Journal of Animal and Veterinary Advances 11 (6): 799-802, 2012
ISSN: 1680-5593

Interval Nutrient Pulses Responses of Compatitive Culture Experiment: *Chaetoceros* Sp. *Thallassiosira allenii* (Takano), *Gomphosphaeria* Sp.

Goknur Sisman Aydin
Department of Hydrobiology, Faculty of Fisheries, Ege University, 35100 Bornova, Izmir, Turkey

Abstract: As phytoplankton are indisputably a major component of many food webs, estimating their abundance, biomass and growth rate has been an essential component of marine studies. The aim of this study is to establish the effects of different nutrient pulses on the cell size and biovolumes in competetive experiments of marine phytoplakton that was cultured from natural seawater. The growth of natural pytoplankton populations taken from Izmir bay (Aegean sea, Turkey) was observed for 6 different nutrient pulse periods (4, 8, 12, 24, 48 and 96 h) and determined Chl a, mean cell sizes and biovolumes. *Thallassiosira allenii* (Takano), *Chaetoceros* sp. and *Gomphosphaeria* sp. were dominated all pulse periods during the batch culture experiment. Nutrient pulses <2 days will be able to limit the exponential growth rate of community markedly. Although, *T. allenii* and *Chaetoceros* sp. cells enlarged their biovolumes with the extension of pulse period, *Gomphosphaeria* sp. cells was not.

Key words: Nutrient pulse, cell size, biovolume, growth, population, phytoplankton

INTRODUCTION

Izmir bay is the biggest natural bay in Turkey and one of major estuaries Aegean sea is formed by Aegean sea inserting 60 km in West Anatolia (Cirik *et al*., 1990). It is naturally divided into three parts: outer, central and inner Izmir bays. Inshore of Izmir bay are subjected to episodic nutrient inputs, mainly by municipal wastewater treatment plant effluents, agricultural and industriel effluents during the all seasons. Its pollution is also reached by atmospheric deposition, shipping, rivers and streams, erosion (Filibeli *et al*., 1995) National comitee reported that Izmir bay receives 60% of the urban and industrial waste water of Izmir.

Similar to the Eastern Mediterranean sea basin, Aegean sea shows more eutrophic characteristics than in other seas. In estuaries, combined Nitrogen (N) is typically the limiting nutrient for phytoplankton communities (Howarth, 1988; Nixon, 1995). The potential for nutrient limitation in both marine and freshwater ecosystems is usually governed by the concentration of nitrogen and phosphorus (Guildford and Hecky, 2000). In Izmir bay similar features was reported N limitation (Buyukisik and Erbil, 1987; Buyukisik, 1986). However, phosphorus limitation in the Eastern Mediterranean sea was demonstrated by several researchers (Krom *et al*., 1991; 1992; Berland *et al*., 1995; Ignatiades *et al*., 2002). Nutrient availability is a major factor controlling phytoplankton growth (Estrada *et al*., 2003). Intermittent inputs of nutrients from various sources also effect the biological processes (Gentilhomme and Rich, 2001) and species diversity.

The importance of nutrient pulses to phytoplankton growth of aquatic systems was reported in the 1980s (Officer and Ryhter, 1980). Although, several papers have demonstrated the effects of pulsed nutrient supply on a single species (Sciandra, 1991; Grover, 1991; Yamamoto and Tsuchiya, 1995), there are few study showing that the dominant phytoplankton species is changeable depending on whether the nutrient supply is pulsed or continuous (Olsen *et al*., 1989; Grover, 1991). The aim of this study is to establish the effects of different nutrient pulses on the marine phytoplankton that was cultured from natural seawater.

MATERIALS AND METHODS

The seawater was taken from inner part of Izmir bay (38°26'36"N, 27°06'24"E) and was kept on f/2 (Guillard, 1975) enrichment medium and ‰ 33 salinity. Culture was maintained in an incubator (NUVE) at 11±0.5°C (natural sea water temperature) under continuous light regime and 38.7 μmol $m^{-2}sec^{-1}$ (PAR) light intensity by using 40 Watt day light flouresans illumination. Algal biomass has been measured for each 4 h period as Chl a by using the Turner Designs 10-AU Field Floumeter (Brand and Guillard, 1981) and added nutrients for previously given each pulse period. The chlorophyll based exponential growth rates were calculated following Guillard (1973):

$$\mu = 1/(t_2-t_1)\times\log_2 (N_2/N_1)$$

Where:

- μ = Specific growth rate (day^{-1})
- N_1 = The Chl a measure at the beginning of the exponential growth phase µg lt^{-1}
- N_2 = Chl a measure at the end of the exponential growth phase µg lt^{-1}
- t_1 = The time period during which N_1 was determined
- t_2 = The time period during which N_2 was determined

The data of exponential growth rates against pulse periods has been fitted to Monod curve. The kinetic parameters was calculated by statistically (Least Square Method). Cell counting were made by single drop technique. Olympus model BH2 research microscope were used for microscopical analysis. The arithmetic mean cell size of each pulse period was used as a standardized biovolume (Monas, 2005).

RESULTS AND DISCUSSION

In this experiments, the maximum biomass that seawater can carry was estimated as 5.51 µg Chl a L^{-1} for these species at the end of 96 h. The lag phase durations were decreased and maximum Chl a concentrations were increased with increasing pulse periods >12 h (Fig. 1).

The other hand, the exponantial growth rates were decreased at the greater pulse periods than 96 h and were limited for shorter pulse periods than 24 h. Relationship between maximum exponentional spesific growth rates (μ_{exp}) and pulse periods (T) was found $\mu_{exp} = 0.046\times[T/((11.3833)+T)]$, ($p<0.05$) (Fig. 2). Although, *T. allenii* cells enlarged its diameters and biovolumes with the extension of pulse period ($p<0.05$), *Gomphosphaeria* sp. and *Chaetoceros* sp. cells was not (Fig. 3). Thus, *T. allenii* cells raise their nutrient supply between two pulse periods. Cell length and biovolume of *T. allenii* and *Chaetoceros* sp. changed depending on pulse periods ($p<0.05$) and the relationships consistent with Monod equation.

Increasing cell numbers of all specieses associate with pulse periods (Fig. 4). This change of morphological parameter provides to maintain the cells aliveness during the pulse interval.

As pulse intervals becomes frequent, diameter of these diatom cells decreases because of the sufficient nutrient amounts in the medium. On the other hand *Gomphosphaeria* sp. increased only its cell number. When pulse period extended, *Gomphosphaeria* sp. cell abundances exponentially ($p<0.05$) (Fig. 4).

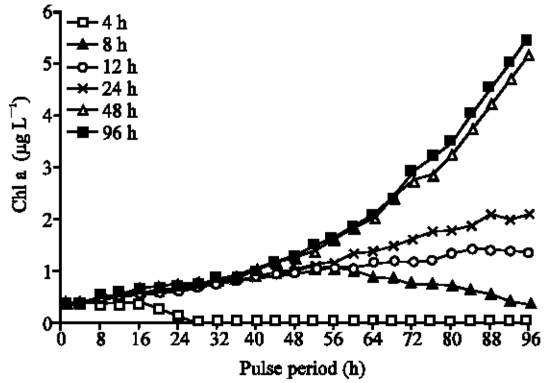

Fig. 1: The growth curve of competitive culture at different nutrient pulse periods

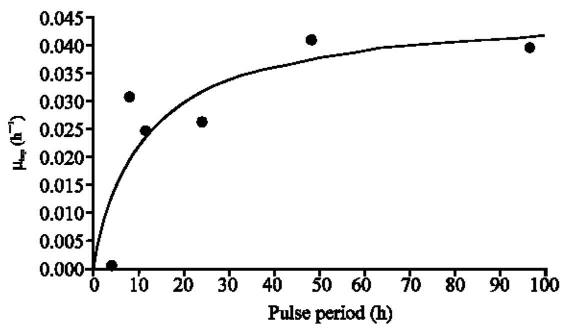

Fig. 2: Relationship between exponentional growth rates (μ_{exp}) of community and pulse periods (T)

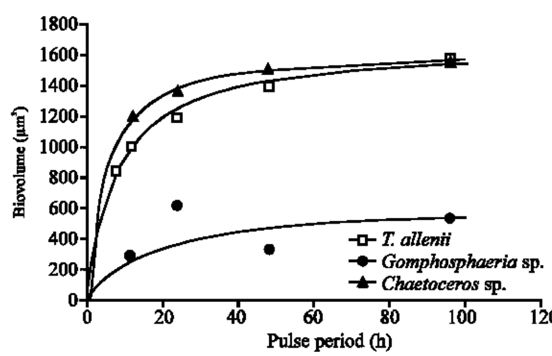

Fig. 3: Relationship pulse periods and biovolume of *Chaetoceros* sp. *T. allenii* and *Gomphosphaeria* sp.

Izmir bay receives approximately 60% of the urban and industrial waste water of Izmir. Generally in temperate ecosystems diatoms are dominant where nutrient and light intensities are high and reproduce relatively fast under these conditions compared to the other groups (Harrison *et al*., 1993). In Izmir bay as all estuaries, phytoplankton are exposed to rapidly changing conditions that may have a great effects on community structure and function. Many papers demonstrating that

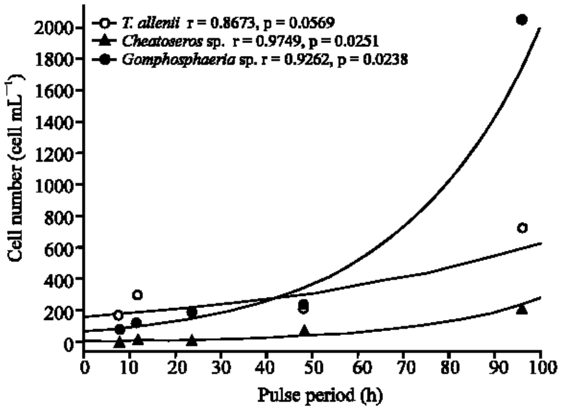

Fig. 4: Cell numbers of *Chaetoceros* sp. *T. allenii* and *Gomphosphaeria* sp. depends on pulse periods

the dominant phytoplankton species is changeable depending on whether the nutrient supply is pulsed or continuous (Olsen *et al*., 1989; Grover, 1991). Although, phytoplankton responses to limiting nutrients may also involve changes in growth rates as well as shifts in community composition (Pinckney *et al*., 1999). Theorical and experimental studies suggest that variability in nutrient supply favors dominance by species with high maximum growth rates (Grover, 1989). In this study, *Thallassiosira allenii* (Takano), *Chaetoceros* sp. and *Gomphosphaeria* sp. were dominated all pulse periods during the batch culture experiment. If capacity to store P (is greater in large cells then large not small, cells may be favored by variability in P supply (Suttle *et al*. 1987)). In this study, algae from a natural community were grown under various nutrient pulse periods in batch cultures, designed so that Si and P would limit algal growth.

Pulses >12 h are typical for domestic waste water discharge and this will be able to increase these species cell volume to saturation value. In the same way, growth rates also increase (Aydin and Buyukisik, 2005). Small cells tend to have both rapid nutrient uptake rates (Smith and Kalff, 1982) and high maximal growth rates (Banse, 1982).

On the otherhands, competition fluctuated nutrient levels results with the dominancy of large specieses in the coastal and tide areas (Turpin and Harrison, 1979). Because Large cells may also suffer lower respiratory losses than small cells during periods of depletion between nutrient pulses (Turpin and Harrison, 1980). In the fluctuating conditions, higher nutrient storage capacity of large specieses in intermittent inputs of nutrients becomes better competitor. Because of the small size and low nutrient storage capacity of these species will caused their population out of competition in nutrient pulse periods <2 days.

CONCLUSION

As a result of this experiments, it can be concluded that nutrient pulses shorter than 2 days will be able to limit the exponential growth rate of phytoplankton community markedly. In estuaries, combined Nitrogen (N) is typically the limiting nutrient for phytoplankton communities (Pinckney *et al*., 1999). If as a result of human activity, nutrient inputs into rivers increased interval nutrient pulses during discharge events may be a main nutrient source to sustain the growth inhibition of primary producers in Izmir bay.

REFERENCES

Aydin, G.S. and B. Buyukisik, 2005. Effects of nutrient loading frequency on the growth of harmful diatom *Thalassiosira allenii* Takano (Bacillariophyceae). Proceedings of the 10th European Ecological Congress, November 08-13, 2005, Kusadasi, Izmir, Turkey.

Banse, K., 1982. Cell volumes, maximal growth rates of unicellular algae and ciliates and the role of ciliates in the marine pclagial. Limnol. Oceanogr., 27: 1059-1071.

Berland, B.R., S.Y. Maestnni and D. Grzebyk, 1995. Observations on possible life cycle stages of the dinoflagellates *Dinophysis cf.* acuininata, *Dinophysis acuta* and *Dinophysis pavillardi*. Aquat. Microb. Ecol., 9: 183-189.

Brand, L.E. and R.R.L. Guillard, 1981. The effects of continuous light and light intensity on the reproduction rates of twenty-two species of marine phytoplankton. J. Exp. Mar. Biol. Ecol., 50: 119-132.

Buyukisik, B. and O. Erbil, 1987. The studies on nutrient dynamics in inner Izmir Bay. Doga. TJ. Eng. Environ., 11: 379-395.

Buyukisik, B., 1986. A comperative studies on the nutrient dynamics in Izmir Bay and ve Gulbahce Bay. Ph.D. Thesis, Bornova, Izmir, Turkey.

Cirik, S., S.L. Gokcen, A. Akyarli and E. Izdar, 1990. Sea researches of Izmir Bay. Proceedings of the Izmir Bay in Past, Today and Future Symposium, November 22-23, 1990, Izmir, Turkey.

Estrada, M., E. Berdalet, M. Vila and C. Marrase, 2003. Effects of pulsed nutrient enrichment on enclosed phytoplankton: Ecophysiological and successional responses. Aquatýc Microbial. Ecol., 32: 61-71.

Filibeli, A., R. Yilmaz and I. Alyanak, 1995. Dredged material of Izmir harbor: Its behavior and pollution potential. Water Sci. Tech., 32: 105-113.

Gentilhomme, V. and M. Rich, 2001. Periodic ammonium pulses: Are they important for the uptake kinetics of Isochrysis galbana?. Hydrobiologia, 459: 223-231.

Grover, J.P., 1989. Effects of Si: P supply ratio, supply variability and selective grazing in the plankton: An experiment with a natural algal and protistan assemblage. Limnol. Oceanogr., 34: 349-367.

Grover, J.P., 1991. Dynamics of competition among microalgae in variable environments: Experimental tests of alternative models. Oikos, 62: 231-243.

Guildford, S.J. and R.E. Hecky, 2000. Total Nitrogen, total phosphorus and nutrient limitation in lakes and oceans. Limnol. Oceanog., 6: 1213-1223.

Guillard, R.R.L., 1973. Divition Rates. In: Handbook of Phycological Methods, Stein, J. (Ed.). Cambridge University Press, Cambridge, UK., pp: 289-312.

Guillard, R.R.L., 1975. Culture of Phytoplankton for Feeding Marine Invertsbrates. In: Culture of Marine Invertebrate Animals, Smith, W.L. and M.H. Chanley (Eds.). Plenum Press, New York, USA., pp: 29-60.

Harrison, P.J., P.A. Thompson, M. Guo and F.J.R. Taylor, 1993. Effects of light, temperature and salinity on the growth rate of harmful marine diatoms, *Chaetoceros convolutes* and C. *concavicornis* that kill netpen salmon. J. Appl. Phycol., 5: 259-265.

Howarth, R.W., 1988. Nutrient limitation of net primary production in Marine ecosystems. Ann. Rev., 19: 89-110.

Ignatiades, L., S. Psarra, V. Zervakis, K. Pagouc, E. Souvermezoglouc, G. Assimakopoulouc and O. Gotsis-Skretasc, 2002. Phytoplankton size-based dynamics in the Aegean Sea (Eastern Mediterranean). J. Mar. Syst., 36: 11-28.

Krom, M.D., N. Kress, S. Brenner and L.I. Gordon, 1991. Phosphorus limitation of primary productivity in the eastern Mediterranean Sea. Limnol. Oceanogr., 36: 424-432.

Krom, M.D., S. Brenner, N. Kress, A. Neori and L.I. Gordon, 1992. Nutrient dynamics and new production in a warm-core eddy from the eastern Mediterranean Sea. Deep-Sea Res., 39: 467-480.

Monas, H., 2005. Biovolumes and size-classes of phytoplankton in the baltic Sea. Proceedings of the 18th Meeting of Monitoring and Assessment Group, November 21-25, 2005, Riga, Latvia.

Nixon, S.W., 1995. Coastal marine eutrophication: A defination, social causes and future concerns. Ophelia, 41: 199-219.

Officer, C.B. and J.H. Ryhter, 1980. The possible importance of silicon in marine cutrophication. Mar. Ecol. Prog. Ser., 3: 83-91.

Olsen, Y., O. Vadstein, T. Anderson and A. Jensen, 1989. Competition between *Staurastrum leutkemuellerii* (Chlorophyceae) and Microcystis aeruginosa (Cyanophyceae) under varying modes of phosphate supply. J. Phycol., 25: 499-508.

Pinckney, J.L., H.W. Paerl and M.B. Harrington, 1999. Responses of the phytoplankton community growth rate to nutrient pulses in variable estuarine environments. J. Phycol., 35: 1455-1463.

Sciandra, A., 1991. Coupling and uncoupling between nitrate uptake and growth rate in *Prorocentrum minimum* (Dinophyceae) under different frequencies of pulsed nutrient supply. Mar. Ecol. Prog. Ser., 12: 472-549.

Smith, R.E.H. and J.K. Kalff, 1982. Size-dependent phosphorus uptake kinetics and cell quota in phytoplankton. J. Phycol., 18: 275-284.

Suttle, C.A., J.G. Stockner and P.J. Harrison, 1987. Effects of nutrient pulses on community structure and cell size of a freshwater phytoplankton assemblage in culture. Can. J. Fish. Aquat. Sci., 44: 1768-1774.

Turpin, D.H. and P.J. Harrison, 1979. Limiting nutrient patchiness and its role in phytoplankton ecology. J. Exp. Mar. Biol. Ecol., 39: 151-166.

Turpin, D.H. and P.J. Harrison, 1980. Cell size manipulation in natural marine, planktonic, diatom communities. Can. J. Fish. Aquat. Sci., 37: 1193-1195.

Yamamoto, T. and H. Tsuchiya, 1995. Physiological responses of Si-limited *Skeletonema costatum* to silicate supply with salinity decrease. Bull. Plankton Soc. Jpn., 42: 1-17.