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The effect of cellular nitrogen on chlorophyll content and growth rate of the green algae *Neochloris oleoabundans*

Jacob Nelson and Bruce Bugbee[1]

[1]Department of Plant, Soils & Climate
Utah State University, Logan, UT

BioEnergy Center

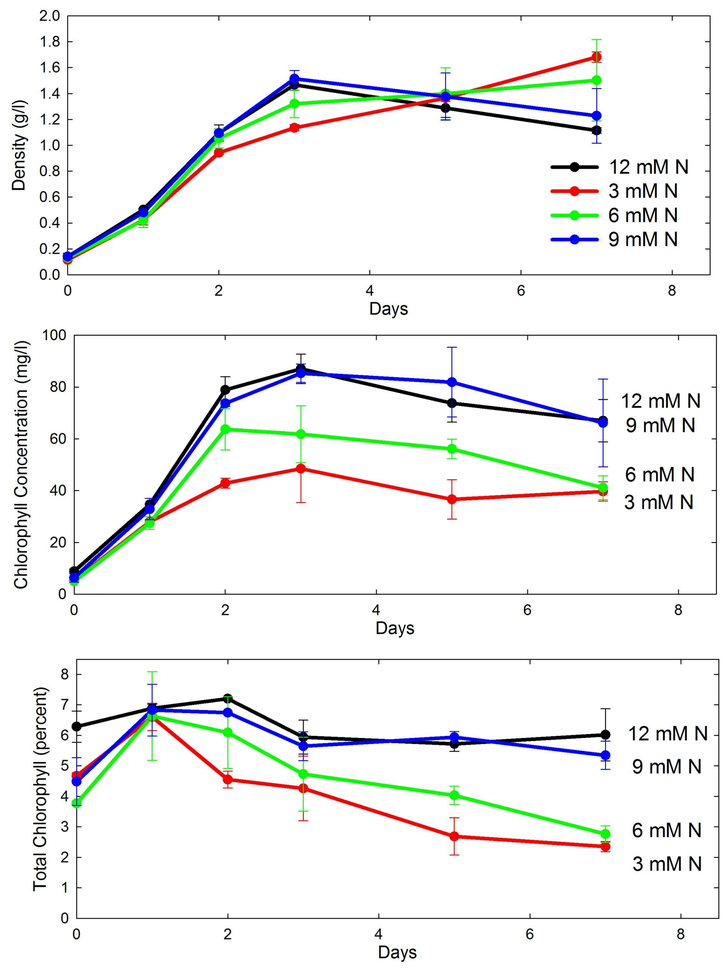
Abstract

Algae appear to overproduce chlorophyll, which interferes with light penetration into cultures and is difficult to separate during harvest. We hypothesized that reduced nitrogen would reduce chlorophyll concentration without reducing yield. Chlorophyll concentration was monitored under four levels of nitrogen stress. Chlorophyll levels dropped to less than half the concentration found in higher nitrogen treatments. The drop in chlorophyll level was associated with decreased growth rates, but not decreased final densities. Carotenoid levels decreased in a similar manner to chlorophyll levels. The chlorophyll a:b ratio also decreased as nitrogen levels decreased. These data indicate that reducing N is effective in reducing chlorophyll.

Introduction

Nitrogen is the most important nutrient to commercial algal production. Nitrogen stress induces neutral lipid accumulation in most algae, but is associated with a cost in growth capabilities. Nitrogen stress also affects chlorophyll content, which in turn affects light harvesting and processing capabilities.

The composition of chlorophyll and it's associated compounds may also give insight into algal functions. This study looked at chlorophyll a and b, which are associated with light energy processing and harvest respectively, and carotenoids, which are associated with protection and stabilization of photosynthetic elements. [1]



Top: Biomass density in grams per liter
Mid: Chlorophyll concentration in mg total chlorophyll per liter
Bottom: Total chlorophyll as a percent of biomass

Results and Discussion

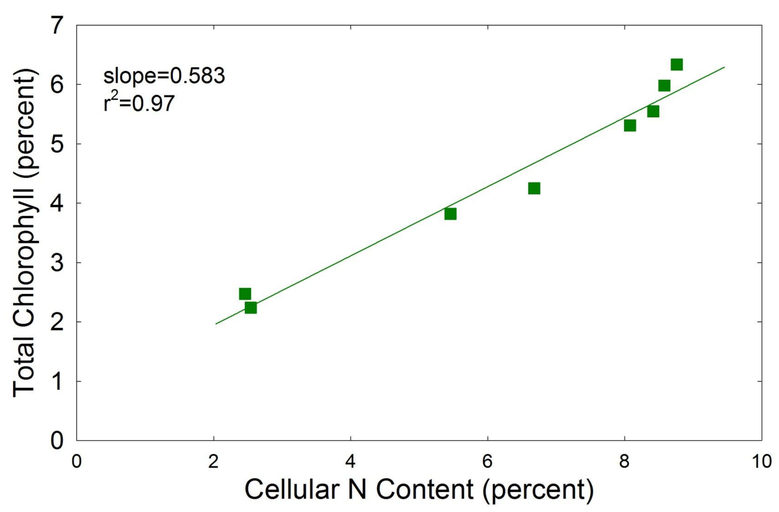
All cultures reached similar final densities, but on different days, indicating that nitrogen stress did not affect final densities, only growth rates. All chlorophyll and carotenoid levels increased linearly with cellular nitrogen content, indicating the effect of nitrogen stress is therefore a decrease in chlorophyll compounds.

The effect on chlorophyll a was more dramatic, with a 75% reduction, as opposed to a 45% and 57% reduction in chlorophyll b and total carotenoids respectively. This may have implications on the stress response of algae, as chlorophyll a is associated with photosystem II and the splitting of water.

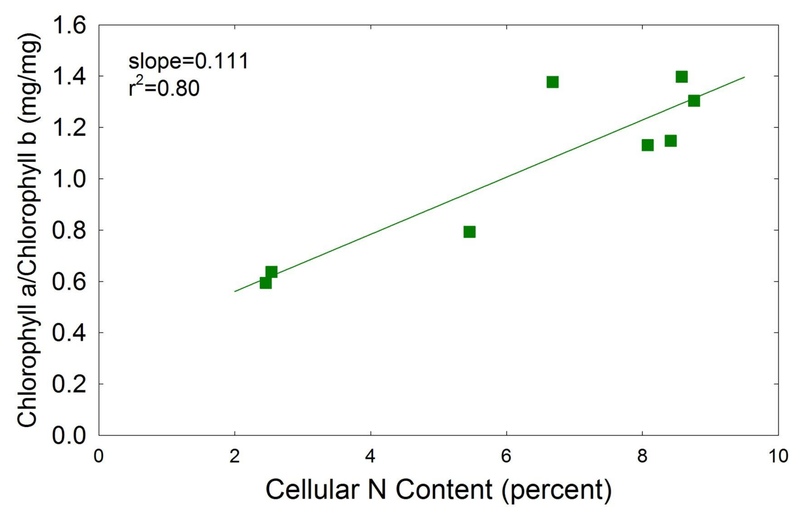
Methods and Materials

N. oleoabundans was inoculated into eight, 1% CO_2 enriched, 1-L bioreactors consisting of four nitrogen treatments: 3, 6, 9, and 12 mM N. Density and chlorophyll content measurements were taken daily. All nitrogen treatments depleted the solution nitrogen by the end of the study, except the 12 mM treatment. Chlorophyll concentrations were determined using a DMSO extraction as described by Wellburn. [2]

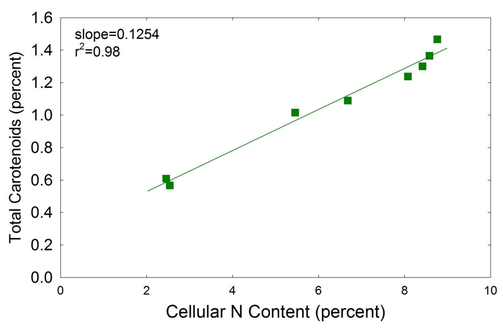
[1] Green, B. R. & Durnford, D. G. (1996) The Chlorophyll-Carotenoid Proteins of Oxygenic Photosynthesis. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* **47**, 685–714
[2] Wellburn, A. R (1994) The Spectral Determination of Chlorophylls a and b, as well as Total Carotenoids, Using Various Solvents with Spectrophotometers of Different Resolution. J Plant Physiol 144: 307-313



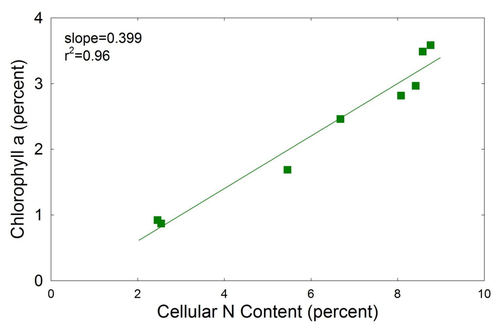
Total chlorophyll as a response to cellular nitrogen content, both as a percentage of biomass, at peak density



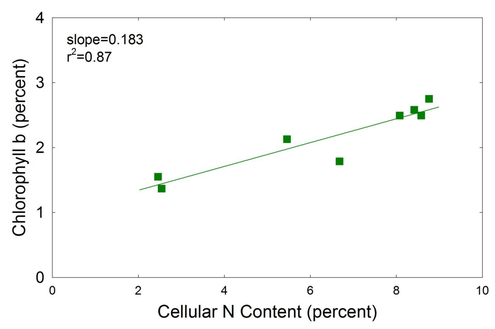
The ratio of chlorophyll a to chlorophyll b as a response to cellular nitrogen, both as a percent of biomass, at peak density.



Total carotenoids as a response to cellular nitrogen, both as percent of biomass, at peak density.



Chlorophyll a as a response to cellular nitrogen, both as percent of biomass, at peak density



Chlorophyll b as a response to cellular nitrogen, both as percent of biomass, at peak density