Nitrogen fixation and metabolism by groundwater-dependent perennial plants in a hyperarid desert

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The Central Asian Taklamakan desert is characterized by a hyperarid climate with less than 50 mm annual precipitation but a permanent shallow groundwater table. The perched groundwater (2-16 m) could present a reliable and constant source of nitrogen throughout the growing season and help overcome temporal nitrogen limitations that are common in arid environments. We investigated the importance of groundwater and nitrogen fixation in the nitrogen metabolism of desert plants by assessing the possible forms and availability of soil N and atmospheric N and the seasonal variation in concentration as well as isotopic composition of plant N. Water availability was experimentally modified in the desert foreland through simulated flooding to estimate the contribution of surface water and temporally increased soil moisture for nutrient uptake and plant-water relations. The natural vegetation of the Taklamakan desert is dominated by plants with high foliar nitrogen concentrations (2-3% DM) and leaf nitrate reductase activity (NRA) (0.2-1 micromol NO2- g(-1) FW h(-1)). There is little evidence that nitrogen is a limiting resource as all perennial plants exhibited fast rates of growth. The extremely dry soil conditions preclude all but minor contributions of soil N to total plant N so that groundwater is suggested as the dominant source of N with concentrations of 100 microM NO3-. Flood irrigation had little beneficial effect on nitrogen metabolism and growth, further confirming the dependence on groundwater. Nitrogen fixation was determined by the 15N natural abundance method and was a significant component of the N-requirement of the legume Alhagi, the average contribution of biologically fixed nitrogen in Alhagi was 54.8%. But nitrogen fixing plants had little ecological advantage owing to the more or less constant supply of N available from groundwater. From our data we conclude that the perennial species investigated have adapted to the environmental conditions through development of root systems that access groundwater to satisfy demands for both water and nutrients. This is an ecologically favourable strategy since only groundwater is a predictable and stable resource.
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