NITRATE-PHOSPHATE INTERACTIONS

IN LIMITING THE GROWTH OF

PAVLOVA LUTHERI

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ABSTRACT

Results from continuous culture experiments with populations of Pavlova lutheri exposed to a series of discrete nitrate: phosphate supply ratios indicated that a threshold, law of the minimum, model adequately predicts interactions of nitrogen and phosphorus cell quotas in determining growth rate. Thus, the ratio in which N and P are required at a given growth rate can be estimated from the growth rate versus cell quota relationships determined separately for nitrogen and phosphorus limited populations. The predicted N:P requirement ratios average just under 40 atoms/atom for growth rates between 0 and 0.05 hr^{-1}, but decline rapidly at higher growth rates.

In all cases studied here, whether nitrogen or phosphorus limited, the cells reduced growth chamber phosphate concentrations to very low levels. When exposed to large phosphate enrichments, cells increased their phosphorus quotas by up to sixty times. Cells could barely double their nitrogen cell quotas, and unassimilated nitrate remained in the growth chamber of all phosphate limited chemostats. The ability to accumulate phosphorus allowed cell N:P to mimic the N:P supply ratio over a range from less than 10 to almost 50.

Maximum net uptake rates for phosphate were of a similar magnitude to the maximum net uptake rates for nitrate despite the lesser requirement for the former nutrient. Phosphate uptake rate increased linearly with growth rate while nitrate uptake rate reached a maximum at intermediate growth rates. The decrease in nitrate uptake rate with further growth rate increases can be explained

as end product inhibition of uptake resulting from nearly full internal nutrient reservoirs. There are apparently two systems responsible for nitrate uptake. System 1 is subject to inhibition in the presence of phosphate, but not subject to end product inhibition. System 2 is independent of phosphate, but subject to end product inhibition. System 1 increases in importance relative to system 2 with increasing growth rate and with increasing N:P.

The cell yield of batch cultures also depended on nitrate and phosphate in a threshold, law of the minimum fashion.

Data from the literature allowed estimation of requirement ratios for two species of diatoms and one chlorophyte. As in the present results, the nutrients were required in ratios substantially higher than the typically cited 15:1, except at high growth rates. The 15:1 composition ratio which has been found in natural phytoplankton may simply reflect the ability of these cells to mimic the medium N:P through luxury consumption of phosphate. This luxury consumption makes it necessary for cells to compete for both nitrogen and phosphorus when nutrients are limiting in the ocean. Excess phosphorus which is accumulated in this way may be differentially excreted by organisms higher in the food chain.