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Managing the nitrogen conservation cascade to reduce nitrogen losses

Agricultural intensification has greatly increased the productive capacity of agroecosystems, but has had unintended environmental consequences including degradation of soil and water resources, and alteration of biogeochemical cycles. Current nutrient management strategies aim to deliver soluble inorganic nutrients directly to crops and have uncoupled carbon and nitrogen cycles in space and time. As a result, agricultural ecosystems are inadvertently maintained in a state of nitrogen saturation and are inherently leaky because chronic surplus additions of nitrogen are required to meet yield goals. Nitrogen-saturation theory predicts that reducing nitrogen leakiness in agricultural systems requires: 1) a reduction of nitrogen additions and 2) an increase in carbon availability combined with improved coupling of carbon and nitrogen cycling. A nutrient management strategy based on this framework involves managing carbon and nitrogen together in order to expand internal nitrogen sinks in space and time and increase the capacity of the ecosystem to cycle nitrogen internally. Carbon and nitrogen cycling are linked through net primary production, decomposition and storage as plant biomass and soil organic matter. Carbon management strategies strongly influence nitrogen flows within the soil-microbial-plant system, including: 1) the balance between mineralization- immobilization, 2) the size of inorganic and labile organic nitrogen pools and 3) the rate of microbially-mediated transformations of NH_4^+ and NO_3^- (i.e. nitrification/ dissimilatory nitrogen reduction pathways). Re-coupling carbon and nitrogen cycles has cascading effects on multiple ecosystem processes and it is these shifts in small scale, fast cycling processes that ultimately reduce the need for surplus nitrogen fertilizer. For example, diversified crop rotations using cover crops contribute to nitrogen retention through a variety of mechanisms and could maintain yields while reducing nitrogen losses. We present a conceptual model of this "nitrogen conservation cascade" and provide specific examples of management practices that capitalize on these intrinsic ecosystem processes.

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