

PHYTOPLANKTON ABUNDANCE AND BIOMASS IN FERTILIZED EARTHEN FISH CULTURE PONDS OF RASHT, IRAN

B TIZKAR¹, A SEIDAVI, M YASEMI² AND JT PONCE-PALAFIX^{*}

Animal Science Department, Rasht Branch, Islamic Azad University, Rasht, Iran

Keywords: Phytoplankton, Biovolume, Temporal variation, Fish pond

Abstract

The effects of both granular and liquid fertilizers on phytoplankton abundance and biomass under fish culture pond conditions were studied. Six fish ponds (1000 m²) were designated for the experiment. Ponds were treated using granular fertilizers (GF) and liquid fertilizer (LF). The fertilization rate was 1 mg/l nitrogen and 1 mg/l phosphorous over a 10 days interval for 10 weeks. The chlorophytes, bacillariophytes and chrysophytes demonstrated a significant difference between LF and GF treatments, whereas there appeared to be no meaningful difference in terms of the population of cyanophytes and euglenophytes.

Introduction

A fish pond constitutes a small ecosystem that is comprised of physical-chemical factors, primary producers, consumers and detritus, with complicated ecological bonds among them. Pond fertilization implemented by fish farmers may increase phytoplankton biomass, thereby altering water transparency and conditions for other primary production development (Broyer and Curtet 2011). This tends to be followed by an increase in zooplankton prey for carp (Wurts 2004) and macro-invertebrates. Recently, there has been a renewed interest on the role of fish in food cycles and energy supply within fish ponds. The use of granular fertilizers is replacing the use of synthetic liquid fertilizers for the production of warm water fish and shrimp species in the leading fish farming countries. However, Seidavi *et al.* (2014) and Tizkar *et al.* (2014) suggested that liquid fertilizers have several advantages over the traditionally used granular inorganics. There is a lack of data comparing the relative effectiveness of liquid and granular fertilizers in earthen ponds. The objective of this study is to compare the effects of both granular and liquid fertilizers on phytoplankton abundance and biomass under fish culture earthen pond conditions.

Materials and Methods

The experiment was carried out at the Bony Fish Hatchery Complex in Rasht, Iran (37°13'23.17"N; 49°36'18.68"E). Six fish earthen ponds (1000 m² each) were designated for the experiment. The pond Nos. 1, 3 and 6 were fertilized using nitrogenous and phosphorus granular fertilizers (GF), whereas pond Nos. 2, 4 and 5 were treated with liquid fertilizer (LF). There were 2 treatments, including 3 replications per each treatment. Treatment 1 included GF and treatment 2 included LF. The ponds were equal in size and shape and each were 1.1 m deep. All of the ponds underwent similar preparations. To disinfect the farming ponds, 200 kg of quicklime was used in each pond. Water was introduced into the ponds, with water flowing through protective filtration nets. The GF involved the use of granulated triple phosphate fertilizer and urea fertilizers, whereas the LF group had a fertilization rate of 1 mg/l nitrogen and 1 mg/l of phosphorous at 10 days intervals.

*Author for correspondence: <jesus.ponce@usa.net>. University of Nayarit. Coastal Bioengineering Laboratory. Nayarit. México. 63155. ¹Gilan Agricultural and Natural Resources Research and Education Center. Agricultural Research, Education and Extension *Organization* (AREEO). Rasht. Iran. ²Applied Scientific Higher Education Institute, Jehade-E- Agriculture, Tehran, Iran.

To characterize the physical and chemical properties of the pond water, the temperature and dissolved oxygen of the water were measured with a digital oximeter (YSI-55), the pH was measured with a digital pH Meter & Digital Tester Hydro New - PH-009, and the transparency was measured using a Secchi Disk a 20 cm-diameter. To specify the phytoplankton composition and abundance within the experimental ponds during the interval between the two fertilizing instances, water samples were collected once every seven days. After the samples were fixed with a 10% formalin solution, the cell counts and the determination of the phytoplankton species were conducted in the laboratory. The Utermöhl method (Utermöhl 1958), with an inverted Zeiss microscope (model Axiovert 135M), was used in random fields for the quantitative analysis of the phytoplankton, as proposed by Uhelinger (1964). The phytoplankton abundance were calculated using the method described by Weber (1973) and the phytoplankton biovolume was calculated using the methods described by Sun and Liu (2003) and converted to biomass, assuming a specific gravity of 1 mg/mm³ (Wetzel and Likens 2000) and expressed as mg/l. The species were categorized according to the functional groups proposed by Padisák *et al.* (2009).

Water quality and phytoplankton groups were subjected to an analysis of t-test to determine differences ($p < 0.05$) between tested groups and analysis of variance (ANOVA) and the mean comparison was carried out using Tukey's test ($p < 0.05$), with honest significant differences (Montgomery 2012). Statistical analyses were performed using the STATISTICA software version 10 for PC (StatSoft Inc., USA).

Results and Discussion

No significant differences ($p < 0.05$) were found in the water temperature of the ponds fertilized with LF and GF and temperature were lowest at 1 to 4 weeks ($17.5 \pm 1.0^\circ\text{C}$) and the highest at 5 to 10 weeks ($27.5 \pm 1.0^\circ\text{C}$). The number of chlorophytes and bacillariophytes tended to rise with increasing temperature. This study confirms that fish ponds have relative phytoplankton abundance changed with time, where chlorophytes and bacillariophytes being the dominant groups in the warm season (Ponce-Palafox *et al.* 2010). Dissolved oxygen concentration was significantly higher (9.5 mg/l) in LF than GF (8.7 mg/l). Higher dissolved oxygen concentration occurred after week 6 of the experiment (11.28 mg/l), while the pH was higher in LF (8.8) than GF (8.0). A pH of 8.5 was determined to be optimal for phytoplankton in ponds due to the uniform shift in all bodies of freshwater that have been studied (Nowrouzi and Valavi 2011). Transparency of water was higher in GF (38.2 cm) than LF (30.5 cm). A more common use of the Secchi disk in aquaculture is to determine the adequacy of the plankton bloom for fish or shrimp culture and to serve as an indicator of the need for fertilizer applications (Boyd 2004). The results of this study showed that the ponds are in good condition. The conditions of ponds remained invariant in terms of the volume type of incoming water. The results of qualitative water analysis also suggested the identical status of the environmental features of the experiment.

In general, the phytoplankton consisted of 5 taxa: Chlorophyta (63.3%), Bacillariophyta (21.9%), Cyanophyta (7.6%), Euglenophyta (6.7%) and Chrysophyta (0.5%). No significant differences ($p > 0.05$) were found in the abundance of cyanophytes and euglenophytes between LF and GF. The chlorophytes (11, 280, 410 org/l) was significantly ($p < 0.05$) higher than bacillariophytes (4,726,487 org/l) in LF.

High biomass was recorded throughout the study in LF (19.9 mg/l), compared to GF (10.72 mg/l). These high biomass concentrations in fish ponds may be explained by the large availability of nutrients and temperature (Oberhaus *et al.* 2007).

Three taxa were dominant in LF: Bacillariophyta (53.4%), Euglenophyta (20.1%) and Chlorophyta (19.1%). The euglenophytes dominated the first five weeks and bacillariophytes and

chlorophytes dominated the subsequent five weeks. The biomass of cyanophytes and euglenophytes populations in GF treated pond (Fig. 1) was higher compared to those of LF treated ponds ($p < 0.05$).

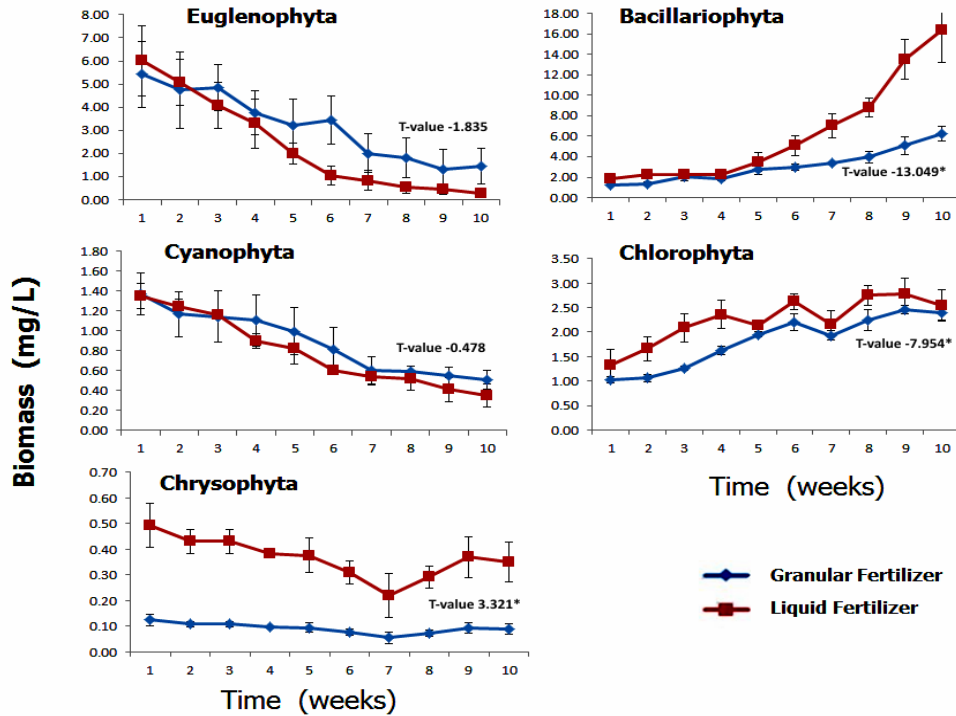


Fig. 1. Temporal variation in the total biomass of phytoplankton groups of fish ponds over 70 days. * $p < 0.05$ as determined by t-test (Granular Fertilizer vs. Liquid Fertilizer).

The phytoplankton biomass in the fish ponds showed a relationship with the time of cultivation in both treatments. The results of the present study demonstrated that the temporal change in algal structure was explained by changes in the physical and chemical conditions of the water.

It was found that in the ponds fertilized with LF increased the populations of bacillariophytes and chlorophytes, resulting in increased productivity of the pond. Considering the important role of bacillariophytes in farmed fish nutrition (Havens 1991), liquid fertilizers proved to perform better than GF in the production of these algal species. The euglenophytes were lower nutritional quality than chlorophytes and bacillariophytes (Lam and Silvester 1979).

The results of the present study indicated that in general, LF was able to boost the algal population within fish farming ponds. Their utilization, in particular, led to a higher concentration of diatomic algae and the green algae that led to the increase of useful algae and in ponds and higher productivity in fish ponds. Therefore, similar to the study performed on fish in the farming pond, it was revealed that the use of LF caused a better algal bloom in fish farming ponds. LF had higher solubility in water and faster absorption possibilities for the phytoplankton, leading to a more helpful algal population for growing cyprinids in farming ponds.

References

- Boyd CE 2004. Secchi disk visibility: Correct measurement, interpretation. *G.A.A.* **7**: 66-67.
- Broyer J and Curtet L 2011. The influence of fish farming intensification on taxonomic richness and biomass density of macrophyte-dwelling invertebrates in French fishponds. *Knowl. Manag. Aquat. Ec.* **400**: 10. doi:10.1051/kmae/2011017
- Havens KE 1991. Fish-induced sediment resuspension: Effects on phytoplankton biomass and community structure in a shallow hyper-eutrophic lake. *J. Plankton Res.* **13**: 1163-1171.
- Lam CWY and Silvester WB 1979. Growth interactions among blue-green (*Anabaena oscillarioides*, *Microcystis aeruginosa*) and green (*Chlorella* sp.) algae. *Hydrobiologia* **63**: 135-143.
- Montgomery DC 2012. *Design and Analysis of Experiments*. 8th Edition. Wiley India Pvt Ltd, 748 p.
- Nowrouzi S and Valavi H 2011. Effects of environmental factors on phytoplankton abundance and diversity in Kaftar lake. *J. Fish. Aquat. Sci.* **6**:130-140.
- Oberhaus L, Gelinas M, Pinel-alloul B, Ghadouani A and Humbert JF 2007. Grazing of two toxic Planktothrix species by *Daphnia pulex*: potential for bloom control and transfer of microcystins. *J. Plankton Res.* **29**(10):827-838.
- Padisák J, Crossetti L and Naselli-Flores L 2009. Use and misuse in the application of the phytoplankton functional classification: A critical review with updates. *Hydrobiologia* **621**: 1-19.
- Ponce-Palafox JT, Arredondo-Figueroa JL, Castillo-Vargasmachuca S, Rodríguez-Chávez G, Benítez-Valle A, Regalado-De Dios M, Medina-Carrillo F, Navarro-Villalobos R, Gómez-Gurrola J. and López-Lugo P 2010. The effect of chemical and organic fertilization on phytoplankton and fish production in carp (cyprinidae) polyculture system. *Rev. Biocienc* **1**: 44-50.
- Seidavi A, Tizkar B, Sudagar M and Ponce-Palafox JT 2014. Temporal variation of phytoplankton populations in response to granular and liquid fertilizers. *Phyton* **83**: 109-116.
- Sun J and Liu D 2003. Geometric models for calculating cell biovolume and surface area for phytoplankton . *J. Plankton Res.* **25**: 1331-1346.
- Tizkar B, Seidavi AR, Sudagar M and Ponce-Palafox JT 2014. Effects of granular and liquid fertilizers on phytoplankton under experimental pond condition. *Bangladesh J. Bot.* **43**(2): 175-181.
- Uhelinger V 1964. Étude statistique des méthodes de dénombrement planctonique. *Arch Scientific* **17**: 121-223.
- Utermöhl H 1958. Zur Vervollkommnung der quantitativen Phytoplankton-Methodik. *Mitt. Internat. Verein. Limnol.* **9**: 1-38.
- Weber CI 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-670/4-73-001. National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency. Cincinnati, Ohio, USA.
- Wetzel RG and Likens GE 2000. *Limnological analyses*. Springer, New York, USA.
- Wurts WA 2004. Organic fertilization in culture ponds. *World Aquac.* **35**: 64-65.

(Manuscript received on 20 April, 2016; revised on 27 January, 2017)