Colimitation of the unicellular photosynthetic diazotroph *Crocosphaera watsonii* by phosphorus, light, and carbon dioxide

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Limnol. Oceanogr., 58(4), 2013, 1501-1512 | DOI: 10.4319/lo.2013.58.4.1501

ABSTRACT: We describe interactive effects of total phosphorus (total P = 0.1 ¯ 4.0 µmol L⁻¹; added as H_2NaPO_4), irradiance (40 and 150 µmol quanta m^{-2} s^{-1}), and the partial pressure of carbon dioxide (; 19 and 81 Pa, i.e., 190 and 800 ppm) on growth and CO_2- and dinitrogen (N_2)-fixation rates of the unicellular N_2-fixing cyanobacterium *Crocosphaera watsonii* (WH0003) isolated from the Pacific Ocean near Hawaii. In semicontinuous cultures of *C. watsonii*, elevated positively affected growth and CO_2- and N_2-fixation rates under high light. Under low light, elevated positively affected growth rates at all concentrations of P, but CO_2- and N_2-fixation rates were affected by elevated only when P was low. In both high-light and low-light cultures, the total P requirements for growth and CO_2- and N_2-fixation declined as increased. The minimum concentration (C_{min}) of total P and half-saturation constant ($K_{share;}$) for growth and CO_2- and N_2-fixation rates with respect to total P were reduced by 0.05 µmol L⁻¹ as a function of elevated . We speculate that low P requirements under high resulted from a lower energy demand associated with carbon-concentrating mechanisms in comparison with low- cultures. There was also a 0.10 µmol L⁻¹ increase in C_{min} and $K_{share;}$ for growth and N_2 fixation with respect to total P as a function of increasing light regardless of concentration. We speculate that cellular P concentrations are responsible for this shift through biodilution of cellular P and possibly cellular P uptake systems as a function of increasing light. Changing concentrations of P, CO_2, and light have both positive and negative interactive effects on growth and CO_2-, and N_2-fixation rates of unicellular oxygenic diazotrophs like *C. watsonii*.