JOURNAL OF THE
ARABIAN AQUACULTURE SOCIETY

Vol. 8 No 3 **December 2013**

The Effect of Total Feed-N and Fertilizer-N Loads on Water Quality and Growth Performance of Nile Tilapia

Elnady* , M.A., Khaled, R.A., Ghalab, M.G.
Animal Production Department, Faculty of Agriculture, Cairo University, Egypt.

***Corresponding Author Email: melnadyahmed@yahoo.com

ABSTRACT

The current experiment investigated the effect of total nitrogen input of both feed-nitrogen and fertilizer-nitrogen on water quality parameters and growth performance of Nile tilapia. Nile tilapia were reared in chemically fertilized and fed (25% crude protein pellets) green water tanks containing Nile tilapia Juveniles (I.W.=87.3-91.7 grams/fish). The experiment included four treatments that lasted 66 days in still water. Two treatments had areal feeding rate of 8 and 9 grams diet (25% crude protein) per square meter of tank water area per day, for the whole experiment. The other two treatments had feed inputs of 8 and 9 grams diet (25% C.P.) per square meter of tank water area per day, respectively along with a chemical fertilizer dose that made both treatments iso-nitrogen regarding the total nitrogen input (i.e. 2.88 g N/m^2/week).The objectives of the study was to investigate the effect of the total nitrogen input in each treatment on oxygen budget and growth performance of Nile tilapia. Within each feed load (8 or 9 g /m^2/day), growth of Nile tilapia was higher in treatments without fertilizer addition. Adding a fertilizer along with feeding, reduced growth rate of fish due to its adverse effect on oxygen budget at high nitrogen load (i.e. 2.88 g N/m^2/week). It is recommended that the sum of feed-N and fertilizer-N inputs into pond water without nighttime aeration, should not exceed areal nitrogen inputs of 2.0 grams N/m^2/week in order to produce positive oxygen budgets at dawn and good growth of Nile tilapia.

Keywords: feed-N load, nitrogen-N load, oxygen dynamics, algae, algal blooms, Nile tilapia.

INTRODUCTION

Feed input produces nitrogen wastes (as metabolic ammonia) that can cause negative impacts to the environment. The amount of these wastes is increased when farmers follow inappropriate feed management strategies and overestimate the required feed inputs (Venero et al., 2007).This excess of feed can cause deterioration of water quality that leads to poor growth and survival with a consequent reduction in production and economic return (Venero et al., 2007).

Organic inputs, senescent phytoplankton,fish fecal solids and uneaten feed settle from the water column to the sediment (Hargreaves, 1998). A simulation model that partitioned the fate of N added to semi intensive shrimp ponds predicted that 48 to 66% would settle to the pond bottom in the form of phytoplankton (Lorenzen et al., 1997). Nutrients added to ponds as inorganic fertilizers, aquatic animal excrement, and uneaten feed stimulate phytoplankton productivity. Boyd (1985) demonstrated that each ton of fish production resulted in the production of about 2.5 tons of dry organic matter in phytoplankton.

Fluctuation of water quality in ponds is the results of variation in nutrients loading from feed and biological processes of organisms in water column and sediment (Burford and Williams 200; Songsangjinda et al., 2006).On average, less than 30% of the nitrogen supplied to fish and shrimpponds as food or fertilizer is recovered as biomass of the target species (Naranjo et al., 2010). Most of the remainder enters the water as ammonia(Jackson *et al.*, 2003).

The inherent efficiency of nutrient utilization by fish implies that N loading of aquaculture ponds may be limited by the capacity to assimilate nitrogenous excretion,which may have a deleterious impact on water quality and fish growth (Hargreaves, 1998).

In fish ponds, the nutrient enrichment by the addition of fertilizers and supplementary feeding, leads to eutrophication, thereby frequently developing dense algal blooms (Padmavathi and Durgaprased, 2007). Further, these blooms have a blanketing effect on the pond, thereby preventing the entry of sunlight into the water. All these factors may affect the pond productivity (Padmavathi and Durgaprased ,2007).

Nitrogen, the product of protein metabolism when it is not deposited as growth is the nutrient that most contributes with eutrophication problems in marine and brackish water environments (Jacksonet al., 2003). Nitrogen enrichment enhances the proliferation of faster growing phytoplankton, epiphytic algae and macroalgae (Hauxwell et al., 2001). Results of total food consumption in relation to phytoplankton blooms indicate that when the chlorophyll a concentration increased, total food consumption of shrimp decreased (Keawtawee et al., 2012).

Blue-green algae can become the dominant algae in nutrient-rich waters,forming blooms so thick that it appears that blue-green paint covers the surface of the water (Rodgers, 2008).Oxygen depletion in eutrophic ponds at night is a well known consequence of “excess” algal biomass (Jewel et al., 2003).

The objectives of the current study were to test growth performance and water quality of Nile tilapia reared in greenwater tanks under different nitrogen loads.

MATERIALS AND METHODS

The study was conducted at the Fish Research Unit, Faculty of Agriculture, Cairo University, Egypt during summer 2010. Rectangular concrete tanks were filled with freshwater obtained from a well to a constant depth of 75.0 cm. Each tank had a surface water area 2.5 m^2.

The experiment tested growth performance and water quality of Nile tilapia in greenwater tanks under different nitrogen loads for 66 days. The commercial pelleted feed (25% crude protein used in the experiment was purchased from Zoo-Control Company, located in the 6-October City, Giza, Egypt. The amount of feed applied daily in each tank was kept constant and did not increase with time during the whole experiment.

Experimental design

Nile tilapia (*Oreochromis niloticus*) with average initial weights of 87.3- 91.7 g/fish were distributed into eight concrete tanks which had constant water depth 75.0 cm during the experiment. Each tank was stocked with 10 juvenile Nile tilapia. Fish in each tank were individually weighed and lengthed at the start and end of the experiment. Treatments were equally replicated and arranged in completely randomized design. The experiment consisted of four treatments, with two replicate tanks per treatment as follows:

The 8 gram diet treatment

The 8 gram diet treatment included feeding fish in each tank with a constant amount of commercial ration (25% crude protein) overtime at 8 g/m^2/day (20 g diet/tank/day), six days a week, during the whole experiment. Nitrogen fertilizer was not applied. The nitrogen load originated solely from feed-nitrogen. The dose of feed nitrogen was equivalent to 1.92 g N/m^2/week.

The 8 gram diet with fertilizer treatment

The 8 gram diet with fertilizer treatment included feeding fish in each tank with a constant amount of commercial ration (25% crude protein) overtime at 8 g/m^2/day (20 g diet/tank/day), six days a week , during the whole experiment. Moreover, nitrogen fertilizer (urea) was applied at the rate of 5.5 g/tank/week and superphosphate (P_2O_5 = 15.5% P) at 7.0 g/tank/week, once every week. The total nitrogen input of both feed-N and fertilizer-N totaled 2.88 g N/m^2/week.

The 9 gram diet treatment

The 9 gram diet treatment included feeding fish in each tank with a constant amount of commercial ration (25% crude protein) overtime at 9 g/m^2/day (22.5 g diet /tank/day), six days a week , during the whole experiment. Nitrogen fertilizer was not applied. The nitrogen input originated solely from feed-nitrogen. The dose of feed nitrogen was equivalent to 2.16 g N/m^2/week.

The 9 gram diet with fertilizer treatment

The 9 gram diet with fertilizer treatment included feeding fish in each tank with a constant amount of commercial ration (25% crude protein) overtime at 9 g/m^2/day (22.5 g diet/tank/day), six days a week , during the whole experiment. Moreover, nitrogen fertilizer (urea) was applied at the rate of 4.0 g/tank/week and superphosphate (P_2O_5 = 15.5% P) at 5.0 g/tank/week, once every week. The total nitrogen included both feed-N and fertilizer-N and totaled 2.86 g N/m^2/week.

Growth performance such as specific growth rate, weight gain and daily weight gain, and feed performance data such as feed conversion ratio and protein efficiency ratio were calculated at the end of the experiment. Water quality indices such as water temperature, dissolved oxygen and pH values were measured twice per day , at dusk and nighttime in order to calculate oxygen budget at dawn and pH dynamics parameters.

Oxygen and pH dynamics

Calculations that predict nighttime decline in DO were based on Boyd *et al*. (1978) and Romaire and Boyd (1979) .The projection method was based on assuming that the DO decline during nighttime is essentially linear with respect to time. When DO concentration at dusk and at nighttime are plotted versus time,a straight line through the two points was projected to estimate DO at dawn or at other times during night (Boyd *et al*. ,1978 ; Romaire and Boyd ,1979). Boyd (1998) indicated the high accuracy of the projection method in predicting DO concentration at dawn compared with measured values. Romaire and Boyd (1979) indicated that the nighttime dissolved oxygen model gave highly reliable prediction of early morning DO concentration. An additional simplifying assumption was made not to correct daytime net primary production (dNPP) or nighttime community respiration (nCR) for diffusion according to Hargreaves and Steeby (1999).

The pH change during daytime was considered as an index for daytime net primary production (dNPP)) in terms of the amount of CO_2 consumed during daytime by algae. Consequently, the pH increase during daytime reflected the daytime net rate of primary production (dNPP).

Determination of nighttime community respiration required measurements of dissolved oxygen. DO and pH were measured two times daily (at dusk and nighttime).

Oxygen and pH budget calculations

Nighttime community respiration per hour ($nCRh^{-1}$) = (dusk oxygen concentration -

nighttime oxygen concentration) /dark period (hours).

Nighttime community respiration (nCR) = hourly nighttime community respiration * nighttime dark period (from dusk to next dawn in hours.).

Dawn oxygen surplus /deficit = dusk oxygen concentration–nCR

Daytime pH gain (dpH gain ,units /daytime) = dusk pH –next morning pH

Growth Performance

Growth performance of cultured fish was measured in terms of final individual fish weight(g) , daily weight gain (g / fish /day), specific growth rate (SGR-%/day), feed conversion ratio (FCR), and protein efficiency ratio (PER). The growth and feed performance parameters were calculated as follows:

Body weight

Individual weights of fish were measured at the start and end of the experimental period using digital balance for weight to the nearest 0.1g.

Daily weight gain (DWG)

DWG = (final body weight -initial body weight)/ experimental period(days).

Specific growth rate (SGR)

Specific growth rate (SGRW) were determined as:

SGRW = (Ln W_t - Ln W_0)*100 /t

Where: W_t is weight at time t, W_0 weight at time 0, and t is the duration of time in days.

Feed conversion ratio (FCR)

Feed efficiency was determined as the grams of dry diet consumed per gram of wet weight gain of fish.

FCR=dry weight of feed fed (g) /fish weight gain (g).

Protein efficiency ratio (PER)

The protein efficiency ratio was calculated as the grams of wet weight gain of fish per gram of protein consumed .

PER = fish weight gain(g)/ protein fed (g)

Water quality parameters

All determination of water quality parameters were carried out at the Fish Research Unit (Faculty of Agriculture, Cairo University) according to the standard methods American Public Health Association (APHA, 1985)and Boyd and Tucker (1992). Temperature and dissolved oxygen were measured by using Hanna Instrument (model 55) dissolved oxygen meter. pH was measured using Hanna digital meter.

Water temperature and dissolved oxygen

Readings of temperature and dissolved oxygen were taken at dusk and late nighttime by integrating the probe of the oxygen over the whole depth of water up to the bottom of the tank.

Secchi disk visibility

Estimates of secchi disk visibility were made in the afternoon in each concrete tank.

pH

pH was measured using digital pH meter (Hanna instruments) at the laboratory just after water sample was collected in a medium container.

Statistical analysis

Growth and feed performances of cultured fish as well as water quality parameters in culture tanks were subjected to one–way analysis of variance to determine statistical differences among treatments. Differences among means were assessed by Duncan multiple range test (Duncan, 1955).Statistical differences were determined by setting the aggregate type I error at 5% ($p < 0.05$) for each comparison. These statistical analyses were performed using the software package SPSS for windows, Release 8.0 (SPSS, 1997).

RESULTS AND DISCUSSION

The nitrogen load experiment

Water quality dynamics

Water temperature

Early morning water temperature ranged from 25.0 to 31.4 ^{0}C among treatments, with overall averages of 27.1-27.8 ^{0}C during the experiment (Table 1). No significant differences were observed among treatments in terms of early morning temperature (P>0.05). There was a gradual decrease in water temperature with time during the experiment, taking place in late summer and early fall. Averages of water temperature were optimal for growth of Nile tilapia. Overall averages of water temperature at dusk time (30.7-31.4 ^{0}C) were higher than those of the early morning temperature (27.1-27.8 ^{0}C) by + 3.6 ^{0}C due to the diel heat gain during daylight hours.

Oxygen at dusk and daybreak

Dusk oxygen concentrations were higher in the fertilizer treatments (P<0.05). Average oxygen concentrations at dusk ranged 11.43 to 15.12 g O_2/m^2 among treatments (P<0.05). However, early morning oxygen concentrations were very low in the fertilizer treatments (-0.74 - 0.74 g O_2/m^2), approaching near-zero concentrations at sunrise (Table 2).This was due to its higher nitrogen load and excessive phytoplankton abundance in rearing tanks. Boyd (1982) reported that high oxygen concentration in surface waters favor diffusion of oxygen to the air, increasing the pH value overtime (Elnady et al., 2012 a and b).

Gab in DO concentration

During daylight hours, photosynthesis leads to an increase in the amount of oxygen, but after

sunset, the respiration and decomposition processes become dominat and draw on the oxygen content, so that its concentration decreases (Mukherjee *et al*., 2008). Increased respiration and decomposition rates over that of the photosynthetic rate leads to a pronounced cyclic fluctuation of oxygen content (Mukherjee *et al.*, 2008).

Table 1. ***Water quality parameters in experimental tanks under different nitrogen inputs.***

Parameter	Nitrogen load			
	8 g/m^2		9 g/m^2	
	without fertilizer	with fertilizer	without fertilizer	with fertilizer
Early morning temperature ^{0}C)	27.3^a ± 1.79	27.1^a ± 1.80	27.7^a ± 1.80	27.4^a ± 1.83
Dusk temperature (^{0}C)	30.7^a ± 2.07	30.9^a ± 2.19	31.5^a ± 2.08	31.4^a ± 2.38
Dusk oxygen concentration (g O_2/m^2)	11.43^b ± 3.50	13.98^{ab} ± 2.88	14.64^a ± 3.58	15.12^a ± 3.74
Estimated dawn oxygen concentration (g O_2/m^2)	1.38	0.74-	1.91	0.74
Secchi disk readings (cm)	26.6^a ± 69	15.1^c ± 5.97	23.5^b ± 5.30	17.1^c ± 4.23
Early morning pH (units)	8.51^c ± 0.36	8.79^b ± 0.22	8.94^{ab} ± 0.19	9.04^a ± 0..23
Dusk pH (unit)	8.99^b ± 0.48	9.37^a ± 0.19	9.44^a ± 0.28	9.51^a ± 0.27
pH gains during daylight period (unit)	0.57 ± 0.23	0.67 ± 0.18	0.54 ± 0.13	0.52 ± 0.11

Means in the same row with different letters are significantly different (P<0.05).

Table 2. *Oxygen budget at dawn time (g O_2/m^2) in water in rearing tanks under different nitrogen loads.*

Measuring date	Nitrogen load			
	8 g/m^2		9 g/m^2	
	without fertilizer	with fertilizer	without fertilizer	with fertilizer
18/8/2010	1.17	-3.47	-2.39	-2.89
25/8/2010	4.88	-1.56	1.69	0.09
20/9/2010	1.15	0.34	6.39	4.02
22/9/2010	1.25	0.18	4.85	1.52
29/9/2010	1.03	1.25	2.0	2.14
9/10/2010	-1.18	-1.19	-1.07	-0.42
Overall	1.38 ± 1.95	-0.74 ± 1.69	1.91 ± 3.35	0.74 ± 2.38

Estimated dawn oxygen concentrations were better in the feed only treatments compared to those of the fertilizer treatments (Table 2). Unfavorable oxygen budgets were observed in the fertilizer treatments during the experiment. The gab in DO concentrations between dusk and daybreak ranged 10.05 to 14.38 g O_2/m^2, which indicated intensive respiration rates in rearing tanks (Table 1).

In green-water tanks, a pronounced diel variation of dissolved oxygen (minimum: close to zero and maximum 15-17 mg/l) was observed (Hargreaves, 2006). This indicated the role of phytoplankton dynamics (photosynthesis and respiration) in controlling oxygen dynamics according to Hargreaves (2006).

Higher densities of phytoplankton restrict light so that photosynthetic oxygen production is restricted to shallower photic depths (Boyd, 1979). This would lower total oxygen production on areal basis. As regards, phytoplankton blooms of excessive density, DO concentration may drop so low during the night and early morning (Boyd, 1979).

Nighttime community respiration

Chlorophyll a concentrations and rates of plankton community respiration (CR), bacterial respiration (BR), and phytoplankton respiration (PR) increased with nutrient enrichment in whole-pond and microcosm experiments (Roberts and Howarth, 2006). High rates of photosynthesis will result in an increase in phytoplankton biomass, resulting in a corresponding increase in the total amount of respiration being carried out by phytoplankton community (Roberts and Howarth, 2006).

Nighttime community respiration rates are illustrated in Tables 3 and 4. Nighttime community respiration rates (nCR/hr) were higher in fertilizer treatments with higher nitrogen inputs (i.e. 2.86-2.88 g N/m^2/week) compared to those with low nitrogen inputs (1.92 -2.16 g N/m^2 /week). The 8 gram treatment with fertilizer had a higher respiration rate (1.24 g O_2/m^2/hour) compared to the 8 gram treatment without fertilizer (0.77 g O_2 /m^2/hour). Similarly, the 9 gram treatment with fertilizer had a higher nighttime respiration rate (1.16 g O_2/hour) compared to the 9 gram treatment without fertilizer (1.05 g O_2/m^2/hour). Hargreaves and Steeby (1999) reported that whole pond respiration rates (mg/l per hour) for Mississippi catfish ponds (WPR) averaged from a minimum of 0.81 mg/l per hour to a maximum of 1.66 mg/l per hour. Net primary productivity is only limited to daylight hours, while whole pond respiration rates extend over 24-hour period.

Robson (2005) assumed that the loss rate due to phytoplankton respiration equals 0.45/day relative to gross primary productivity. The increase in phytoplankton community biomass should result in a corresponding increase in the total amount of respiration being carried out by phytoplankton community (Roberts and Howarth, 2006). This is consistent with the notion of bacteria utilizing excreted DOC from phytoplankton as a carbon source during p-saturated conditions (Roberts and Howarth, 2006).

The positive rates effect of the nitrogen load on nighttime community respiration rates could be due to the increased algal and bacteriad

Table 3. ***Nighttime community respiration (nCR=g O_2/m^2) during dark period (from dusk to next dawn) under different nitrogen loads.***

Measuring date	**Nitrogen load**			
	8 g/m²		**9 g/m²**	
	without fertilizer	**with fertilizer**	**without fertilizer**	**with fertilizer**
18/8/2010	13.13	19.32	18.27	19.64
25/8/2010	8.40	14.60	12.39	14.07
20/9/2010	8.63	15.04	10.61	11.77
22/9/2010	8.28	15.27	12.13	14.11
29/9/2010	4.32	8.40	6.60	7.68
9/10/2010	9.48	11.40	10.56	11.16
Overall	$8.70^{b} \pm 2.8$	$14.00^{a} \pm 3.7$	$11.76^{ab} \pm 3.8$	$13.07^{ab} \pm 3.99$

Means in the same row with different letters are significantly different (P<0.05).

Table 4. ***Nighttime community respiration per hour (g O_2/m^2/hour) in water under different nitrogen loads.***

Measuring date	**Nitrogen load**			
	8 g/m²		**9 g/m²**	
	without fertilizer	**with fertilizer**	**without fertilizer**	**with fertilizer**
18/8/2010	1.25	1.84	1.74	1.87
25/8/2010	0.80	1.39	1.18	1.34
20/9/2010	0.74	1.29	0.91	1.01
22/9/2010	0.71	1.31	1.04	1.21
29/9/2010	0.36	0.70	0.55	0.64
9/10/2010	0.79	0.95	0.88	0.93
Overall	0.77 ± 0.28	1.24 ± 0.39	1.05 ± 0.39	1.16 ± 0.42

abundance with the addition of nitrogen fertilizer and the subsequent higher algal and bacterial respiration rates. This was indicated by the shallower seechi disk readings with the addition of nitrogen fertilizer (i.e. secchi disc = 15.1-17.1 cm) compared to those treatments without nitrogen fertilizer (23.5-26.6 cm). Recent studies indicated that algae consume at least 50% of its total daytime oxygen production on a daily basis (Madenjian et al., 1987; Robson, 2005). Increasing algal abundance at higher nitrogen inputs resulted in a similar increase in nighttime community respiration (nCR).

Oxygen budget at dawn and accumulation of algal sediments

Oxygen budget in catfish ponds described in the literature as whole pond respiration (WPR) includes phytoplankton respiration (57.5%), fish respiration (22.5%) and sediment respiration (19.4%) (Santa and Vinetea, 2007). Hargreaves (1997) indicated that based on empirical (Boyd, 1985) and theoretical (Piedrahita, 1991) evidence , fish respiration has a relatively small effect on pond dissolved oxygen budgets and that fish nitrogenous excretion has a much more important effect on water quality. Most of oxygen demand in pond aquaculture is accounted for by plankton and sediment respiration rather than by fish (Tucker, 2005).

Nutrient enrichment in the high nitrogen load (fertilizer) treatments increased algal sedimentation and its rate of decomposition (oxygen demand) by bacterial activities. The combined effect of the two processes resulted in the production of near zero or negative oxygen budgets at dawn. The oxygen budgets observed in the high nitrogen input treatments indicated unfavorable oxygen concentrations in water before sunrise (Table 2). The high nitrogen load induced by fertilizer addition increased algal production and algal sedimentation. The decomposition (oxygen demand) of the sedimented algae by bacterial activities resulted in unfavorable oxygen budget.

Pond sediment oxygen demand (SOD) is a major contributor to total pond respiration, accounting for as much as 38-80% of total respiration in shallow aquaculture ponds (Steeby *et al*., 2004a). Results of the best model were used to produce the predicted average industry SOD which equaled to 0.48 g O_2/m^2/hour (Steeby *et al*., 2004a).The total diel predicted industry-wide average SOD equaled 11.5 g O_2/m^2/day (Steeby *et al*., 2004a). In shrimp ponds, sediment respiration can constitute more than 50% of the oxygen demand of the entire pond (Madenjian *et al*., 1987).

Under low DO conditions, as in the hypolimmion of a pond, most unused organic matter and senescent algal biomass are incompletely oxidized and are potentially a source of major oxygen deficits (Chang, 1989). Losordo (1980) found that water column respiration accounted for in average; about 60% of the overnight DO decrease in the Auburn pond which could be attributed to the plankton respiration rate.

The current study indicated that the loading limit of total nitrogen as the sum of feed-N and fertilizer-N, without nighttime aeration, should not exceed 2.0 g N/m^2/week in order to reduce algal sedimentation rates and sediment oxygen demand and reach a steady-state sustainable positive oxygen budgets at dawn. Hargreaves and Tucker (2003) indicated that excessive algal bloom (due to nutrient enrichment with high nitrogen inputs) and its sedimentation rate result in a higher algae load at the bottom sediment which affect the waste assimilative capacity of static water. The same authors (Hargreaves and Tucker, 2003) indicated that, excessive algal bloom reduce the photosynthetic activities and rates of oxygen production in water on areal basis.

In catfish ponds, sediment concentration of organic matter increased from the beginning to the end of culture period (from 3.4 to 6.3%), which resulted in a higher oxygen demand by decomposing bacteria (Steeby *et al*., 2004a).This may explain why oxygen budget deteriorated in the fertilizer treatments in the current experiment. The estimation of the nighttime dissolved oxygen decline during dark period due to community respiration rates using the free sampling method , are considered to include the respiration exhibited by the pond bottom sediments. Ghosh and Tiwari (2008) reported that when dissolved oxygen fall below a certain threshold value (1.0 mg/l), sediment respiration was assumed to decline to zero.

Dense algal load in water column negatively affects oxygen production through increased algal sedimentation and shortening the photic zone depth (Boyd, 1990). Most of the variations in oxygen budgets during the current experiment was explained by the shallower photic zone induced by nutrient enrichment and high nitrogen inputs rates in the fertilizer treatments. Boyd (1985) indicated that each kilogram of pelleted feed applied in earthen ponds, produce approximately 1.25 kilogram of algae on a dry matter basis.

The shallow water depth in concrete tanks (i.e. 75.0 cm water depth) in the current study, increased light availability (photic zone :dark zone ratio =2:1) and phytoplankton density (secchi desk readings =15.1-26.6 cm) ,which contributed to high rates of algal photosynthesis. The higher primary production results in higher ammonia uptake rates and the transformation of ammonia into algal protein.

Algal sedimentation

Liquidized heaps of algal sediments with green color were observed at the tank bottom in the high nitrogen input (fertilizer) treatments during harvest hours. Those algal slurry heaps had H_2S odour at harvest time, indicating anaerobic conditions in the fertilizer treatments. It is widely accepted that each gram ammonia-N released in water produce ammonia oxygen demand of 4.17 gram O_2 (Timmons, 2007). Consequently, the high nutrient enrichment in the from of nitrogen fertilizer aggravated oxygen budget.

From the standpoint of microbial utilization of organic sediments, the settled organic matter is readily biodegradable because it consists of senescent phytoplankton and detritus of phytoplankton origin (Hargreaves, 2006). Such high-quality organic matter is rapidly and nearly completely mineralized when conditions are favorable (Hargreaves, 2006).

Nutrient enrichment and algal blooms

There was a positive relationship between the amount of nitrogen input (in terms of g N/m^2/week) and algal abundances in terms of secchi disk readings. Shallower secchi disk readings were observed in the high nitrogen treatments (i.e. treatments with fertilizer addition). The high nitrogen treatments had shallower secchi disk readings of 15.1-17.1 cm in contrast to those of the lower nitrogen load treatments (secchi disk readings = 23.5-26.6 cm), with significant differences among means ($p<0.05$).

Wurts and Masser (2004) reported that fertilizers containing nitrogen and phosphorus stimulate the growth of microscopic plants (phytoplankton) and animals (zooplankton). Intensive nutrient inputs lead to abundant community of phytoplankton (Ray et al, 2010). Boyd (1979) indicated that blue-green algal blooms are always associated with water containing high concentration of nitrogen and phosphorus. Moreover, excessive plankton abundance may be detrimental to fish production by causing problems with water quality (Boyd, 1979).

The release of nutrients by fish excretion and organic matter mineralization stimulate the development of dense phytoplankton population that constitute the major component of pond respiration (Hargreaves and Steeby, 1999). Nutrient enrichment in the high nitrogen input treatments increased algal density in water and decreased photic zone depth available for photosynthesis ($P<0.05$). This had increased oxygen cycling during the last month of the experiment.

pH gains and losses

In greenwater systems, carbon dioxide is added through community respiration and is removed through photosynthesis (Hargreves, 2006). Mukherjee et al. (2008) indicated that the change in the carbon cycle due to photosynthesis and respiration could be quantified by measuring the pH. Early morning pH values averaged 8.51-9.04 units among treatments during the experimental period, while dusk pH values averaged 8.99-9.51 units, with significant differences among treatments ($p<0.05$). Average pH gains during daylight hours ranged 0.52 to 0.68 unit among treatments, reflecting good photosynthetic activities.

Growth and feed performance

Body weight

Growth and feed performance patterns of Nile tilapia Juveniles are shown in Table 5. Starting from initial weights of 87.3-91.7 grams/fish at the beginning of the experiment, Nile tilapia grew to 100-131.8 grams/fish at harvest time, with different growth patterns among treatments ($p<0.05$). The lowest average harvest weight of Nile tilapia was observed in the fertilizer treatments (100.0-105.0 grams/fish) due to the negative effects of the high nitrogen inputs (i.e. 2.86 -2.88 g N/m^2/week) due to excessive algal blooms, algal sedimentation rates and aggravated oxygen budget. The highest harvest weights of Nile tilapia were obtained in low nitrogen input treatments, without fertilizer addition. At higher nitrogen loads, oxygen budgets and algal abundance were adversely affected due to the increase in sediment respiration rates augmented by high algal sedimentation. Nile tilapia reared with no fertilizer inputs were heavier than those reared under high nitrogen inputs.

Fish respiration constitutes approximately 25% of total whole pond respiration (Hargreaves and Steeby, 1999). An adequate concentration of dissolved oxygen is needed to avoid stress and to assure good growth of the culture species (Boyd, 2008). When DO levels in aquaculture ponds are low, the cultured organisms may become stressed or even die (Ghosh and Tiwari, 2008*)*. Fish do not feed or grow well under chronically low concentrations of dissolved oxygen (Chang and Ouyang, 1988). Adequate levels of dissolved oxygen are essential for maintaining optimal fish growth *(*Steeby *et al*., 2004b*)*.

Daily weight gains

The lowest daily weight gains of Nile tilapia (0.18-0.2 g/fish/day) were observed in the high nitrogen input treatments, where fish were reared in fertilizer treatments along with feeding. Overabundance of nitrogen salts increased algal production, sedimentation rates and (detrital) sediment respiration rates.

Fish reared under low nitrogen inputs had significantly higher daily weight gains (0.4-0.64 g/fish/day), with significant differences among treatments ($p<0.05$). Consequently, it can be concluded that water should not be fertilized when fish are fed supplemental diets (25% crude protein) at the rate of 8-9 grams diet/m^2/day (i.e. 32-36 kg diet/acre/day), when supplemental aeration is not offered in the pre-dawn hours.Fish are known to reduce feed intake when oxygen are short supply (Tucker, 2005).

The results showed that there was no need for fertilizer application in non-aerated systems when feed and/or fertilizer are applied at a load of 1.92-2.16 g N/m^2/week. Metabolic ammonia and metabolic phosphate will be excreted by metabolic activities of fish. The amount of excreted metabolites will be enough to produce dense algal density and optimal algal fertility to nourish fish, without the need for external chemical fertilization. It is well known that when artificial aeration is used, feed-nitrogen inputs can be increased up to 4.32 g N/m^2/day (Hargreaves and Tucker, 2003; Hargreaves, 1997).

Table 5. ***Growth and feed performance of Nile tilapia under different nitrogen loads***.

Parameter	Nitrogen load			
	8 g/m²		9 g/m²	
	without fertilizer	with fertilizer	without fertilizer	with fertilizer
Initial weigh (grams/fish)	89.5[a] ± 4.34	91.7[a] ± 13.74	89.3[a] ± 10.20	87.38[a] ± 8.83
Final weight (grams/fish)	116.85[a] ± 19.27	105.07[b]±18.24	131.80[a] ± 16.05	100.0[b] ±19.56
Weight gain (g/fish)	27.35[b] ± 15.04	13.35[c] ± 6.39	42.50[a] ± 7.24	12.16[c] ± 13.38
Daily weight gain (g/fish/day)	0.41[b] ± 0.22	0.20[c] ± 0.09	0.64[a] ± 0.11	0.18[c] ± 0.20
PER	0.96[b] ± 0.62	0.46[c] ± 0.26	1.33[a] ± 0.29	0.38[c] ± 0.56
FCR	4.18[c] ± 2.36	8.57 [a] ± 4.88	3.0[c] ± 0.42	10.71[a] ± 6.39

Means in the same row with different letters are significantly different (P<0.05).

Feed conversion ratios

Feed conversion ratios and protein efficiency ratios were significantly deteriorated in the high nitrogen input treatments (8.57-10.7:1 and 0.38- 0.46, respectively). The deterioration in feed conversion ratios may be due to the adverse effect of high nitrogen inputs, without nighttime aeration, on dissolved oxygen in the early morning hours. Low DO levels at dawn have been associated with reduced growth and causes stress which brings reduced feed intake (Bhuhjel, 2000). The data suggested that fertilizer-N should not applied when feed-N is applied at the rate of 1.92-2.16 g N/m^2/week, without artificial aeration. Tucker (2005) reported that depending on how low the dissolved oxygen concentration is and how long it remains low, fish may consume less feed, grow more slowly, convert feed less efficiently and be more susceptible to infections diseases.

REFERENCES

Bhujel, R .C. (2000). A review of strategies for the management of Nile tilapia (*Oreochromis niloticus*) brood fish in seed production systems, especially hapa-based systems. Aquaculture, 181: 37 - 59.

Boyd, C.E.; Romaire, R.P. and Johnson, E. (1978) . Predicting early morning dissolved oxygen concentration in channel catfish ponds. Trans. Am. Fish. Soc., 107(3): 484- 492.

Boyd, C.E. (1979). Water quality in warmwater fish ponds. Auburn, Alabama: Auburn University, Agricultural Experiment Station.

Boyd, C.E. (1982). Water Quality Management for Pond Fish Culture.Elsevier, New York, NY, 318pp.

Boyd, C.E. (1985). Chemical budgets for channel catfish pond. Trans. Am. Fish. Soc., vol. 114:291-298.

Boyd, C.E. (1990). Water Quality in Ponds for Aquaculture.Alabama Agricultural Experimental Station, Auburn, University, Auburn, AL, 482 p.

Boyd, C .E. (2008). Calculating the feed oxygen demand (FOD) of aquafeeds Kasetsart University Fisheries Research Bulletin, 32(3):26-31.

Chang, W.Y.B. (1989). Estimates of hypolimnetic oxygen deficit in ponds. Aquaculture and Fisheries Management, 20:167-172 .

Chang, W.Y.B. and Ouyang, H. (1988). Dynamics of dissolved oxygen and vertical circulation in fish ponds. Aquaculture, 74: 263-276.

Elnady, M.A., Abd El-Wahed, R.K. and Abduljabbar, A.A. (2012). Nighttime pH dynamics and oxygen-pH relationships under different fertilizer loads in green water tank culture. Journal of the Arabian Aquaculture Society.Vol. 7 (No2): 127-142**.**

Elnady, M.A., Abd El-Wahed, R.K. and Abduljabbar, A.A. (2012). Nighttime dissolved oxygen dynamics under different fertilizer loads in green water tank culture. Journal of the Arabian Aquaculture Society.Vol. 7 (No2): 109-126**.**

Ghosh, L. and Tiwari, G.N.(2008).Computer modeling of dissolved oxygen performance in greenhouse fishpond: An experimental validation. International Journal of Aquaculture research, 3(2):83-97.

Hargreaves, J.A. (1997).A simulation model of ammonia dynamics in commercial catfish ponds in the southeastern United States. Aquacultural Engineering 16:27–43.

Hargreaves, J.A. (2006). Photosynthetic suspended-growth systems in aquaculture .Aquacultural Engineering, vol.34: 344–363.

Hargreaves, J.A. and Steeby, J.A. (1999). Factors affecting metabolism of commercial channel catfish ponds as indicated by continuous dissolved oxygen measurement. Journal of the World Aquaculture Society, 30: 410 -421.

Hargreaves, J.A. and Tucker, C.S. (2003). Defining loading limits of static ponds for catfish aquaculture. Aquacultural Engineering, 28:47 -63.

Howarth, W. (2006). Global challenges in the regulation of aquaculture. 13-36 pp.

Losordo, T.M. (1980). An investigation of the oxygen demand materials of the water column in prawn grow -out ponds. MS Thesis, University of Hawaii, 100 pp.

Madenjian, C.P.; Rogers, G.L. and Fast, A.W. (1987). Predicting night time dissolved oxygen loss in prawn ponds of Hawaii. Part II. A new method. Aquacultural Engineering , 6: 209–225.

Mukherjee, B.; Mukherjee, D. and Nivedita, M. (2008).Modeling carbon and nutrient cycling in a simulated pond system at Ranchi.Ecological Modeling, 213: 437 -448.

Piedrahita. R. H.(1991) . Modeling water quality in aquaculture ecosystem . In: D.E. Brune and I. R . Tomas (Editors). Aquaculture and Water Quality . World Aquaculture Society, Baton Rouge. L .A .322-362 pp.

Ray, A.J.; Seaborn, G.; Leffler, J.W.; Wilde, S.B.; Lawson, A. and Browdy, C.L. (2010). Characterization of microbial communities in minimal-exchange, intensive aquaculture systems and the effects of suspended solids management.Aquaculture, 310: 130–138.

Robson, B. J. (2005). Representing the effects of diurnal variations in light on primary production on a seasonal time-scale. Ecological Modeling , 186 : 358–365.

Roberts, B.J. and Howarth, R.W. (2006). Nutrient and light availability regulate the relative contribution of autotrophs and heterotrophs to respiration in freshwater pelagic ecosystems. Limnol.Oceanogr., 51(1): 288–298.

Romaire ,R .P . and Boyd ,C.E .(1979). Effects of solar radiation on the dynamics of dissolved oxygen in channel catfish ponds .Trans. Am. Fish Soc., 108 :473 – 480 .

Santa, K.D. and Vintea, L. (2007). Evaluation of respiration rates and mechanical aeration requirements in semi-intensive shrimp *Litopenaeus vannamei* culture ponds . Aquacultural Engineering, 36: 73 – 80.

Steeby, J.A.; Hargreave, J.A.; Tucker, C.S. and Kingsbury, S. (2004a). Accumulation, organic carbon and dry matter concentration of sediment in commercial channel catfish ponds. Aquacultural Engineering, 30: 115–126.

Steeby, J. A.; Hargreaves, J. A.; Tucker, C. S. and Cathcart, T .P. (2004b). Modeling industry-wide sediment oxygen demand and estimation of the contribution of sediment to total respiration in commercial channel catfish ponds. Aquacultural Engineering , 31: 247–262.

Timmons , M.B. and Ebling , J. M. (2007) . Recirculating aquaculture . Cayuga Aqua Ventures , 489 pp.

Tucker, C .S. (2003). Best management practices for pond aquaculture.Pages 93 -110 In: R .C. Summerfelt and R . D. Clayton (editors).Aquaculture effluents: Overview of EPA guidelines and standards and BMPS for ponds raceways, and recycle culture system. Proceedings from the Conference, Ames, Iowa. Publication Office, North Central Regional Aquaculture Center, Iowa StateUniversity, Ames, Iowa.

Tucker, C.S. (2005).Pond aeration .SRAC Publication, No. 3700, 8pp.

Wurts, W.A. and Masser, M.P. (2004). Liming ponds for aquaculture. Southern Regional Aquacultura center (SRAC), U.S.A.

تاثير الاحمال النيتروجينيه الكليه علي جوده المياه واداء النمو في البلطي النيلي

محمد النادي احمد محمد - رشا خالد عبد الواحد - مي جمال غلاب
قسم الانتاج الحيواني- كلية الزراعة - جامعه القاهرة

الهدف من هذة الدراسة هو دراسة تاثير الحمل النيتروجيني الكلي فى المياة (الذي يشمل مجموع نيتروجين العليقة ونيتروجين السماد معا) علي مؤشرات جودة المياة واداء النمو في البلطي النيلي . وقد تم تربية البلطي النيلي في أحواض بنظام المياة المياة الخضراء باستخدام التغذية الصناعية (٢٥% بروتين خام) والتسميد الكيميائي. ترواح الوزن الابتدائي للبلطي النيلي بين٨٧,٣ – ٩١,٧ جرام للسمكة الواحدة. واشتملت التجربة علي أربعة معاملات لمدة ٦٦ يوم في الاحواض الأسمنتية بنظام المياة الساكنة. وتشمل المعاملة الاولى والثانية معاملتين تغذية صناعية فقط حيث تم تغذية الأسماك بمعدل ٨ جرام عليقة (المعاملة الاولي) و٩ جرام عليقة (المعاملة الثانيه) في المتر المربع المائي من مساحة الحوض يوميا خلال فترة التجربة كلها. ولم يتم زيادة معدل التغذية عن هذا المستوي طوال فتره التجربة (تغذية مساحية ثابتة ٨ جم عليقة /م٢ / يوم و ٩ جم عليقة/ م٢/ يوم). اما المعاملة الثالثة والرابعة اشتملت علي التسميد الكيميائي بالإضافة التغذية الصناعية بحيث يصبح الحمل النيتروجيني الكلي متساوي في المعاملتين عند ٢,٨٨ جرام نيتروجين في المتر المربع المائي في الإسبوع . وكان الهدف من هذة الدراسة هو اختبار تاثير الحمل النيتروجيني الكلي في كل معاملة علي ميزانية الأكسجين واداء النمو في البلطي النيلي. و عند مقارنة الأربعة معاملات إتضح ان سرعة نمو البلطي النيلي كانت عالية في حالة عدم إستخدام التسميد الكيميائي. وعند إستخدام التسميد بالإضافة إلي التغذية الصناعية إنخفضت سرعة نمو الأسماك . وهذا يرجع إلي التاثير السلبي للأحمال النيتروجينية العالية (٢,٨٨ جرام نيتروجين/متر مربع/أسبوع) علي ميزانية الأكسجين في الأحواض . وتوصي التجربة بأن لا يزيد الحمل النيتروجيني الكلي (مجموع نيتروجين العليقة بالإضافة إلي نيتروجين السماد في المياة) عن ٢ جم نيتروجين في المتر المربع في الأسبوع لكي نحصل علي ميزانية أكسجين موجبة عند الفجر ونمو جيد للبلطي النيلي.

الكلمات الدالة: حمل نيتروجين العليقة – حمل نيتروجين السماد – الحمل النيتروجينى الكلى - ديناميكا الأكسجين – الطحالب – ازدهار الطحالب - البلطي النيلي.