Effect of CO2 supply and demand on zinc uptake and growth limitation in a coastal diatom

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ABSTRACT: We conducted culture experiments with *Thalassiosira pseudonana* to determine the effect of CO_2, photoperiod, and light intensity on cellular zinc concentrations and zinc requirements for growth. Cellular zinc requirements were dependent on the supply of CO_2 relative to its photosynthetic demand. Decreasing the CO_2 concentration (via an increase in pH from 8.2 to 9.0) increased the cellular zinc required to achieve a given growth rate or that needed for maximum growth. This increase is apparently linked to a greater demand for the zinc enzyme carbonic anhydrase (CA), which is needed for cellular CO_2 acquisition. A decrease in photoperiod had a similar effect. Based on the present and previous results, a decrease in photoperiod from 24 h d'' (continuous light) to 7 h d'' was accompanied by an estimated 2.2-fold increase in the net specific rate of photosynthetic C fixation, which increased the cellular demand for CA. The higher cellular requirement for zinc under decreased CO_2 or photoperiod was accentuated at high growth rates because of a disproportionate increase in the cellular demand for CA with increasing specific rate of C fixation. The increased demand for cellular zinc was largely met by a decrease in the daily specific growth rate, which increased cellular zinc concentrations by decreasing biodilution rates. In addition, there was an approximately twofold increase in cellular zinc uptake rates at high zinc concentrations (and high growth rates) for cells grown at low CO_2 concentration. In contrast to the effects of decreased CO_2 or photoperiod, a tenfold decrease in light intensity reduced the cellular zinc requirement, apparently linked to a 2.8-fold decrease in the maximum specific growth rate, and resultant decreased demand for CA and other biosynthetic zinc enzymes. Other factors (e.g., iron limitation) that decrease specific growth rate should have a similar effect.

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