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Nitrogen fluxes at the root-soil interface show a mismatch of nitrogen fertilizer supply and sugarcane root uptake capacity

Erich Inselsbacher (1,2), Susanne Schmidt (3), Torgny Näsholm (2,4), Nicole Robinson (3), Stéphane Guillou (3), Kerry Vinall (3), Prakash Lakshmanan (5), and Richard Brackin (3)

(1) Department of Geography and Regional Research, University of Vienna, AT-1090 Vienna, Austria (erich.inselsbacher@univie.ac.at), (2) Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, SE-90183 Umeå, Sweden, (3) School of Agriculture and Food Sciences, The University of Queensland, QDL, 4072 Brisbane, Australia., (4) Department of Forest Genetics and Plant Physiology, Umeå Plant Science Center, Swedish University of Agricultural Sciences, SE-90183 Umeå, Sweden., (5) Sugar Research Australia, 50 Meiers Road, Indooroopilly, QLD 4068 Brisbane, Australia.

Nitrogen (N) uptake by agricultural crops is a key constituent of the global N cycle, as N captured by roots has a markedly different fate than N remaining in the soil. Global evidence indicates that only approximately 50% of applied N fertilizer is captured by crops, and the remainder can cause pollution via runoff and gaseous emissions. This inefficiency is of global concern, and requires innovation based on improved understanding of which N forms are available for and ultimately taken up by crops. However, current soil analysis methods based on destructive soil sampling provide little insight into delivery and acquisition of N forms by roots. Here, we present the results of a study in sugarcane fields receiving different fertilizer regimes comparing soil N supply rates with potential root N uptake rates. We applied microdialysis, a novel technique for in situ quantification of soil nutrient fluxes, to measure flux rates of inorganic N and amino acid N, and analyzed N uptake capacities of sugarcane roots using 15N labelled tracers. We found that in fertilized sugarcane soils, fluxes of inorganic N exceed the uptake capacities of sugarcane roots by several orders of magnitude. Contrary, fluxes of organic N closely matched roots' uptake capacity. These results indicate root uptake capacity constrains plant acquisition of inorganic N. This mismatch between soil N supply and root N uptake capacity is a likely key driver for low N efficiency in the studied crop system. Our results also suggest that the relative contribution of inorganic N for plant nutrition may be overestimated when relying on soil extracts as indicators for root-available N, and organic N may contribute more to crop N supply than is currently assumed. Overall, we show a new approach for examining in situ N relations in soil in context of crop N physiology, which provides a new avenue towards tailoring N fertilizer supply to match the specific uptake abilities and N demand of crops over the growth cycle.