Geophysical Research Abstracts
Vol. 17, EGU2015-11926-1, 2015
EGU General Assembly 2015

Restoring Tropical Grassland Productivity with Facilitated Biofertilisation

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Grazing is the major economic activity in northern Australia's subtropical grasslands, savannah and shrublands that cover >1.9 million km2 however; there has been significant decline in soil fertility that has led to the need to consider ways to improve management.

Terrestrial cyanobacteria primarily inhabit complex soil microbial communities that drive physical and biological processes in the topsoil. These microbes facilitate resilience to drought and maintain soil function. They transform their environment through the secretion of mucilaginous organic compounds that improve aggregate stability, porosity, rainfall infiltration rates and water storage, reduce evaporation and soil erosion and, improve seedling emergence.

In the northern Australian savannah cyanobacterial communities dominate soil surfaces of the perennial tussock grasslands. The core focus of this research has been to better understand the function of cyanobacteria within the climate-soil-plant ecosystem. The recent discovery that cyanobacteria are programmed to detect and respond only to wet season rains, and remain inactive and unproductive during the dry season even if it rains, has rewritten our understanding of soil nutrient cycles in the northern Australian savannah.

In this project we have established:
1. For the wet season trials (Dec 2009–May 2010) the mean values of cyanobacterial crust (0–1 cm depth; n=100) plant-available N fluctuated, yet significantly increased incrementally from Dec to Feb (2.74 $\pm$ 0.37SE–5.62 $\pm$ 0.82 mg NH4+ kg-1 soil; p = 0.003) and peaked from Mar–May (9.59 $\pm$ 1.5SE–16.04 $\pm$ 3.2SE mg NH4+ kg-1 soil; p = 0.127) that represented the concluding stages of the wet season.
2. Cyanobacterial rates of N-fixation (determined by Acetylene Reduction assays, n=6 per month), increased significantly from the commencement to the height of the wet season (13.2 $\pm$ 2.9SE–30.2 $\pm$ 1.9SE kg N ha-1; p = 0.001) and decreased towards the end of the wet season (10.4 $\pm$ 1.8SE kg N ha-1; p = 0.000).
3. Average cyanobacterial biomass (Chlorophyll a) increased from 112.1 $\pm$ 21.3SE μg Ca g-1 soil (Nov) throughout the wet season; peaked in Feb (171.9 $\pm$ 2.4SE μg Ca g-1 soil) and declined towards the end of the wet season (153.8 $\pm$ 19.9SE μg Ca g-1 soil).
4. Diversity was underpinned by an abundance of the N-fixing cyanobacteria – Scytonema, Nostoc and Stigonema.

We studied net productivity throughout the wet season and estimated that in these environments cyanobacteria contribute 40–50 kg N ha-1 to soil fertility in this time. Peak biofertilisation occurred at the height of the wet season (Feb–Mar). This seasonal pattern was also present in carbon sequestration data from parallel research at the same study site (Büdel and Williams' unpublished data). These studies suggest that such well-defined seasonal trends and synchrony in cyanobacterial-mediated C and N cycling significantly contributes to pasture plant production and soil fertility in the northern Australian savannah.