae were *Gleocapsa*, which peaked during July. Bacillorophyta is more abundant in August and less abundant in September. The most abundant taxa among Bacillariophyceae were *Cyclotella*, which peaked during August Euglinophyta is more abundant in July and less abundant in August. The most abundant taxa among the Euglenophyceae were *Euglena* which peaked during July.

Schroeder (1987) correlated the isotopic carbon ratios of various microbial species present in fertilized ponds with the fish harvested from the pond. The bacterial component is the primary nutrient source for Tilapia cultured in a fertilized pond and cyanobacteria (blue-green algae) provide the second important nutrient source.

CONCLUSION

The highest stocking density (8fish/m^3) with low feeding rate (2.5%) was positively correlated with best water quality and high abundance of phytoplankton in earthen ponds of *Oreochromis niloticus*.

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ARABIC SUMMARY

تأثير الكثافه العددية ومعدل التغذية علي جودة المياة ووفرة الهائمات النباتية لأسماك البلطى النيلى (*Oreochromis niloticus*) المرباه فى الأحواض الترابية

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يهدف هذا البحث إلى دراسه تأثير كثافة التسكين ومعدل التغذية على جودة المياه ووفرة الهائمات النباتية لأسماك البلطى النيلى (*Oreochromis niloticus*) المرباه فى الأحواض الترابية.

تم إجراء التجربة بمزرعة برسيق، منطقة ادكو، محافظة البحيرة، جمهورية مصر العربية والتجربة عبارة عن أحواض ترابية (١٢حوض)، مساحة الحوض ٢ فدان ومتوسط عمق الحوض ١م مملوء بمياه الصرف الزراعي . تم تربية زريعة البلطي النيلي وحيد الجنس لمدة ٢١٤ يوم بكثافات تخزينية مختلفة ومعدلات تغذية مختلفة. إستمرت فترة التجربة ٧ شهور من مايو الي نوفمبر٢٠١٦م . المعاملة الاولي (T_1) كثافة تخزين ٦سمكة /م^3 بمعدل تغذية ٢٫٥% . المعاملة الثانية (T_2) كثافة تخزين ٦سمكة /م^3 بمعدل تغذية ٣٫٥% . المعاملة الثالثة (T_3) كثافة تخزين ٨سمكة /م^3 بمعدل تغذية ٢٫٥% . المعاملة الرابعة (T_4) كثافة تخزين ٨سمكة /م^3 بمعدل تغذية ٣٫٥% . وكان لكل معاملة ثلاث أحواض ترابية . تم تغذية الأسماك مرتين يومياً، ستة أيام في الاسبوع علي نظام غذائي يحتوي علي ١٨% بروتين بمعدل تغذية ١٠% ' ٧%' ٥% ' ٤% من الكتلة الحية خلال مايو ويونيو وأغسطس علي التوالي .تم تغيير معدلات التغذية فى الفترة من سبتمبر إلى نوفمبر وكان معدل التغذية ٢٫٥ % من الكتلة الحية للأسماك في المعاملة الاولي (T_1)، المعاملة الثالثة (T_3) . وكان معدل التغذية ٣٫٥% من الكتلة الحية في المعاملة الثانية (T_2) ' المعاملة الرابعة (T_4). وتم تغيير حجم نصف المياة لجميع الأحواض كل أسبوع.

أوضحت النتائج أن أعلى قيمة متوسط للملوحة، الأملاح الذائبة، درجة الحموضة، عسر الماء وأملاح النيتريت سجلت فى المعاملة الأولى T_1 و الثانية T_2(أقل كثافة) وأقل قيمة لهم سجلت فى المعاملة الثالثة T_3 و الرابعة T_4(أعلى كثافة). وعلى الجانب الأخر، سجلت أعلى قيمة متوسط للكلوروفيل أ سجلت فى المعاملة الثالثة T_3 و الرابعة T_4(أعلى كثافة) وأقل قيمة لهم سجلت فى المعاملة الأولى T_1 و الثانية T_2(أقل كثافة).

أظهرت النتائج أن أعلى قيمة متوسط لمحتوى الأكسجين فى الماء سجل فى المعاملة الثانية T_2 و الرابعة T_4 (أعلى معدل غذائى) وأقل قيمة لهم سجلت فى المعاملة الأولى T_1 و الثالثة T_3(أقل معدل غذائى). بينما سجلت أعلى قيمة متوسط للنترات والفوسفات فى المعاملة الأولى T_1 و الثالثة T_3(أقل معدل غذائى) وأقل قيمة لهم سجلت فى المعاملة الثانية T_2 و الرابعة T_4 (أعلى معدل غذائى). كانت درجة حرارة وقاعدية الماء متشابهة تقريبا فى كل المعاملات طوال فترة التجربة.

بينت النتائج أن أعلى قيمة متوسط لوفرة الهائمات النباتية (٣٧٥٨٤٥٥٩٫٨ ± ٢٢٢٧٢٨٦٦٧ خلية/ لتر)سجلت فى المعاملة الرابعة (T_4)، وأقل قيمة (١٥٦٨١٣٤٦٧ ± ٢٢٠٢٢٣٨١٫٣ خلية/ لتر)سجلت في المعاملة الثانية (T_2).بينت نتائج الاحصاء أن التنوع في وفرة الهوام النباتية كانت غير مميزة بين المعاملات.

أظهرت نتائج تحليل الهوام النباتية أنها عبارة عن أربع طوائف وهى الطحالب الخضراء - الطحالب الخضراء المزرقة - الطحالب العصوية واليوجلينات. كانت معظم الوفرة في كل أحواض التجربة ممثلة في الطحالب الخضراء (٤٢٫٤٦%)، ثم الطحالب اليوجلينية (٣٣٫٨٥%). بينت نتائج الاحصاء أن التنوع في طوائف الهوام النباتية كانت مميزة بين المعاملات. وأن وفرة الهوام النباتية تختلف فى المعاملات باختلاف الشهور. وعموماً سجل أعلى متوسط فى كل المعاملات في الفترة من شهر سبتمبر الى شهر نوفمبر وأقل متوسط سجل في شهر يونيو.

والخلاصة ان الكثافة العددية المرتفعة ومعدلات التغذية المنخفضة (٨ سمكة / م^{3}مع معدل تغذية ٢٫٥%) مرتبطة ايجابياً بجودة المياه ووفرة الهائمات النباتية فى استزراع أسماك البلطي النيلى المرباه في الاحواض الترابية.