Iron availability, cellular iron quotas, and nitrogen fixation in Trichodesmium

Berman-Frank, Ilana, Jay T. Cullen, Yeala Shaked, Robert M. Sherrell, Paul G. Falkowski

Limnol. Oceanogr., 46(6), 2001, 1249-1260 | DOI: 10.4319/lo.2001.46.6.1249

ABSTRACT: Iron availability is suggested to be a primary factor limiting nitrogen fixation in the oceans. This hypothesis is principally based on cost-benefit analyses of iron quotas in the dominant nitrogen-fixing cyanobacteria, *Trichodesmium* spp., in the contemporary oceans. Although previous studies with *Trichodesmium* have indicated that iron availability enhanced nitrogen fixation and photosynthesis, no clear relationship has been reported between cellular iron quotas and nitrogen fixation. We re-examined the proposed link between iron availability and nitrogen fixation in laboratory isolates and natural populations collected from coastal waters north of Australia. In laboratory cultures grown under iron-limiting conditions, we measured a decline in cellular iron quotas, photochemical quantum yields, the relative abundance of photosystem I to photosystem II reaction centers, and rates of nitrogen fixation. Nitrogen fixation displayed a critical threshold of the dissolved sum of total inorganic Fe species ([Fe']) of ca. log [Fe'] = -9.7. Field populations of *Trichodesmium*, collected during bloom conditions, showed high iron quotas consistent with high nitrogen fixation rates. Using seasonal maps of aeolian iron fluxes and model-derived maps of surface water total dissolved Fe, we calculated the potential of nitrogen fixation by *Trichodesmium* in the global ocean. Our results suggest that in 75% of the global ocean, iron availability limits nitrogen fixation by this organism. Given present trends in the hydrological cycle, we suggest that iron fluxes will be even more limiting in the coming century.