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Water & Nutrient Stress Increase Root Exudation

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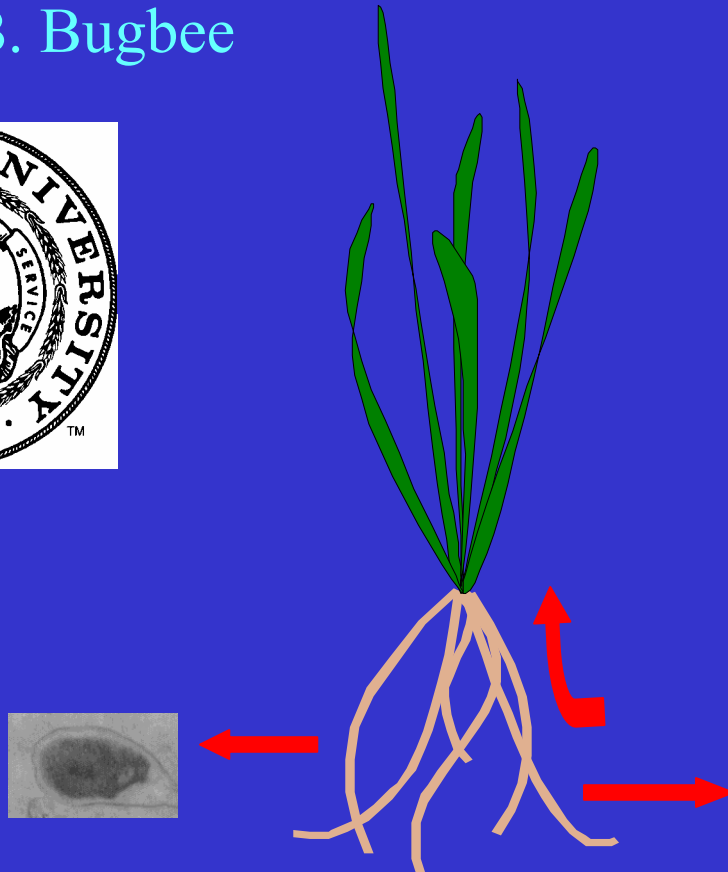
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A. Henry, J. Chard, J. Norton, M. Petersen, Bruce Bugbee, M. Hamilton, C. Palmer, and J. R. Hess

Water & Nutrient Stress Increase Root Exudation

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Objectives

Develop procedures to:

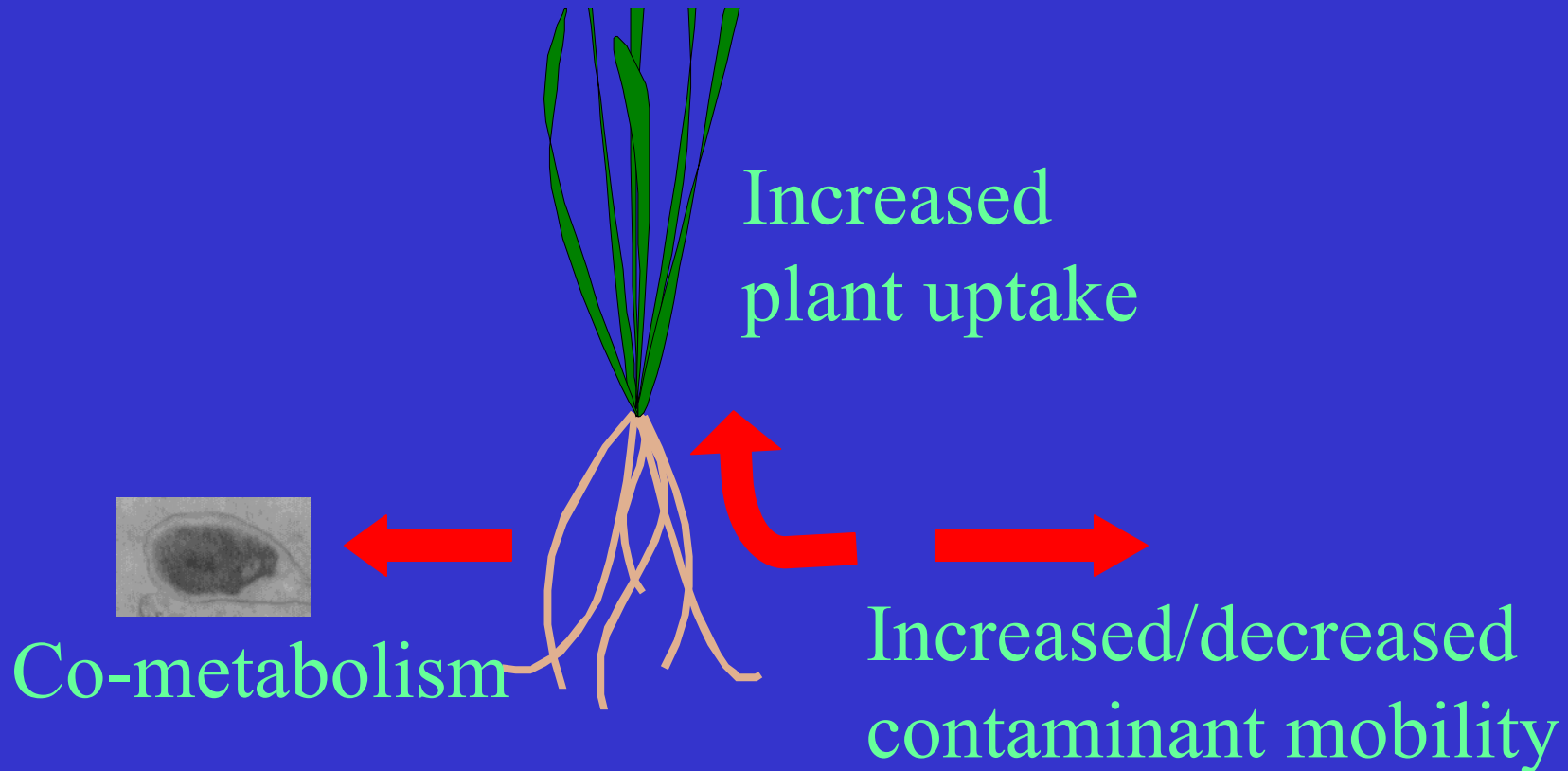
- Grow *healthy* plants under sterile conditions
- Manipulate root exudation with stress
- Quantify total organic carbon in exudates
- Determine composition of exudates using GC-MS

Implications for Phytoremediation

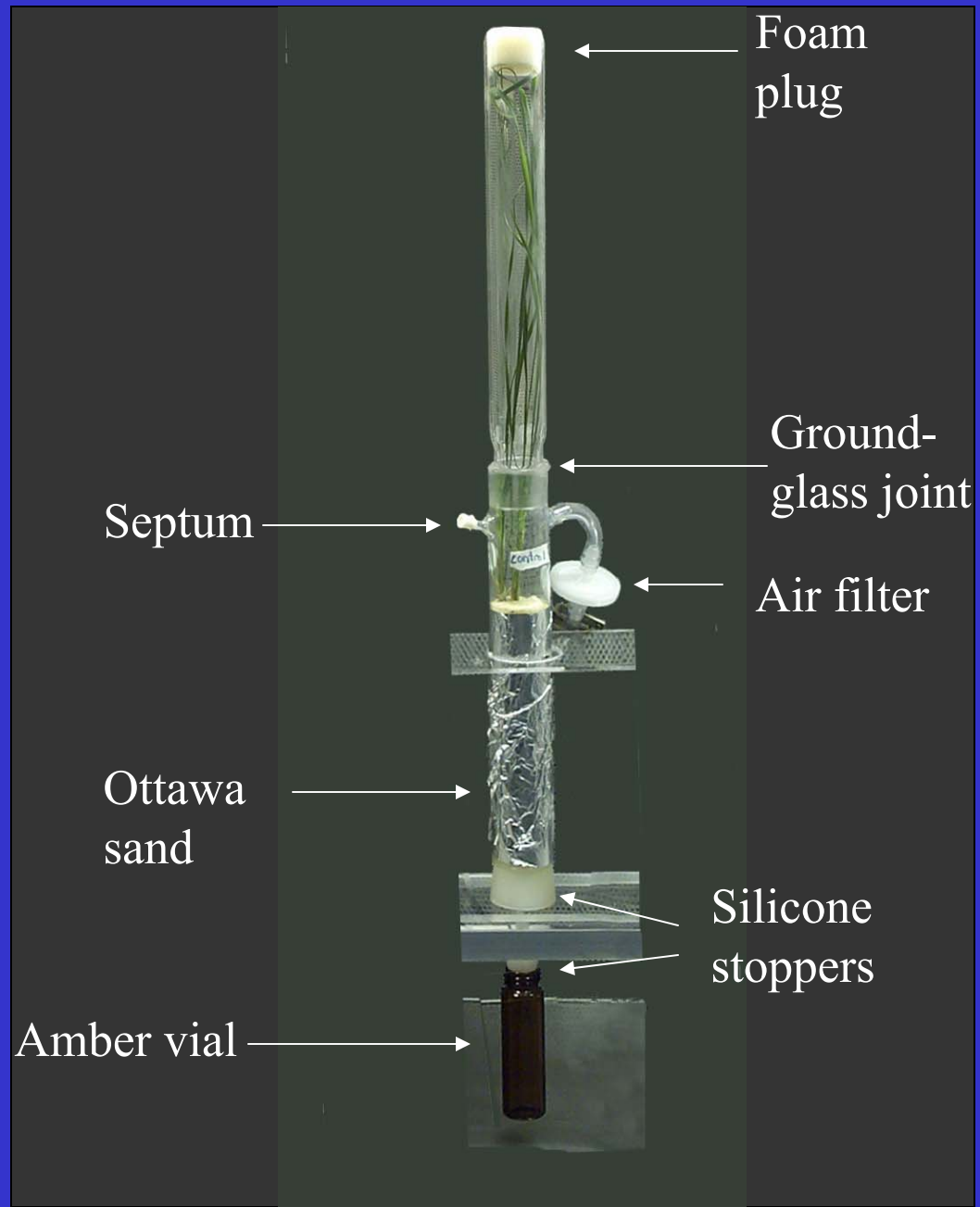
Our focus for the qualitative analysis: organic acids



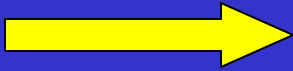
The chelating properties of these compounds can be useful for phytoremediation, and they are a class of compound most likely to be found in root exudate



System for sterile culture



HPS
lamps

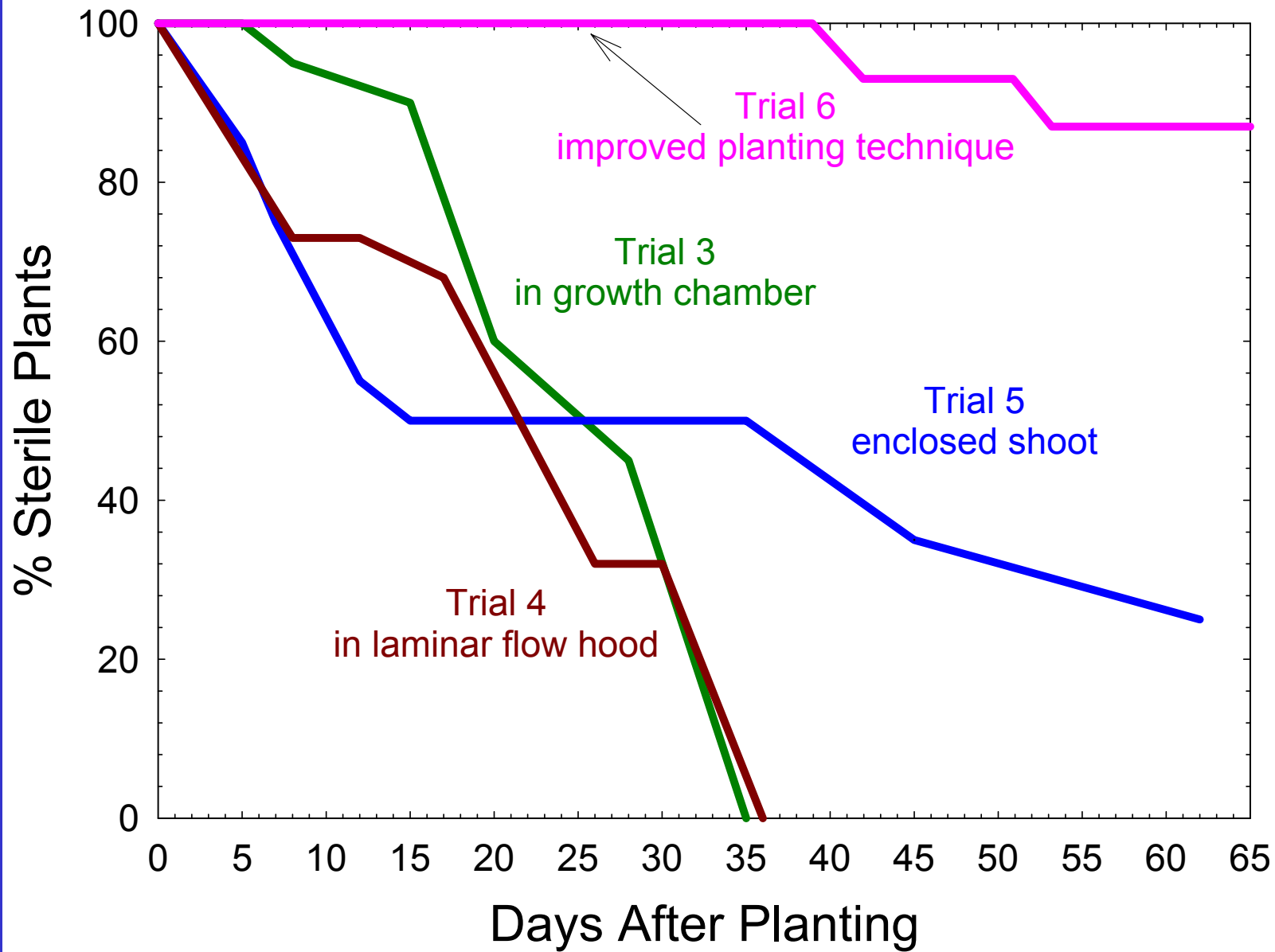


Laminar
flow hood



Treatments

- High NH_4^+
- K^+ stress
- Drought
- Flooding



Assessing microbial contamination



Verifying Plate Counts: Acridine Orange Stain of Leachate

Clean sample

10 μm




Root debris

Verifying Plate Counts: Acridine Orange Stain of Leachate

Contaminated
sample

10 μm

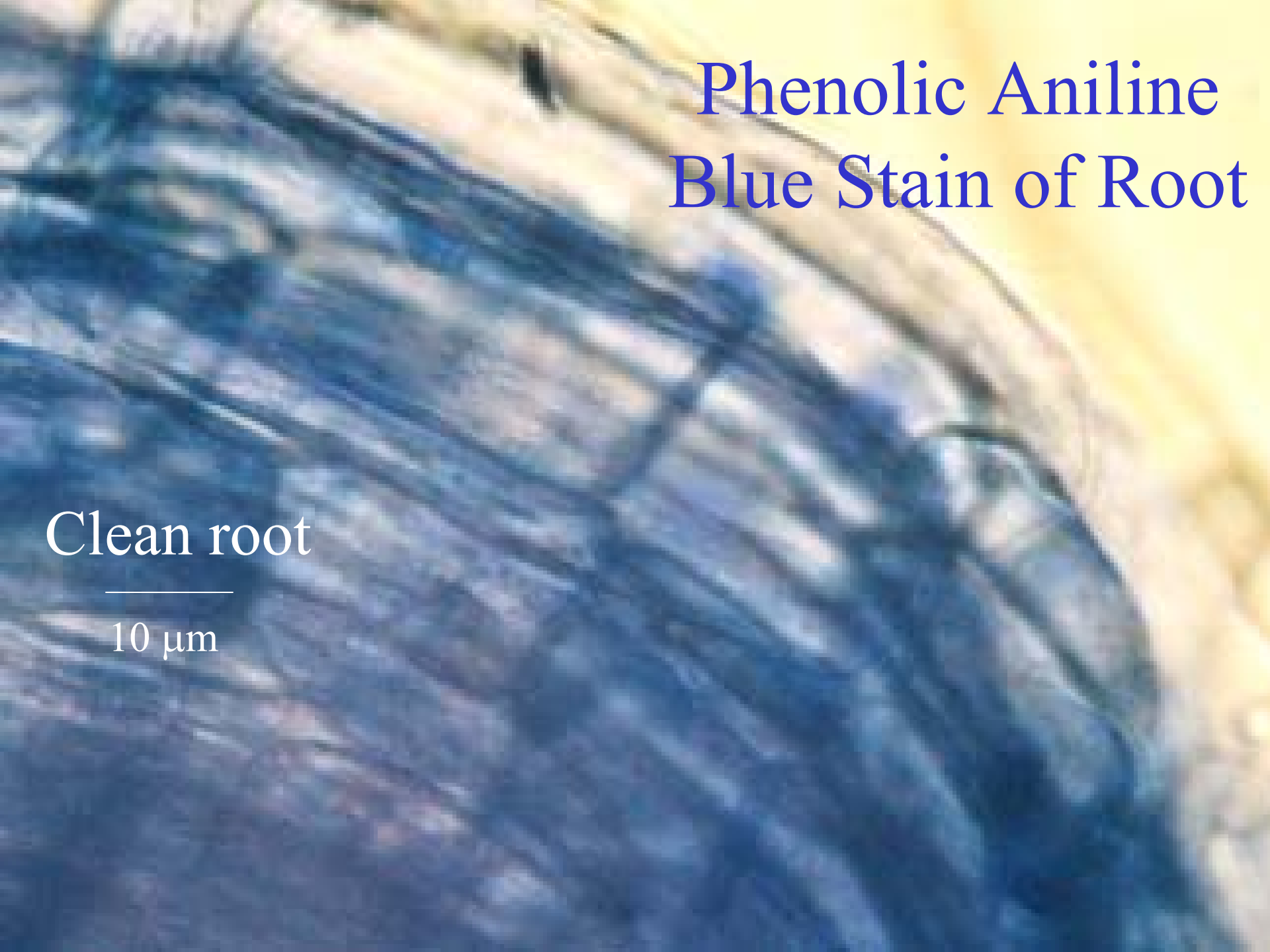

bacteria



Phenolic Aniline Blue Stain of Root

Clean root

10 μm

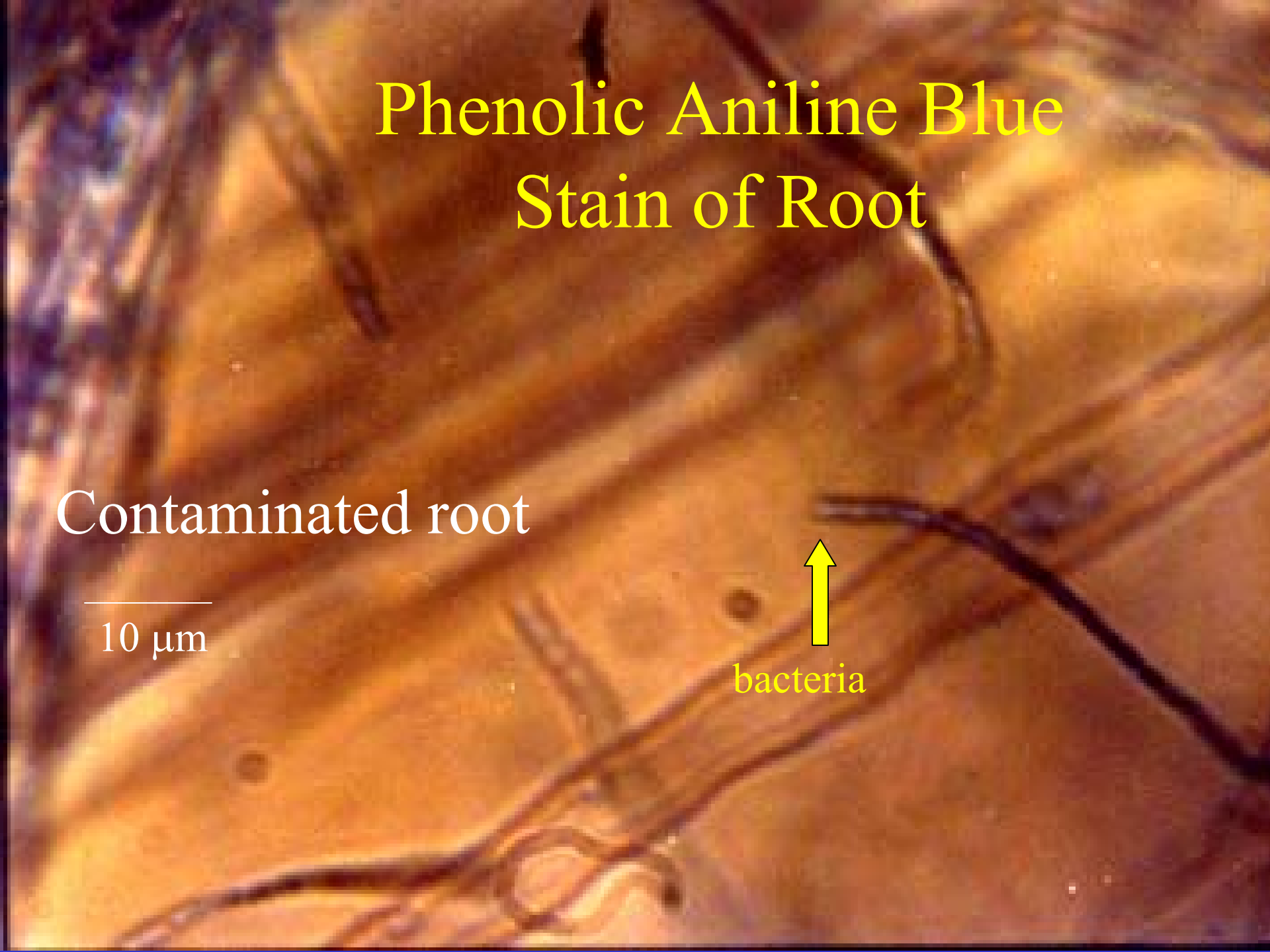


Phenolic Aniline Blue Stain of Root

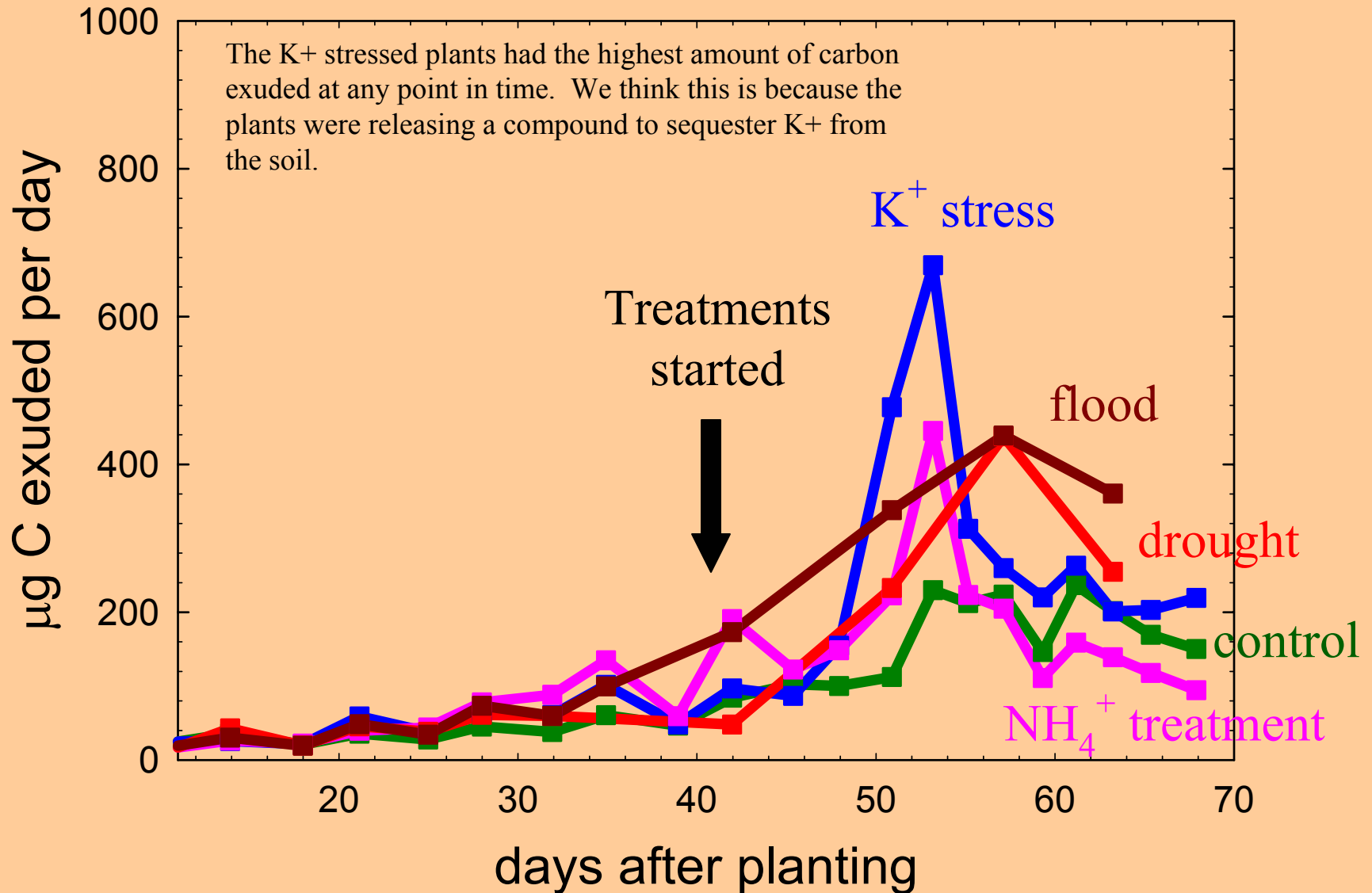
Contaminated root

10 μm

bacteria



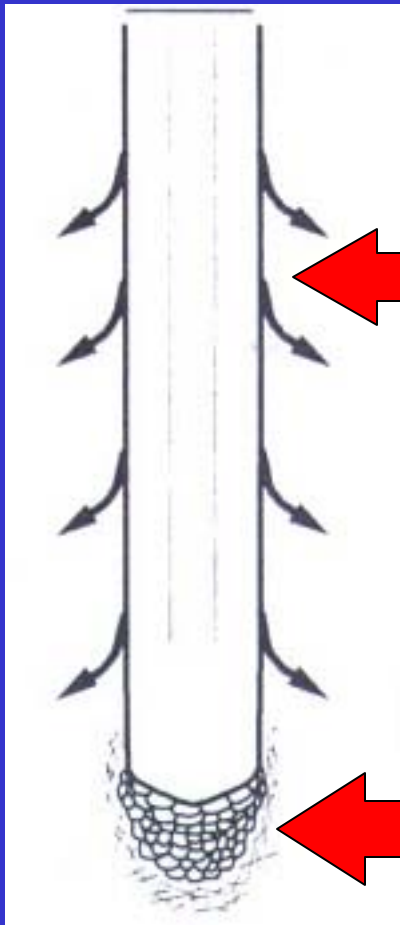
Treatment Averages



Cumulative carbon exuded per gram dry plant

	mg C exuded per g dry plant		Percent of control
	Average	Std. dev.	
control	2.6	0.4	
NH₄⁺	2.3	0.1	90
K⁺	3.7	0.6	144
flood	3.8	0.9	145
drought	4.4	0.5	170

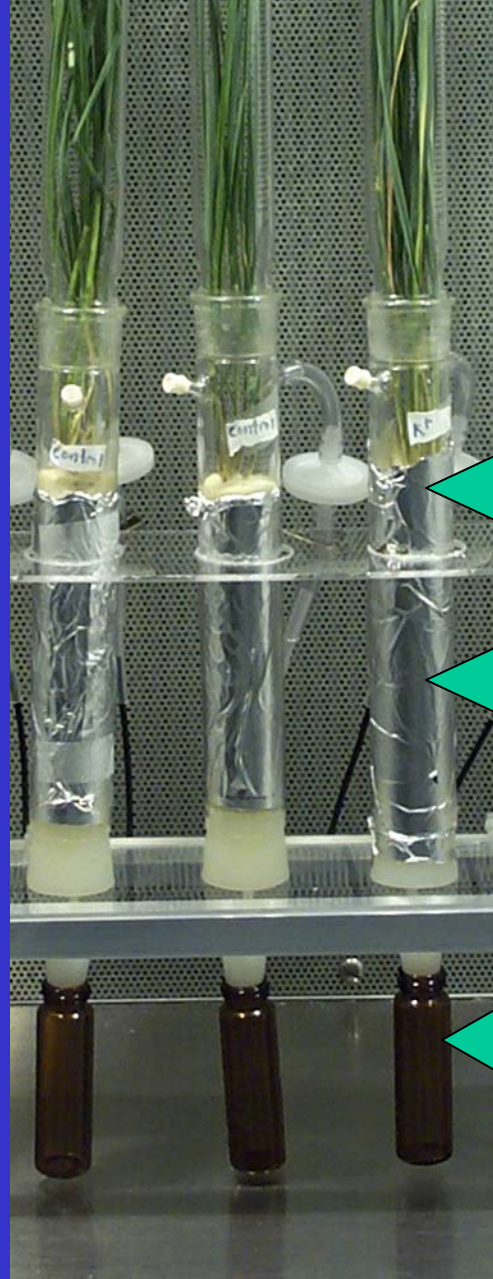
Primary types of exudates



Compounds released
by roots

Sloughed-off cells

Distribution of Carbon



Rhizosphere
sand

17 %

Bulk sand

9 %

Leachates

63 %

Soluble

11 %

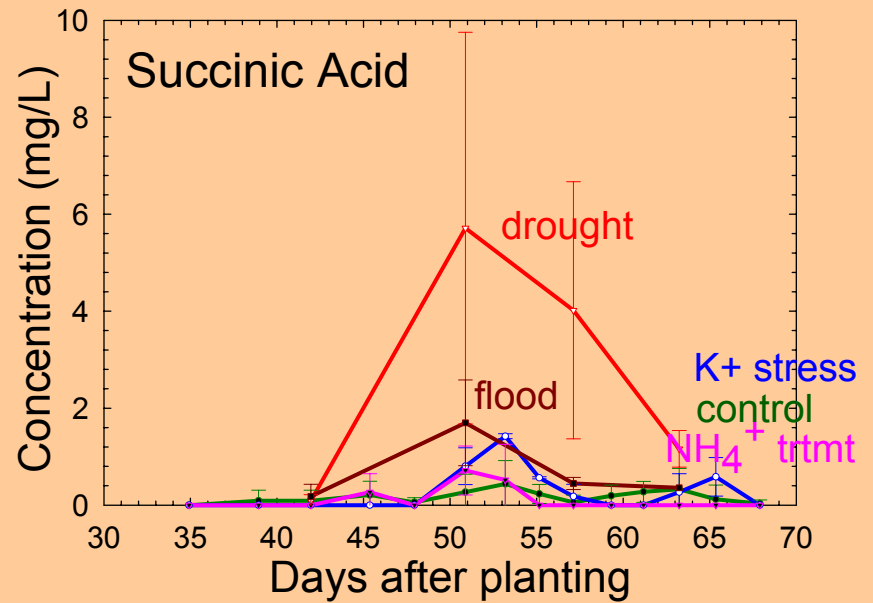
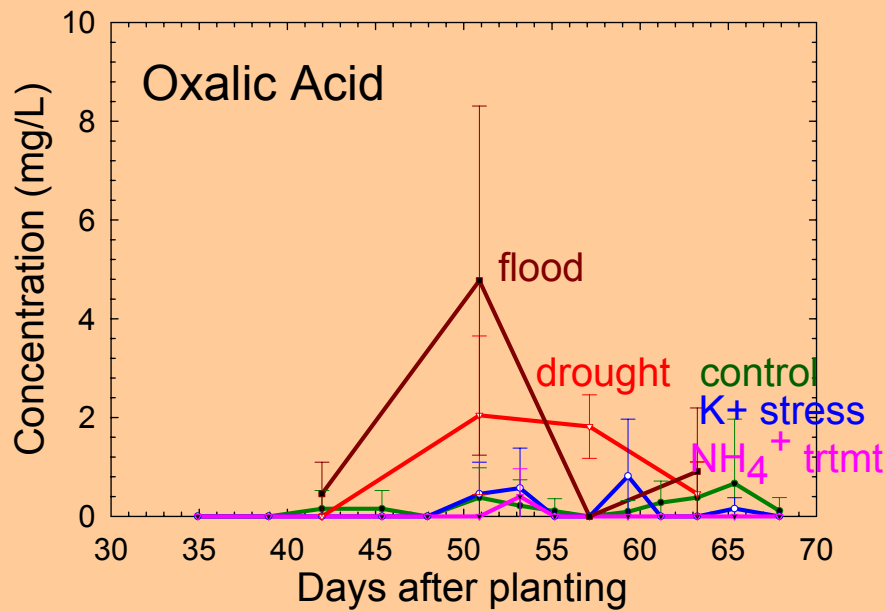
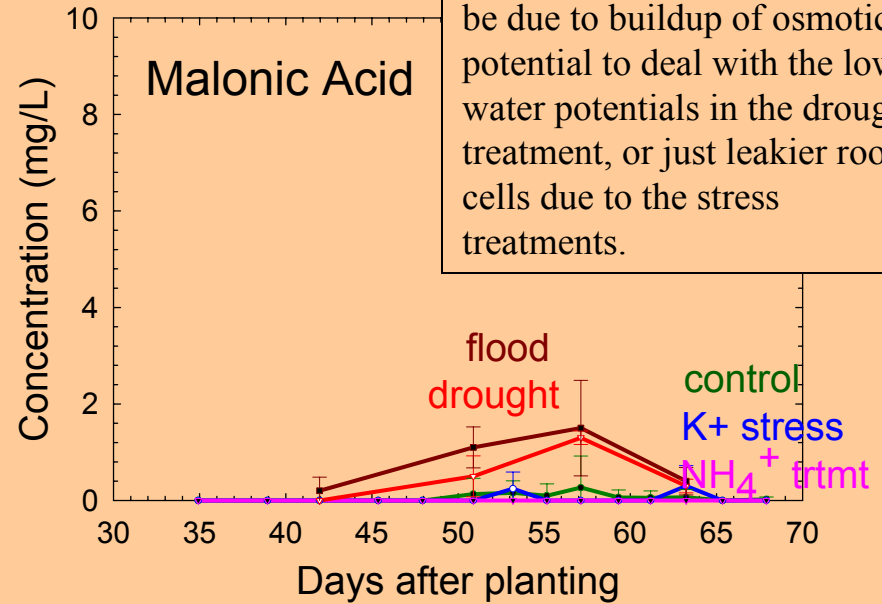
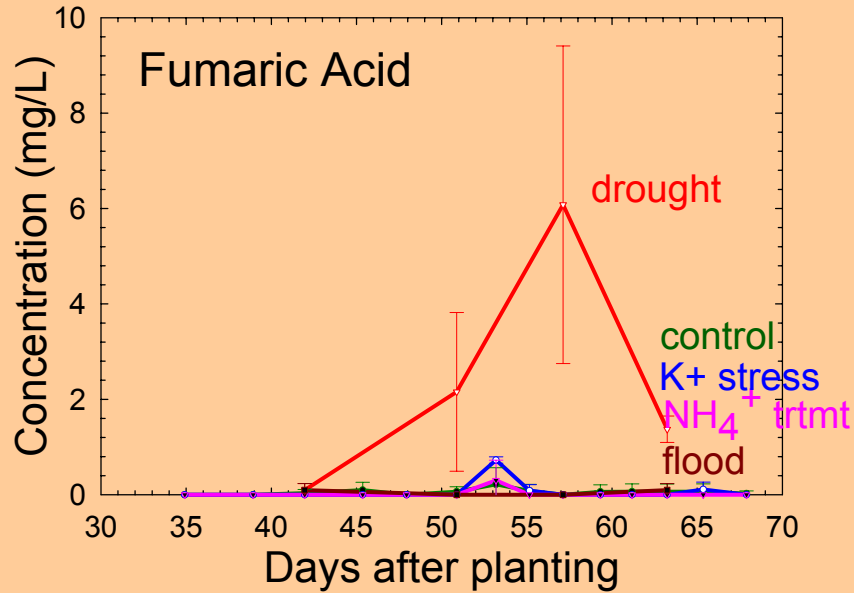
Insoluble

100 %

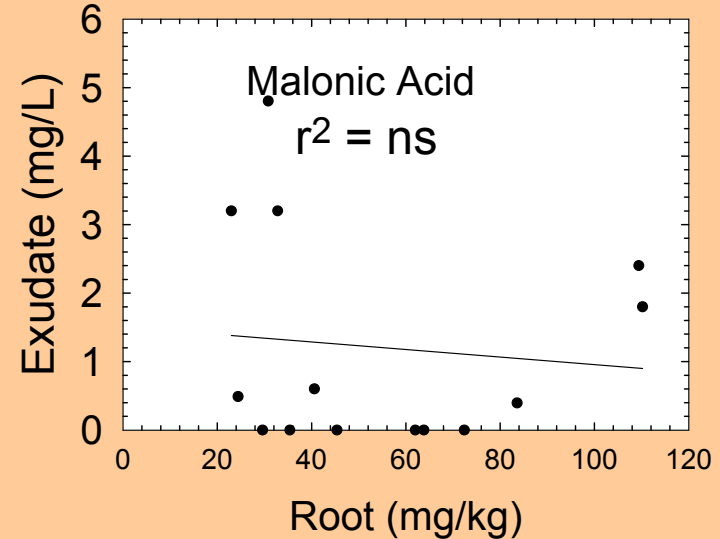
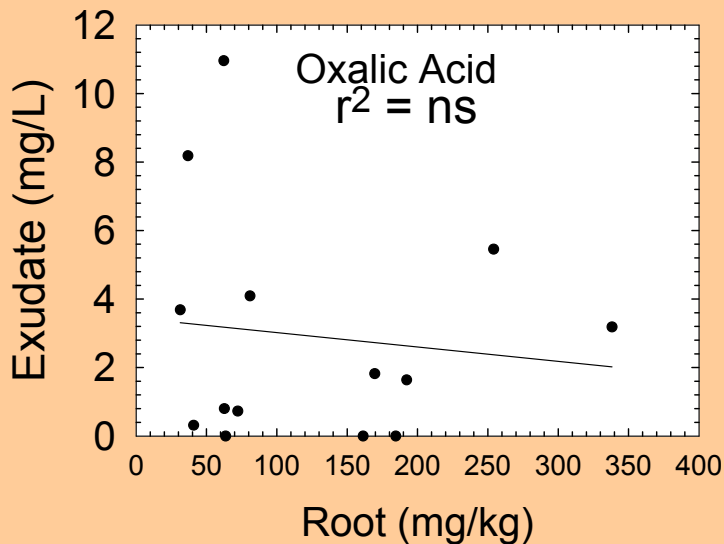
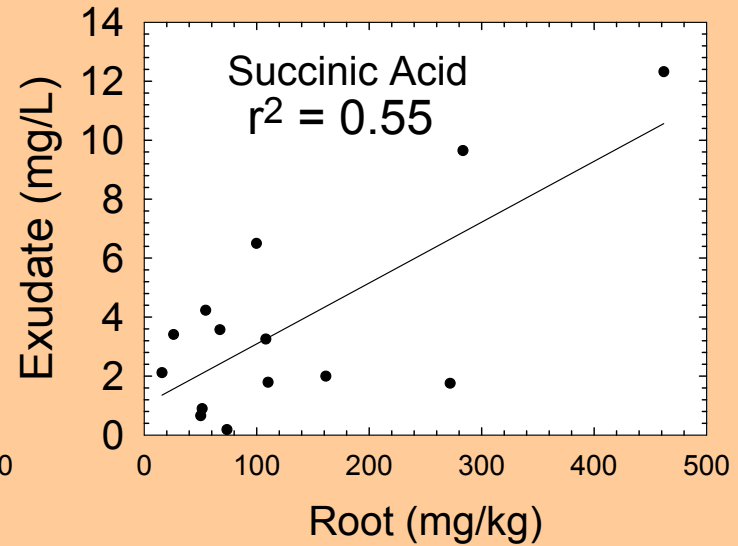
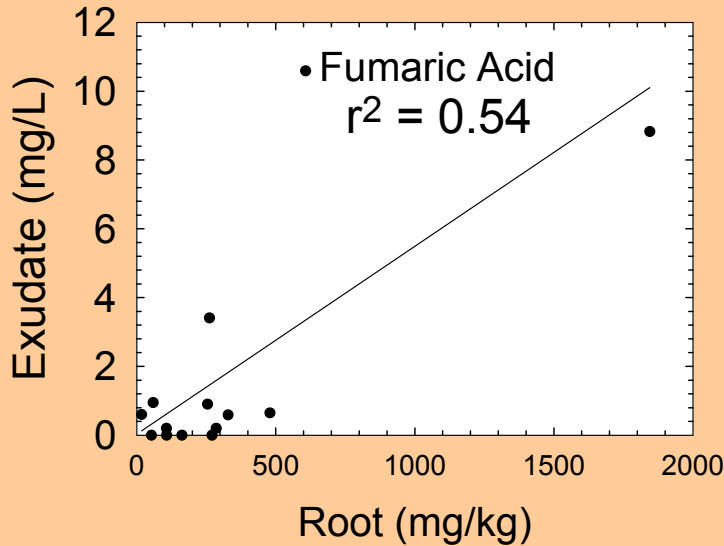
Based on the distribution of carbon released by the roots (mostly soluble with not much left on the sand), we conclude that the exudates we're seeing are mostly compounds released directly from the root, not whole cells released from the root.

GC-MS Data: Exudates

Unlike the TOC graph, organic acids were exuded in the largest amounts from the drought and flooding treatments. This may be due to buildup of osmotic potential to deal with the low water potentials in the drought treatment, or just leakier root cells due to the stress treatments.



What's in the root vs. what's released by the root



Conclusions

1. Stress increases root exudation. Drought and flooding treatments increased release of organic acids.
2. Concentrations of succinic and fumaric acid in the root correlated with amounts released by the root.

