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Quorum Sensing affects Rhizosphere Microbial Community Function and Plant Nutrition

Environmental Issues

Plant Nitrogen Accumulation

Nitrogen is the most limiting nutrient to plant growth in temperate terrestrial ecosystems, though most soils contain abundant N to support plant growth. Most soil N is in the organic form primarily as chitin, proteins, lignoproteins and nucleotides. Plants cannot access this organic N, and rely or microbial enzyme activity to mineralize it to inorganic N before uptake. Establishment of QS as a signaling condiut through which plants direct N mineralization would rewrite the current paradigm of the passive nature of plant-microbial interactions.

QS Disruption and Biological Control

Disruption of QS has been suggested to control plant bacterial infection because many virulence factors are induced in a quorum. QS is naturally attenuated by competitive inhibitors or lactonases, but the natual balance of production versus attenuation is not understood. The success of biological control strains requires an understanding of the ecology of the rhizosphere environments, including the effects of signalling on biological activity. Disruption of QS could be potentially very dangerous to plant health.

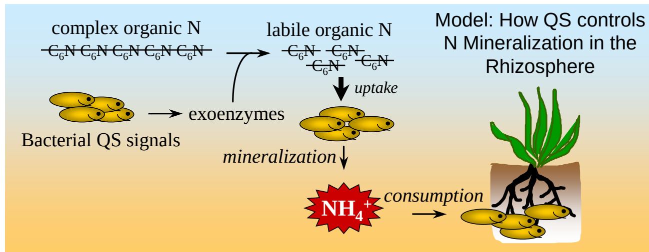
Industrial Agriculture Fertilizer Dependence

The widespread use of fertilizers with high inorganic N content applied to agricultural soils is a major source of nitrogen nonpoint pollution of surface waters. Severe dependence on N causes eutrophication of terrestrial, freshwater, and nearshore marine ecosystems, leading to decrease in species diversity and species extinctions. Plant enhanced ability to access organic N in the soil would result in less reliance on N-based fertilizers for plant growth.

Scientific Approach

Hypothesis

Quorum sensing is a control point for rhizosphere nitrogen (N) mineralziation, and so also plant N availability and nutrition.



Objectives

1. Determine microbial activity in rhizosphere vs bulk soils.
   - Enzyme assays demonstrate increased chitinase in the rhizosphere compared to bulk soil
   - Q-PCR chtiniase and protease genes; whole-cell biosensors

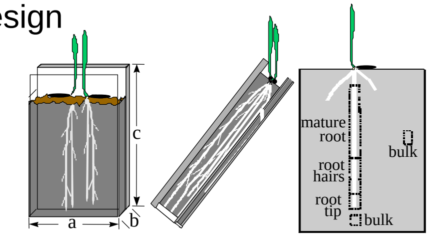
2. Understand the prevalence of QS in the rhizosphere, and to what extent QS controls enzyme activity that converts complex organic N to labile organic N.
   - Isolate rhizosphere organisms, determine proportion of exoenzyme producers, and QS-control of exoenzymes

3. Demonstrate the extent to which plants rely on bacterial QS-controlled exoenzyme activity for their N nutrition.
   - compare AHL-producing tobacco to wild-type, and track changes in N min, enzyme activity, and microbial community

Experimental Design

Experimental microcosms designed to facilitate study of the rhizospehre.

a = 50 mm or 15 cm
b = 6 mm or 3 cm
c = 75 mm or 60 cm



California naturalized exotic grass *Avena barbata* (wild oat) rhizosphere and bulk soils can be separated, and whole-cell biosensors applied easily.

Results to Date

The rhizosphere is distinguished by high cell counts.
Proteobacteria make up a large fraction (up to 66%) of rhizosphere microbial community diversity.
Soil **chitinase activity** is significantly higher in the rhizosphere, especially the root zone, compared to bulk soil ($p<0.05$).
Whole-cell AHL biosensors show that **microbial AHL availability** is higher in rhizosphere than bulk soil ($p=0.018$, $n=10$).
Whole-cell nitrate biosensors reveal that **nitrate** is in lowest availability in the rhizosphere, especially the root tip zone.

Impact

In general, this research will contribute to the basic understanding of N cycling in soil and plant-microbial interactions that applies to all environments.

Specifically this research will promote testing and understanding of biocontrol agents and their effects on the rhizosphere microbial community function as well as plant health.

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