Biological nitrogen fixation by biological soil crusts in arid dune ecosystems

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In arid and semi-arid regions water is be considered to be the controlling factor for productivity and the vegetation pattern. Several investigations emphasised that nutrients are critical for the productivity in arid lands. The main N input pathways into the ecosystems are atmospheric deposition in wet, dry and gaseous forms, and the biological fixation of atmospheric nitrogen N_2. In most drylands a biological soil crust build up by cyanobacteria, green algae, soil lichens and mosses covering the first millimetres of the top soil (Veste *et al*. 2001). Nitrogen-fixing cyanobacteria of the genera *Nostoc, Microcoleus, Chroococcus* and *Calothrix* and soil lichens with cyanobacterial phytobionts are common in such soil crusts. The importance of biological N fixation by soil crusts is emphasised by several authors, although determining N-fixation under field conditions has several methodological problems. In this paper we present field measurements of biological N fixation (BNF) obtained by the natural ^{15}N abundance method and use them to estimate the annual nitrogen input by the soil crusts into desert sand dunes of the north-western Negev. We perform a novel approach of the natural ^{15}N abundance technique by using the non-N_2-fixing lichens as a reference in order to determine N_2–fixation by the biological crust *in situ*.

Biological fixation by cyanobacterial biological crusts and *Collema tenax* lichens of 9–12 kg N $ha^{-1}yr^{-1}$ and of about 43kg N ha-$1yr^{-1}$, respectively are very important nitrogen input pathways (Table 1). N input by dust at just 2–4 kg N ha^{-1} yr^{-1} (Littmann 1997) and by the shrub *Retama raetam* (Fabaceae) at just 0.11 kg N ha^{-1} yr^{-1} can be considered as minor pathways into the sand dune of the north-western Negev.

Table 1. Biological N_2 fixation (BNF) by biological soil crusts and soil lichens in arid sand dunes of the NW Negev, Israel (ID interdune, NWS north-west-facing slope). *Fulgensia fulgens* contaminated by free living N-fixing cyanobacteria.

Crust type (location)	N stock g N m^{-2}	NdfA %	N growth g N m^{-2} yr^{-1}	Abs. BNF g N m^{-2} yr^{-1}
Fulgensia fulgens (ID) (lichens)	17.7	68	2.5	1.7
Collema tenax (ID) (lichens)	34.0	88	4.9	4.3
Cyanobacterial biologicalcrust (ID)	5.4	91	1.4	1.2
Cyanobacterial biologicalcrust (NWS)	6.5	84	1.1	0.9

References

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