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EFFECTS OF STOCKING DENSITY ON GROWTH PERFORMANCE AND FEED UTILIZATION OF NILE TILAPIA FINGERLINGS UNDER BIOFLOC SYSTEM

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ABSTRACT

This study aims to investigate the effect of stocking density under biofloc technique (BFT) on growth performance, feed utilization, water quality and zooplankton counts of Nile tilapia (*Oreochromis niloticus*) fingerlings. Three stocking density (200, 300 and 400 Fish / m^3) under Biofloc system (BS) and clear system (CS) (without external carbon addition) were applied. Nile tilapia with an initial body weight of 20.35±0.35 grams were stocked in 18 cylindrical fiberglass tanks with water volume 50 litters for 75 days. The fish was fed commercial diet containing 30% protein, Starch was added on Biofloc system treatments as the carbon source to set the C/N ratio at 15/1. Results showed that the best growth performance and feed utilization were recorded for 200 fish/m^3 under Biofloc system. For both CS and BS systems, water quality parameters were within the normal range. It could conclude that the growth performance, feed utilization and zooplankton count were all improved with following the biofloc system (limited water exchange) compared with clear system with a superior performance with the stocking density 200/ m^3 under this experimental conditions.

Key words: Biofloc system, Stocking density, Nile tilapia, Fingerlings, Growth performance, Feed utilization, Water quality, Zooplankton.

INTRODUCTION

The increasing global population and the limiting global capture fisheries undeniably increase the demand of aquaculture. On the other hand, land and water utilization will bring limitation to aquaculture expansion. Therefore, productivity enhancement in term of total production per input used becomes one of the major priority in the development of aquaculture (Avnimelech *et al.*, 2008).

Aquaculture is the culture of aquatic organisms under controlled conditions (FAO, 2016). Among these organisms, tilapia (*Oreochromis niloticus* L.) is the second main species cultured in the world. However, the development of aquaculture has faced challenges because of lack of land and water source, feed costs and degradation of environment (Rahman, 2012).

The common approaches to maintain water from deterioration and avoid nitrogen increases are through water exchange, using nitrifying biofilters and the microorganisms that grow while using a carbon source (Avnimelech and Kochba, 2009). For decades, re-circulating system (RAS) has been considered as the main application for intensive rearing of several species. However, operating and implementation costs of all structure considered high. for tilapia culture, BFT was more effective in terms of cost–benefit than RAS (Luo *et al.*, 2014).

The biofloc technology system (BFT) provides the intensive aquaculture with no or minimum water renewal reducing its environmental impact (Poli *et al.*, 2019). In this system, the management of the microbial community is determinant to keep the water quality, especially the development of heterotrophic bacteria, through the complementary carbon source, which stimulates its growth and improves the process of removing inorganic nitrogen from water, besides allowing its transformation into bacterial biomass (Robinson *et al.*, 2019).

The stocking density in a BFT depends on the manipulation of the physicochemical variables that determine the quality of the water. The amount of dissolved oxygen (DO) is the first limiting factor to increase the density of the culture and the second one is the ammonia nitrogen that comes from the metabolism of food in fish (Timmons *et al.*, 2002 and Ali *et al.*, 2020). In this context, the objective of this experiment was to study the effect of stocking under BFT application on water quality, growth performance, and feed utilization of Nile tilapia fingerlings (*Oreochromis niloticus*).

MATERIALS AND METHODS

Study site:

The experiment was conducted at the experimental Fish Lab, Department of Animal and Fish Resources, Faculty of Agriculture, Suez Canal University, Egypt during the period from July 2019 to October 2019.

Experimental Fish:

Monosex **N**ile tilapia, *O. niloticus* fingerlings were obtained from private fish Hatchery (Khalil Saad Hatchery) that located in Tall El Kebir, Ismailia Governorate. Fish was transported in oxygenated containers and Experimental fish were acclimatized to laboratory conditions for two weeks and fed twice daily with commercial diet (38 % C.P.) prior to start the experiment.

Experimental design:

All experimental tanks were stocked with Monosex Nile tilapia fingerlings with an initial average body weight of 20.35±0.35 grams and average body length 10±0.25 cm at three different stocking densities. Completely randomized designed experiment with three different stocking densities (200, 300 and 400 Fish/m^3) under Biofloc system and Clear system representing six experimental treatments (three densities X two systems) in triplicate. Experiment was carried out in 18 cylindrical fiberglass tanks with water volume 50 litre.

Experimental conditions:

All experimental tanks were supplied with aerated water. Aeration was continuously provided using an air blower (220 Watt add the power and the flow of the blower). Fish were held under natural light (12:12 h, light: dark schedule). In the tanks representing the control treatments (clear system); water was exchanged daily, while for experimental BFT tanks, no water exchange was done (zero water exchange) except the evaporation compensate. Starch was used in biofloc treatments as an external carbon source, it was added at the same amount of feeding ration to maintain the optimal C: N ratio for activate heterotrophic bacteria growth (>15) (Avnimelech, 1999). Starch was completely mixed in a glass beaker with tank water sample and spread to the tank surfaces at the afternoon time (Azim and Little, 2008).

Feeding:

The experiment was lasted for 75 days. Fish in all experimental groups were fed six days per week with commercial floating pellet containing 30% crude protein content and its diameter is 3 mm from Skretting Egypt for animal feed Company (Table 1). The daily ration was 3% of the total stocked biomass divided into two equal amounts and offered two times a day (9.00 and 14.00). Fish in each tank were weighed every 15 days and the amount of the daily allowance feed was accordingly adjusted.

Table 1. The approximate composition % of experimental diets

Chemical Composition	%
Dry mater	90.1
Crude Protein	30.3
Fat	6.1
Ash	4.95
Carbohydrate	53.85
Crude fiber	4.8
Organic carbon	37.45
Gross Energy **Kcal/ 100g**	450.70

GE= gross energy was calculated as 5.65, 9.45 and 4.12 Kcal/100gram of protein, lipid and carbohydrate, respectively after (NRC, 2011).

Water quality assessment:

Water temperature and dissolved oxygen were recorded daily using a portable oxygen meter (OxyGuard). pH values were recorded twice a week using a portable pH meter (OxyGuard). Total Ammonia Nitrogen (TAN), nitrite and nitrate were detected every two weeks using analytical kits (Lovebird®, Multidirect, co 210070 England) , Total suspended solid (TSS) values were measured twice during the experimental period using Spectrophotometer model LKB Bichrom UV visible spectrophotometer according to (APHA, 1992; Mullin and Riley, 1955).

Total bacterial count (TBC) was determined according to (AOAC, 1995 and APHA, 1992) then reported as CFU mL^{-1}. Biofloc volume (water settleable solids) was determined weekly using Imhoff cone to monitor the developing of biofloc (Avnimelech and Kochba, 2009).

Growth parameters:

Growth performance of the experimental fish was evaluated using the following parameters: Fish Weight gain (WG), Weight gain % (WG %), Specific growth rate (SGR) and Survival rate% (SR) which were calculating according to the formula

- Weight gain (WG) = Final body weight (g) - Initial body weight (g).
- Weight gain % (WG%) = (Weight gain (g) / Initial body weight(g)) ×100.
- Specific growth rate % (SGR) = [(Ln FBW - Ln IBW) /day of experiment] ×100. (where: FBW is final body weight (g); IBW is initial body weight (g); ln= natural logarithmic).
- Survival rate % (SR) = (Final number of fish / Initial number of fish) ×100.

Feed utilization evaluation:

Feed intake (g/fish) is the amount of feed given or supplied during the experimental period for each fish per gram, and used for calculating the following feed utilization parameters:

- Feed conversion ratio (FCR) = Feed intake (g)/Weight gain (g).
- Feed conversion efficiency (FCE) = Weight gain (g)/ Feed intake (g).
- Protein efficiency ratio (PER) = weight gain (g)/protein intake (g).

Statistical analysis:

The data were analyzed by Two-way with interaction ANOVA using Statistical Analysis System (SAS) version 9.0.0 (2004) program at $P<0.05$ level to test the effects of stocking densities (200, 300, and 400 Fish/m^3) and system condition (clear and biofloc system) supplementation, as well as their interactions The ANOVA was followed by Duncan test (1955) at P<0.05 level of significant when needed.

RESULTS AND DISCUSSION

Water quality:

Table (2) present water quality criteria of monosex tilapia fingerlings tanks as affected by different stocking densities and reared in tanks under clear and biofloc system. High stocking densities were combined with highly nitrogenous diets in intensive fish culture negatively affect the water quality especially the accumulation of inorganic nitrogen forms (NH_3 and NO_2) (Hargreaves and Tucker, 2004). As means of the water quality parameters recorded during the trial were as followings; temperature (28.3 ± 1.10ºC), pH (7.3 ± 0.03), DO (5.4 ± 0.1 mg/L), TAN (0.34 ± 0.02 mg/L), NO_2 (0.21 ± 0.02 mg/L), NO_3 (5.04 ± 0.02 mg/L) and TSS (286± 67.5 mg/L) Table (2). Only stocking density had significant effect on water characteristics including pH, TAN and NO_2. TAN and NO_2 values increased significantly ($P < 0.05$) as the density increased and recorded the highest values in group (400 fish/m^3) over the low density (200 fish/m^3) while DO decreased following the same trend for both clear and biofloc system which is in agreement with Gibtan *et al.* (2008).

Higher stocking densities normally resulted in poor water quality which is the main stress factor in the aquaculture ponds (De Oliveira *et al.*, 2012). Oxygen required for fish is generally affected by nitrite and ammonia levels in

the culture system (Remen *et al*., 2008). Exchanging the water in the culture system is essential to maintain the properties of water quality from deterioration. Frequently, using techniques with minimum or zero-water exchange increases nitrogen levels in water (Randall and Tsui, 2002). In the current study, the level of inorganic nitrogen concentrations was increased in BFT tanks with increasing the stocking density (Labib, 2016). These findings agree with some studies demonstrating that the in situ biofloc formation accelerates the nitrification process in the water of tanks (Labib, 2016). The bacteria formed in BFT system is helping to keep the nitrogen at safe levels for fish rearing by utilizing nitrogen in situ microbial protein and increasing the nitrification process to maintain the ammonia and nitrite at safe levels for Nile tilapia (Mansour and Esteban, 2017a, b). In contrast some studies suggested that stocking density had no effect on water quality parameters as reported by Li et *al.* (2012).

In contradiction with our results Abdel-Tawwab (2012) reported that, unionized ammonia was significantly affected by rearing density which in agreement with Ayyat *et al.* (2011) who reported that the fish stocking density significantly affected the concentrations of dissolved oxygen (DO) and pH as they decreased with increasing fish density. The results revealed that Total Ammonia Nitrogen (TAN) values were in the softy range (0.35±0.10 mg/L). Also Nitrite (NO_2) during the experimental period showed values around the normal rang (0.5 mg/L). On the other hand, Nitrate (NO_3) was recorded for higher values than normal range (5 mg/L) for all experimental treatments. The records of TAN and NO2 concentrations at biofloc treatments were lower as compared to the control ($P<0.05$), which was also agreed with other researchers such as (Gaona *et al*., 2011; Kuhn *et al*., 2009 and Wasielesky *et al*., 2013).

The concentration of solids tends to increase with the increase of the stocking density which may be explained with the increase in food, feces and carbon source (De Silva *et al.*, 2015). The present results were similar to that in Rajkumar *et al*. (2016) study, who found that TSS was within the recommended level of <500 mg/L (Samocha *et al*., 2007).

Growth performance:

Growth performance parameters of Nile tilapia in different stocking densities of 200, 300 and 400 fish/m^3 and management conditions (CS, BS) are presented in Table (3). The highest final body weight (FBW), weight gain (WG), weight gain percent and specific growth rate (SGR%) values were all recorded for fish at density 200 fish/m^3 under biofloc system while the lowest results were noticed for 400 fish/m^3 under clear system (CS). Generally, growth parameters improved under biofloc system. It could assume that starch addition to biofloc tanks activate growth of bacterial floc and algae which in turns act as secondary protein source for fish under those treatments. These results are in agreement with the finding of (Burford *et al*., 2003) who suggested that adding starch helps to develop and control of dense heterotrophic microbial bioflocs in the water column. Carbohydrate addition leads to elevate the C/N ratio which helps to convert inorganic nitrogen into organic nitrogen as dense flocs. Similarly, Avnimelech *et al.* (2008) and Azim *et al.* (2007) concluded that growth performance for Nile tilapia in biofloc system was improved and it contributed 43% of growth compared with system without BFT.

Table 2. Water quality parameters (Mean ± SE) for Nile tilapia (*O. niloticus*) fingerlings reared with different stocking densities under clear and biofloc systems throughout an experimental period (75 days).

Item	Stocking density (fish/m^3)					
	200		300		400	
	CS	BS	CS	BS	CS	BS
DO (mg/L)	6.65±1.10	6.04±1.10	5.54±1.10	5.02±1.10	4.99±1.10	4.23±1.10
Temp	28.34±1.02	28.55±1.0	28.36±1.0	28.68±1	28.20±1.10	28.30±1.10
pH	8.0±1.10	7.58±0.50	7.8±0.50	7.35±0.50	7.6±0.50	7.12±0.50
TAN (mg/L)	0.39±0.10^c	0.22±0.10^f	0.47±0.10^b	0.31±0.10^e	0.54±0.10^a	0.36±0.10^d
NO_2 (mg/L)	0.22±0.10^c	0.11±0.10^f	0.25±0.10^b	0.13±0.10^e	0.33±0.10^a	0.15±0.10^d
NO_3 (mg/L)	5.1±1.10^c	3.8±1.10^f	5.6±1.10^b	4.33±1.0^e	6.83±1.10^a	4.8±1.10^d
TSS mg/L	239±89.6^f	285±76.9^d	246±75.5^e	298±89.6^c	309±37.4^b	344±74.2^a

* Means ±SE

* Means in the same row having the same superscript letter are not significantly different (P<0.05).

Contrastively, some other studies suggest that biofloc led to the level of production well below commercially viable levels (Little *et al*., 2008). However, there might be several reasons attributed to the poor fish growth and production. Increased turbidity due to biofloc reduces the visibility and hence artificial feed intake. Even when flocs separator was used, it was not easy to maintain 500 mg L^{-1} TSS level, and very often the level reached to 1000 mg L^{-1} TSS. Maintaining optimum floc levels was also identified as a critical issue in managing BFT systems (Little *et al.*, 2008). Another reason for the poor fish growth and production, water quality parameters were not stable, high fluctuation of pH and alkalinity, high concentrations of inorganic nitrogen species might have chronic effects on fish health (Azim and Little, 2008).

Corroborating to this work, other studies show that regardless of the growth stage, the increase in stocking density tends to reduce the growth of fish in recirculating water systems and ponds (Ferdous *et al.*, 2014), cages (Moniruzzaman *et al.*, 2015) and BFT (Zaki *et al.*, 2020). The growth of tilapia (*O. niloticus*) depends on the stocking density, food quality, energy content of the diet, its physiological status, reproductive state and environmental factors such as temperature, pH, etc. (Lovell, 1989).

In this study, there was a significant difference in growth ($P < 0.05$) with increasing stocking density in all treatments. This result is in agreement with the findings of Tadesse (2007), who studied the effects of stocking density (50, 100, 150 and 200 fish m^{-3} cages) for the same species, and found that the fish size and production were significantly affected by the stocking density. Ouattara *et al.* (2003) also studied the effects of stocking density (20, 50, 100 and 150 fish m^{-3} cages) for tilapia, and found that fish size and production were significantly affected by stocking density. Canario *et al.* (1998) also studied the effect of stocking density (0.35, 1.3 and 3.2 kg m^{-3}) on the growth of gilthead sea bream, *S. aurata* , and found that fish in the highest density group grew 25% slower than fish in the lowest density group.

Table 3. Growth performance of Nile tilapia (*O. niloticus*) fingerlings reared with different stocking densities under clear and biofloc systems throughout an experimental period (75 days).

Items		Body weight (g)		Weight gain (g)	Weight gain%	Specific growth rate (%/day)	Survival rates %
		Initial	Final				
Stocking density	200	20.36	53.225[a]	32.85[a]	161.390[a]	1.272[a]	99.00[a]
	300	20.19	47.468[b]	27.27[b]	135.087[b]	1.137[b]	96.00[b]
	400	20.12	43.987[c]	23.86[c]	118.552[c]	1.038[c]	94.00[c]
SE		0.351	0.882	0.707	3.605	0.021	4.515
System Condition	Clear system (CS)	20.234	43.931[b]	23.697[b]	117.034[b]	1.031[b]	94.00[b]
	Biofloc system (BS)	20.222	52.522[a]	32.3[a]	159.651[a]	1.267[a]	98.00[a]
SE		0.287	0.720	0.577	2.943	0.017	3.687
Interaction	CS200	20.400	46.923[d]	26.520[d]	130.020[d]	1.110[d]	98.00[b]
	BS200	20.330	59.527[a]	39.19[a]	192.770[a]	1.430[a]	100.00[a]
	CS300	20.220	44.430[e]	24.210[e]	119.730[e]	1.050[e]	95.00[e]
	BS300	20.170	50.507[b]	30.340[b]	150.440[b]	1.220[b]	97.00[c]
	CS400	20.080	40.440[f]	20.360[f]	101.360[f]	0.930[f]	94.00[f]
	BS400	20.170	47.533[c]	27.370[c]	135.750[c]	1.140[c]	96.00[d]
SE		0.175	7.410	7.489	36.988	0.165	2.441

* Data are presented as means ± standard error (SE).
** Means followed by different letters in each column are significantly (P<0.05) different.

Some studies have demonstrated that the stocking density can affect fish growth performance even though water quality in aquaculture systems was kept in good conditions (Tolussi *et al.*, 2010). High stocking density of Amur sturgeon (*Acipenser schrenckii*) has negative effects on growth where, a significant decrease in specific growth rate was observed as stocking density was increased; high stocking density might inhibit fish growth through decreasing food conversion efficiency (Li *et al.*, 2012). A stocking density of 200 fish/m^3 produced the best growth performance for tilapia fish. In the same context, increase of stocking density inversely affected the growth of Nile tilapia compared with high stocking density where, final body weight and weight gain percent were significantly ($P < 0.05$) higher at lower stocking

density. Abdel-Tawwab (2012) reported that fish growth was inversely affected by rearing density, which may explain that density of 200 fish/m^3 produced the best growth performance. Same results for Nile tilapia were showed by (El-Sayed, 2002 and Ayyat *et al*., 2011).

Normally, stress due to agglomeration, competition for food, and social interactions can reallocate metabolic energy intended for growth to restore homeostasis (Martínez-Porchas *et al.*, 2009). In this context, the increase in the fish stocking density tends to increase the time needed for tilapia to reach harvest weight (Garcia *et al.*, 2013), as was observed in the present study.

Moreover, other fish species Chinook salmon *Oncorhynchu stshawytscha* (Walbaum) (Martin and Wertheimer, 1989), African catfish (Haylor, 1991) and Arctic chirr, *S. alpinus* (Jørgensen *et al.*, 1993) also showed an inverse relationship between stocking density and growth parameters difference of the effect of stocking density can be obtained from the results of specific growth rates. Silva *et al.* (2000) also studied the effect of stocking density (2, 3 and 4 kg m^{-3}) on the growth of tetra hybrid red tilapia, and found that the final body weight gain was significantly higher at densities of 2 and 3 kg/m^3, while the largest biomass and feed consumption were observed at a density of 4 kg/m^3.

In this regard, Studies of stocking density of tilapia in BFT are usually done for a short period of growth using fish at larvae or juvenile stages (Liu *et al.*, 2018 and Zaki *et al.*, 2020) The growth parameters were generally better in BFT units than the control groups. These results are in consistence with those obtained with Nile tilapia reared in BF system (Mansour and Esteban, 2017a, b). The increased growth performance in fish reared in BF with stocking density (200 fish/m^3) resulted from the optimum water quality values and availability of BF for the fish (Qasem, 2016; Yoo and Lee, 2016).

Feed Utilization:

Feed utilization of different treatment is presented in Table (4). Regards to stocking density, tilapia stocked at 200 fish/ m^3 under biofloc showed the

highest values for feed intake (FI), and the best feed conversation ratio (FCR) and the highest protein efficiency ratio (PER). Tilapia fed under biofloc condition noticed for the Best feed utilization parameters. With increasing stocking density, depression in feed utilization parameters were recorded.

These results in agreements with the finding of (Li *et al.*, 2012) who suggested that with increasing stocking density depression in feed utilization parameters was noticed. It was assumed that chronic stress, due to the high density, increases the fish's overall energy demand, which is then unavailable for growth (Wendelaar Bonga, 1997). Moreover, fish density can affect the efficiency of feed utilization; as the number of fish stocked in a pond increases, the amount of feed available to each fish decreases (Chang, 1988). Moreover, the food conversion ratio trend that was seen in this experiment is in agreement with that obtained by Ouattara *et al.* (2003), This enhancement in the feed conversion ratio suggests efficient food utilization through the extraction of more nutrients from the feed and converting it into flesh (Bhijkajee and Gobin, 1997). In this study, the food conversion ratio increased significantly ($P < 0.05$) under low stocking density than high stocking density. This result is in agreement with those obtained by Ouattara *et al.* (2003) and Bolivar *et al.* (2006), who reported that the feed conversion ratio decreased with increasing stocking density.

On the contrary, Siddiqui *et al.* (1989) reported no difference in the growth or the food conversion ratio of *O.niloticus* (40.3 g average weight) reared in a brackish water (3.5–3.9 ppt) tank for 164 days fed on supplementary feeding at densities of 16, 32 and 42.6 fish/m^3. Watanabe *et al.* (1990) also reported that feed conversion of Florida red tilapia fed supplementary feed did not differ at densities ranging from 100 to 300 m^{-3}. The considerable variations in the results of the present study with those recorded by Siddiqui *et al.* (1989) and Watanabe *et al.* (1990) for feed conversion ratio might be due to the variations in fish size, age, stocking density, food quality, hygiene, environmental conditions and other unknown factors.

Table 4. Feed utilization of Nile tilapia (*O. niloticus*) fingerlings reared with different stocking densities under clear and biofloc systems throughout an experimental period (75 days).

Items		Feed intake (g)	FCR	FCE	PER
Stocking density	200	52.027[a]	1.625[c]	0.626[a]	2.088[a]
	300	47.856[b]	1.767[b]	0.568[b]	1.894[b]
	400	45.963[c]	1.958[a]	0.517[c]	1.724[c]
SE		0.983	0.072	0.018	0.058
System Condition	Clear system (CS)	46.042[b]	1.959[a]	0.513[b]	1.712[b]
	Biofloc system (BS)	51.188[a]	1.607[b]	0.628[a]	2.092[a]
SE		0.802	0.059	0.014	0.048
Interaction	CS200	48.793[c]	1.840[b]	0.544[c]	1.812[d]
	BS200	55.260[a]	1.410[e]	0.709[a]	2.364[a]
	CS300	45.339[e]	1.872[b]	0.534[c]	1.781[e]
	BS300	50.373[b]	1.661[d]	0.602[b]	2.008[b]
	CS400	43.995[f]	2.164[a]	0.463[d]	1.543[f]
	BS400	47.930[d]	1.752[c]	0.571[c]	1.904[c]
SE		2.680	0.256	0.104	0.345

* Data are presented as means ± standard error (SE).

** Means followed by different letters in each column are significantly (P<0.05) different.

Significant (P<0.05) differences were obtained an in feed conversion ratio between treatments. However, feed conversion ratio was 1.62, 1,76 and 1.96 for stocking densities (200, 300 and 400 Fish/m^3) respectively. The better feed efficiency ratio of tilapia was found at lower stocking densities (Moniruzzaman *et al*., 2015). According to Ellis *et al.* (2002), the increased energy demand associated with stress has a negative effect on feed conversion ratio, a fact not observed in this study. However, it is possible that if the fish from treatments of higher stocking densities were allowed more time to reach the same final body weights as from the treatments of lower stocking densities, the feed conversion ratio would be worse.

With increasing stocking density under biofloc system a decrease in PER values were noticed. Avnimelech *et al.* (1994) estimated that feed utilization is higher under biofloc system. For Tilapia better values for feed conversion ratio and protein efficiency ratio were observed in all the bioflocs treatments

compared to those treatments without biofloc (Avnimelech, 2007). Same trend was noticed for tilapia feed utilization under biofloc system by Azim and Little (2008). These observations suggested also for shrimps by Zhao *et al*. (2012) who reported that the biofloc treatment for shrimp resulted in 12.0% higher protein efficiency ratio, and 7.22% lower feed conversion rate comparing with treatments without biofloc. Low toxic inorganic nitrogen levels and utilization of microbial cells are demonstrated to be an effective potential food source for tilapia and shrimp (Avnimelech, 2007). Furthermore, lower ammonia nitrogen in the sediment positively influenced the food intake and health (Avnimelech and Ritvo, 2003). Another reason for the improvement of feed utilization under biofloc system is that the increased activities of digestive proteinases indicated enhanced digestive capabilities of the feed (Xu *et al*., 2012). Additionally, massive number of live microorganisms existed in the bioflocs, they could transit through the stomach into the intestine and interfere with resident intestinal micro flora balance which plays an important role in the production or secretion of digestive enzymes (Xu *et al*., 2012).

Biofloc volume and bacterial counts:

BF volume and bacterial counts were significantly ($P<0.05$) lower (23 mg L^{-1} and 3.7× 10^6 CFU L^{-1}, respectively) at 200 fish/m^3 and increase with increasing stocking level where the highest values were 34 mg L^{-1} and 5.8×10^6 CFU L^{-1}, respectively at 400 fish/m^3 (Table 5). In the present study, higher values of BF volume and bacterial counts were recorded in fish reared at 300 and 400 fish/m^3 as compared to the low density (200 fish/m^3). The surface of BF and its particle size can increase the surface area required for bacterial growth to increase the produced BF (Mansour and Esteban, 2017a, b). Increasing the substrate surface area in BF tanks resulted in increased bacterial growth and improvement of water quality as well as food availability (Ferreira *et al.*, 2016; Nunes Caldini *et al.*, 2015). The increased amounts of BF can be also attributed to the increased levels of nitrogen emissions as a result of

increasing the stocking density. The differences may be due to the differences in fish size, duration and experimental conditions.

Table 5. Biofloc volume and total bacterial count of Nile tilapia (*O. niloticus*) fingerlings reared with different stocking densities under clear and biofloc systems throughout an experimental period (75 days).

Items		BFV (ml/ L)	Total bacterial counts (10^6 CFU/ L)
Stocking density	200	23^c	3.7^c
	300	28^b	4.5^b
	400	34^a	5.8^a
SE		1.09	0.34

* Means ±SE

* Means in the same column having the same superscript letter are not significantly different (P<0.05).

CONCLUSION

It could be concluded that stocking density (200 fish/m^3) was the best under biofloc system in terms of growth performance, feed utilization, water quality and the total count of zooplankton under this experimental conditions. This system can play a key role in developing a sustainable aquaculture via better water quality maintenance decrease in feed requirements, and higher production to achieve more profit in fish farming in Egypt.

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تأثير كثافه التخزين على أداء النمو والاستفادة من الغذاء لاصبعيات البلطى النيلى باستخدام نظام البيوفلوك

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الملخـــص العربـــى

أجريت هذه التجربه لدراسة تأثيركثافة التسكين (٢٠٠، ٣٠٠ ، ٤٠٠ سمكة/م^{٣}) باستخدام نظام الكتلة الحيوية (البيوفلوك) على أداء نمو والاستفادة من الغذاء وجودة المياه وعدد الهائمات الحيوانية لاصبعيات البلطي النيلي. تم تقييم تأثير نفس الكثافات ايضا تحت النظام التقليدى (بدون اضافة مصدر كربون خارجى). استخدمت اصبعيات بلطي نيلي بمتوسط وزن ٢٠± ٠,٣٥ جم فى ١٨ حوض مخروطى (نظامين تربيه / ثلاثه كثافات/ ثلاثه مكررات) بحجم مياه ٥٠ لتر لمدة ٧٥ يومًا. أوضحت النتائج أن نظام البيوفلوك متفوقا على النظام التقليدى فى اداء النمو متمثلا فى الوزن النهائى والزيادة فى الوزن ومعدل النمو النوعى. تم تسجيل أفضل أداء تحت كثافة تخزين ٢٠٠ سمكة/م^{٣} تحت نظام البيوفلوك. لوحظ أقل اداء للنمو عند كثافة الاسماك (٤٠٠ سمكة/م^{٣}) في النظام التقليدى. أشارت النتائج الى ان زيادة الكثافة تؤدى الى انخفاض في أداء نمو البلطي تحت نظام البيوفلوك. أوضحت النتائج أن افضل كثافة تخزين من حيث الاستفادة الغذائية هى كثافة التخزين ٢٠٠ سمكة/م^{٣} تحت نظام البيوفلوك حيث كان معدل التحويل الغذائى أفضل فى نظام البيوفلوك كما لوحظ مع زيادة كثافة التخزين انخفاض الإستفادة من الغذاء. معايير جودة المياه لكثافات التخزين المختلفة فى النظامين كانت مناسبة لاستزراع اصبعيات البلطى النيلى فإن قيم النيتروجين الكلي والنتريت والنترات تتغييرفى النطاق الطبيعي طوال فترة التجربة. أدت اضافة مصدر الكربون فى نظام البيوفلوك الى خفض الامونيا والنيتريت والنترات. لوحظ تكون اللون البنى بعد الأسبوع الثالث في جميع معاملات البيوفلوك حيث تطور حجم البيوفلوك والمواد الصلبه المعلقة على مدارمدة التجربة. واظهرت النتائج ان حجم البيوفلوك والمواد الصلبه المعلقة بهم فروق معنوية عالية في نظام البيوفلوك مقارنة بالنظام التقليدى. يستنتج من هذه الدراسة ان استخدام نظام البيوفلوك تحت كثافة تخزين ٢٠٠ سمكة /م^{٣} هو الافضل من حيث اداء النمو والاستفاده من الغذاء تحت هذه الظروف التجريبية.