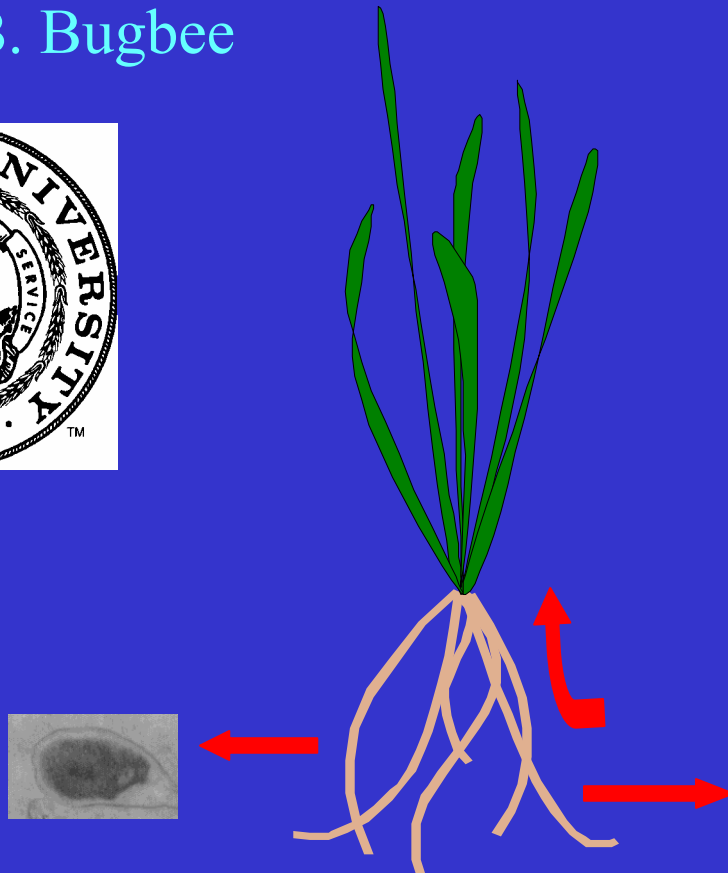


# Water & Nutrient Stress Increase Root Exudation

A. Henry, J. Chard, J. Norton  
M. Petersen, B. Bugbee

M. Hamilton, C. Palmer,  
J.R. Hess



# Objectives

Develop procedures to:

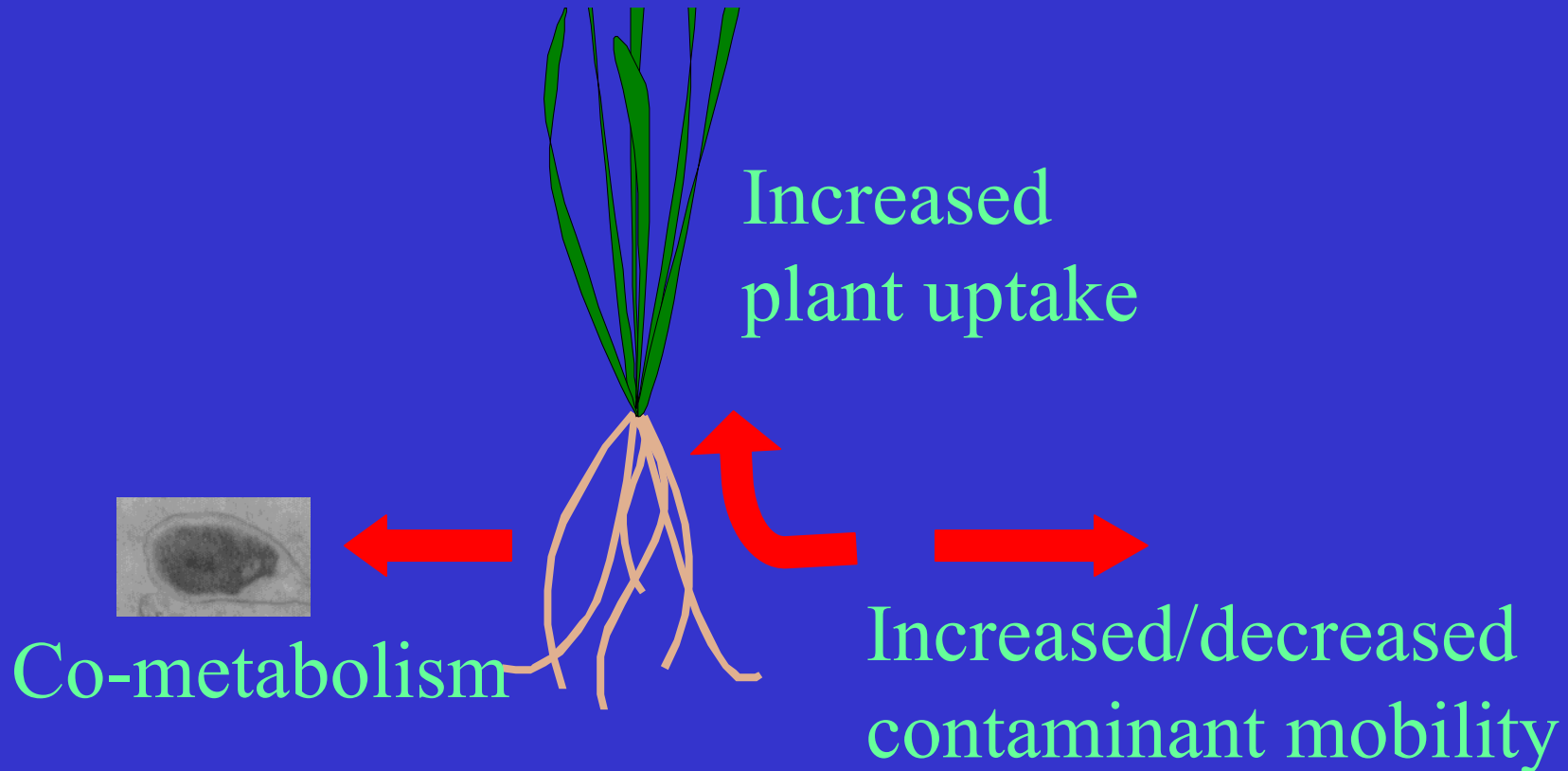
- Grow *healthy* plants under sterile conditions
- Manipulate root exudation with stress
- Quantify total organic carbon in exudates
- Determine composition of exudates using GC-MS

# Implications for Phytoremediation

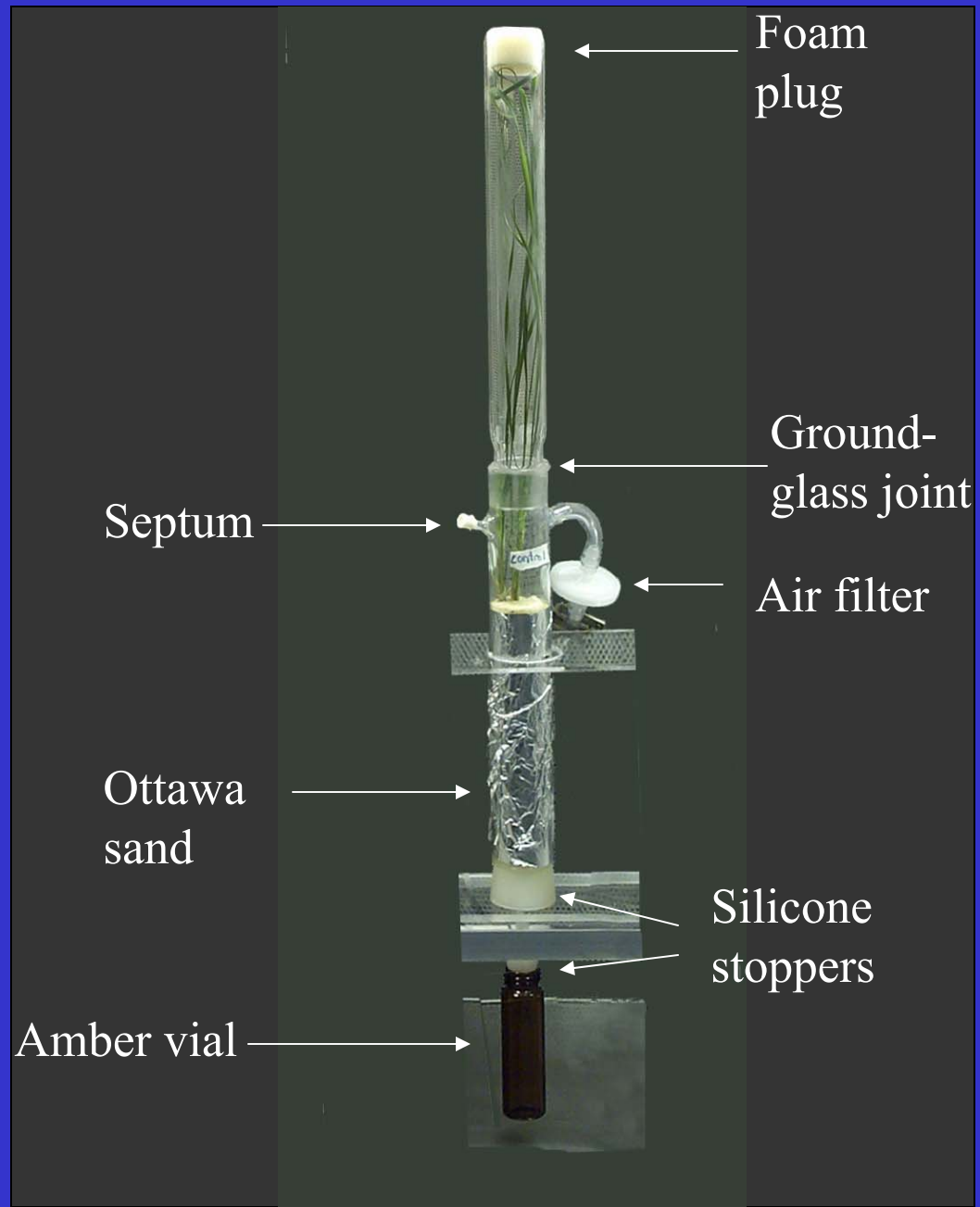
Our focus for the qualitative analysis: organic acids



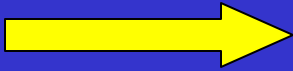
The chelating properties of these compounds can be useful for phytoremediation, and they are a class of compound most likely to be found in root exudate



# System for sterile culture



HPS  
lamps

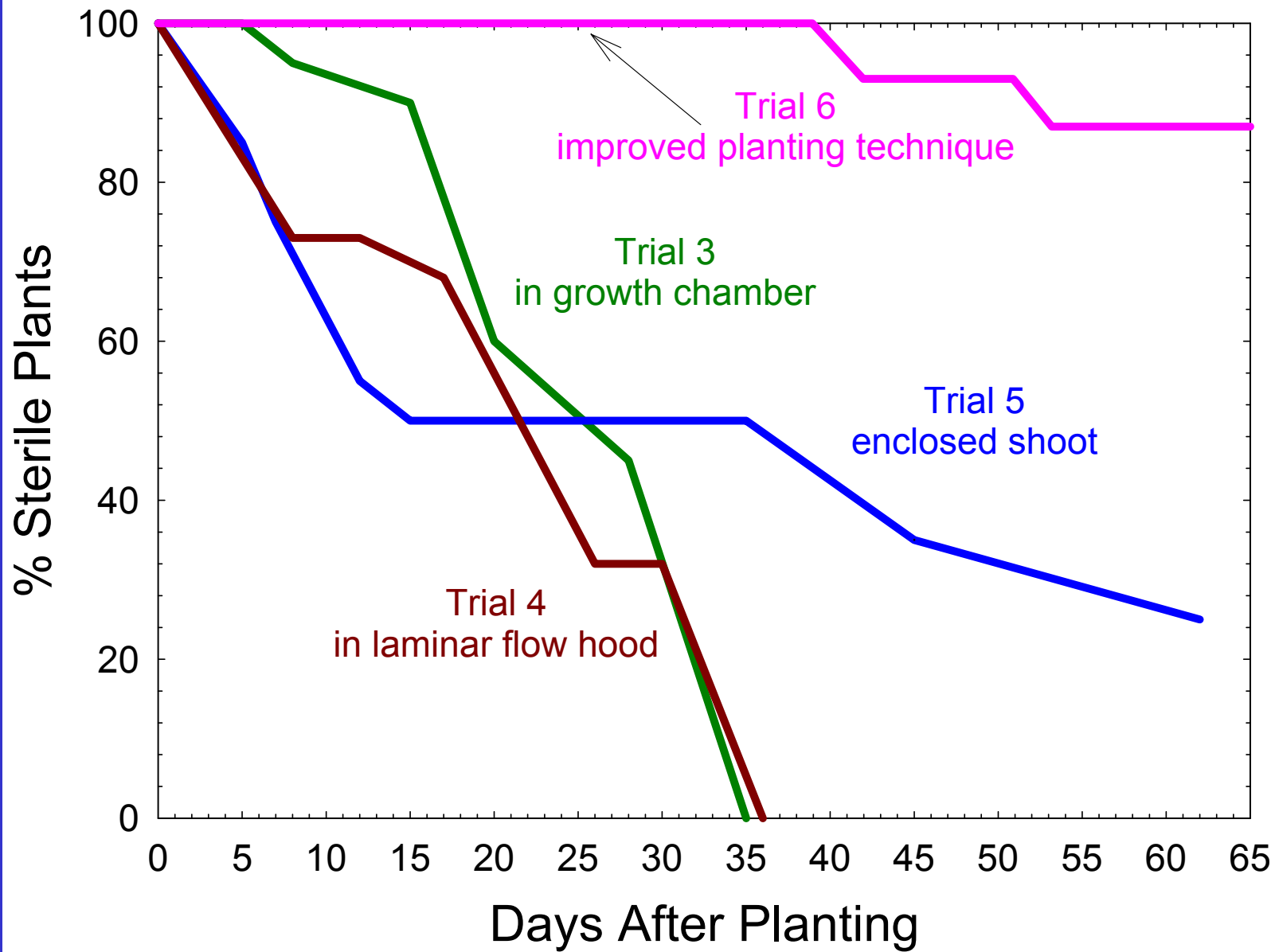


Laminar  
flow hood



# Treatments

- High  $\text{NH}_4^+$
- $\text{K}^+$  stress
- Drought
- Flooding



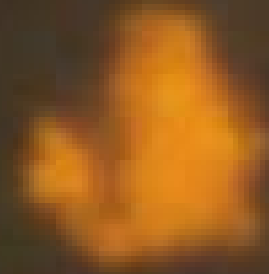
# Assessing microbial contamination



# Verifying Plate Counts: Acridine Orange Stain of Leachate

Clean sample

10  $\mu\text{m}$



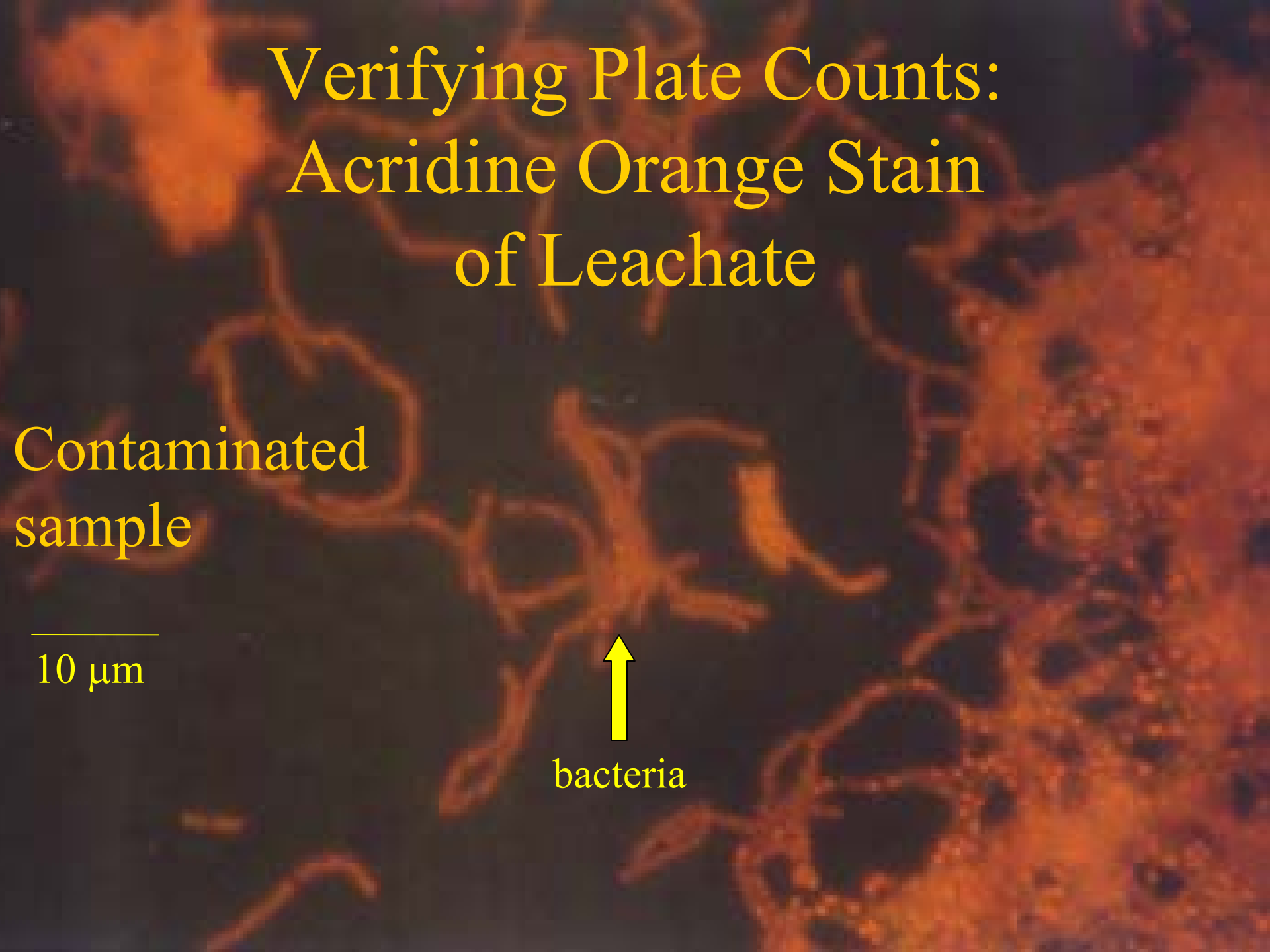
Root debris

# Verifying Plate Counts: Acridine Orange Stain of Leachate

Contaminated  
sample

10  $\mu\text{m}$

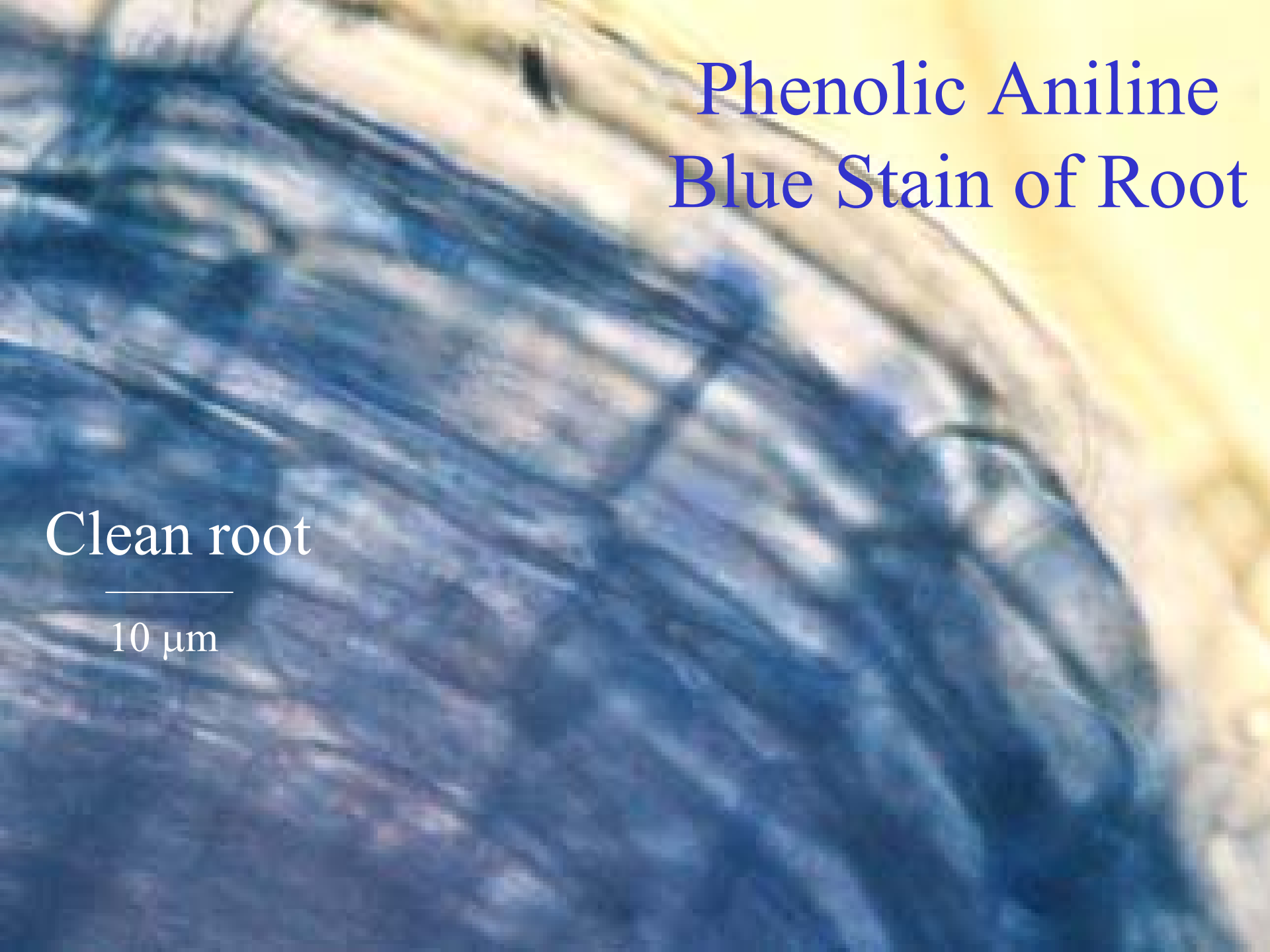
↑  
bacteria



# Phenolic Aniline Blue Stain of Root

Clean root

10  $\mu\text{m}$

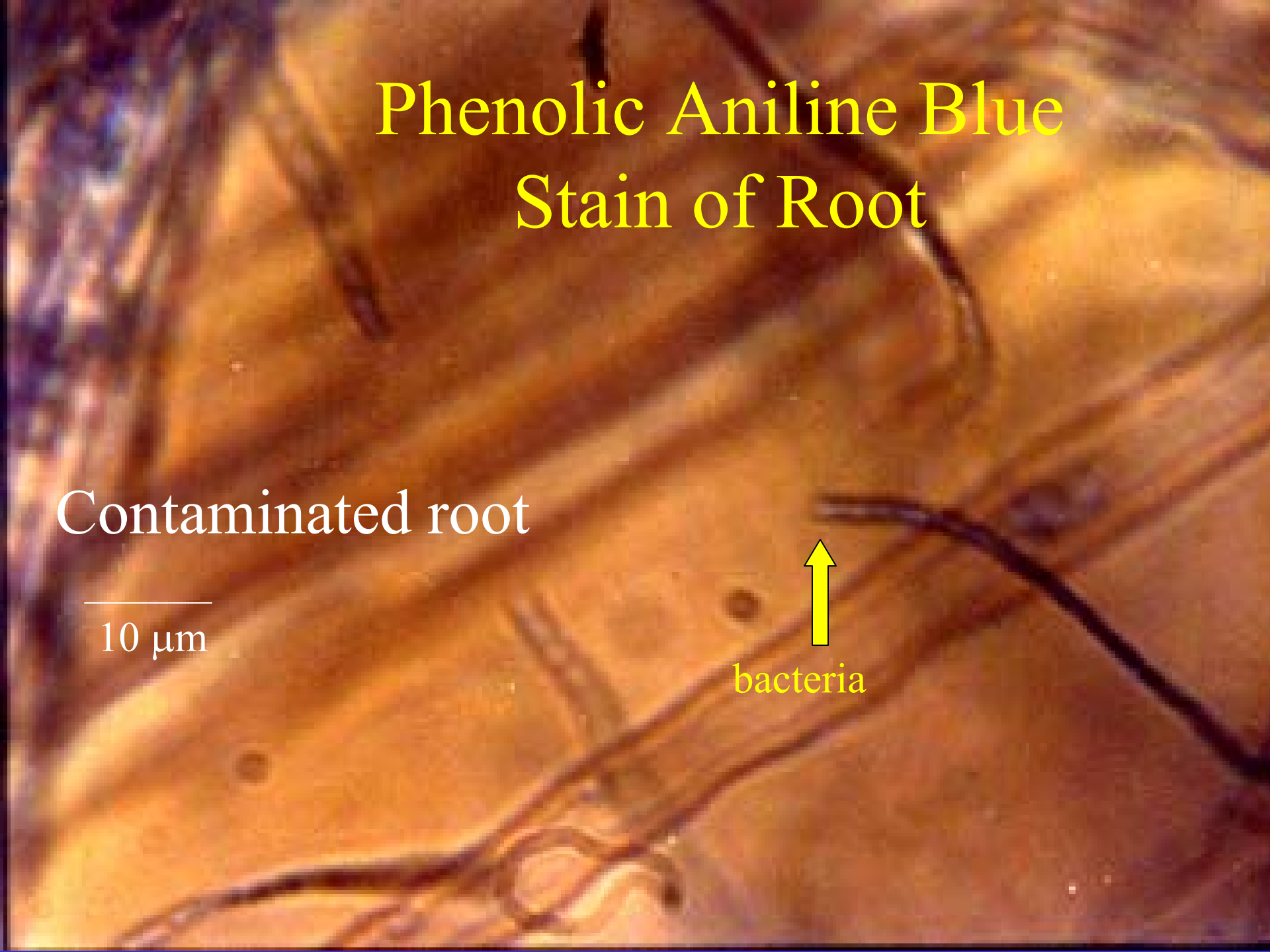


# Phenolic Aniline Blue Stain of Root

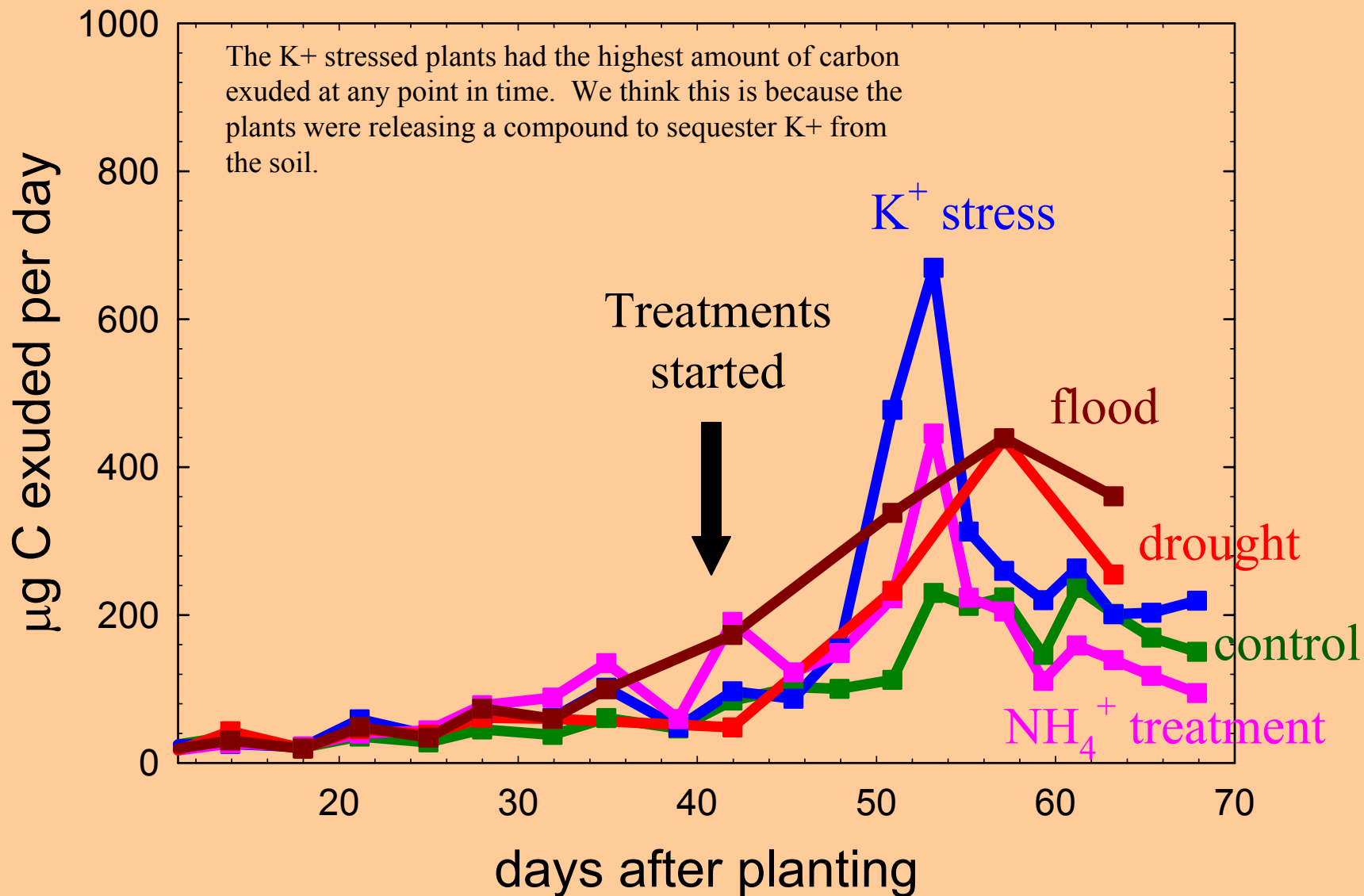
Contaminated root

10  $\mu\text{m}$

bacteria



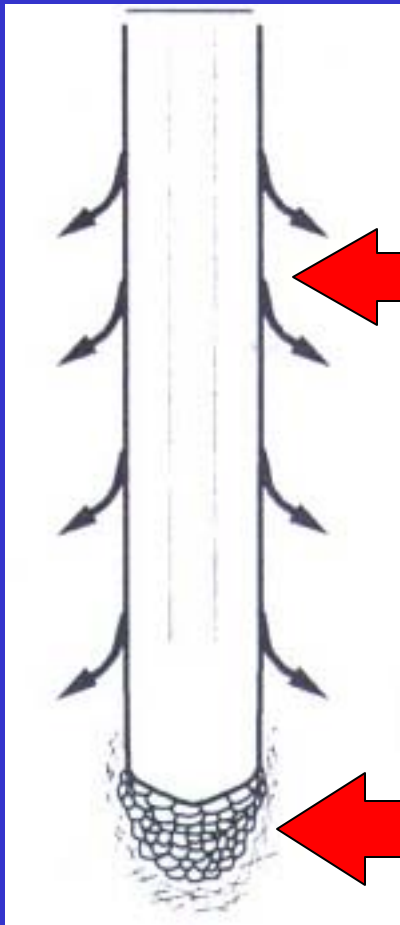
# Treatment Averages



# Cumulative carbon exuded per gram dry plant

	mg C exuded per g dry plant		Percent of control
	Average	Std. dev.	
<b>control</b>	2.6	0.4	
<b>NH<sub>4</sub><sup>+</sup></b>	2.3	0.1	90
<b>K<sup>+</sup></b>	3.7	0.6	144
<b>flood</b>	3.8	0.9	145
<b>drought</b>	4.4	0.5	170

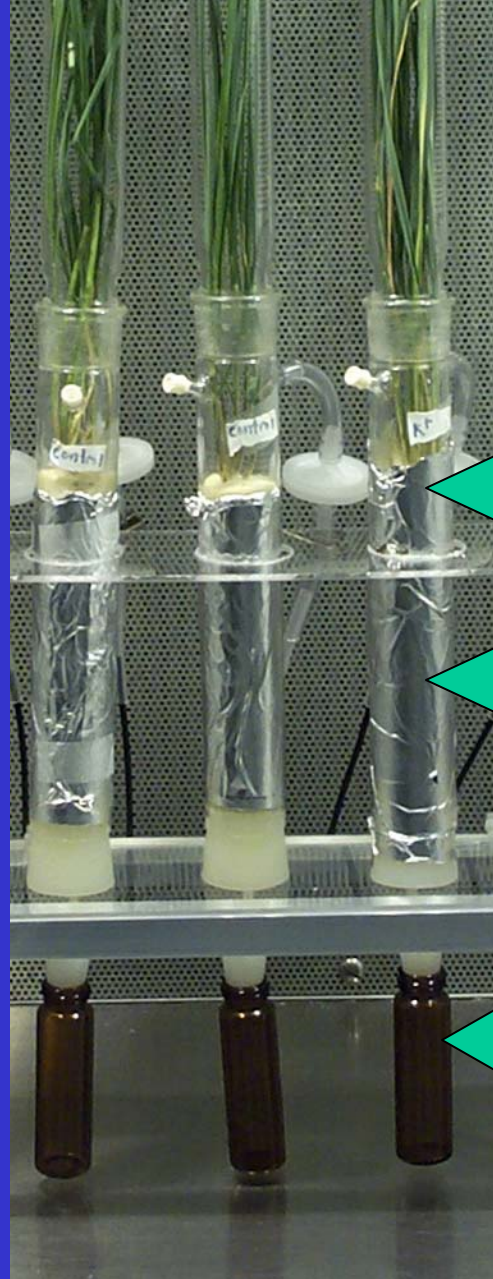
# Primary types of exudates



Compounds released  
by roots

Sloughed-off cells

# Distribution of Carbon



Rhizosphere  
sand

17 %

Bulk sand

9 %

Leachates

63 %

Soluble

11 %

Insoluble

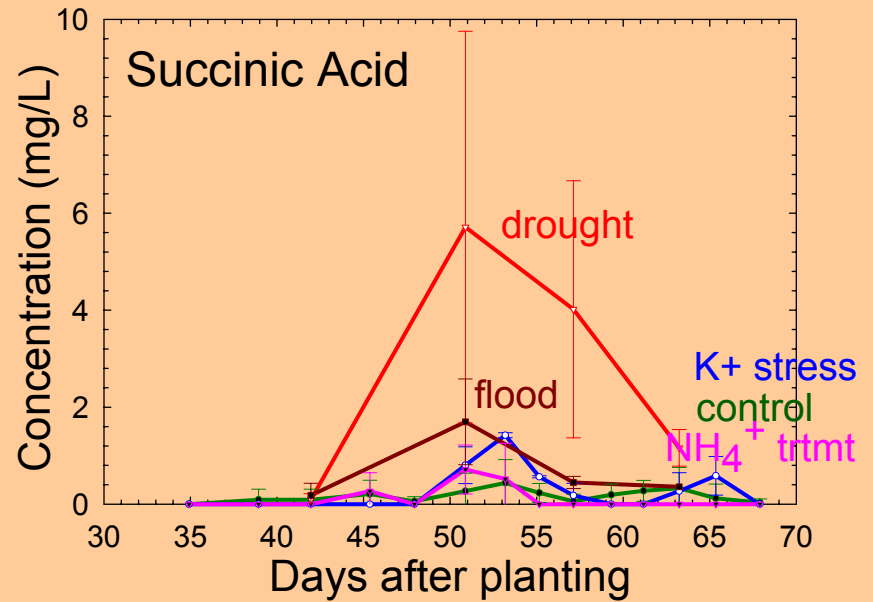
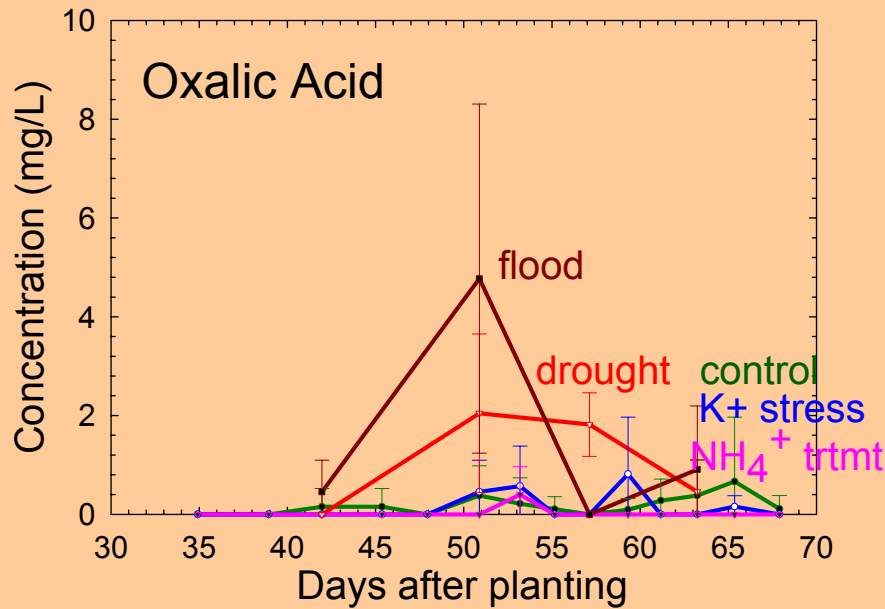
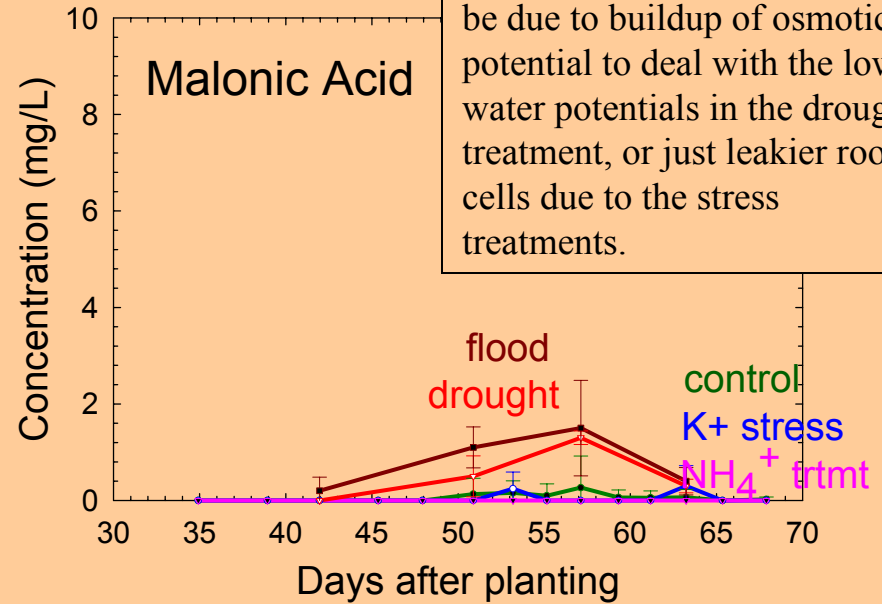
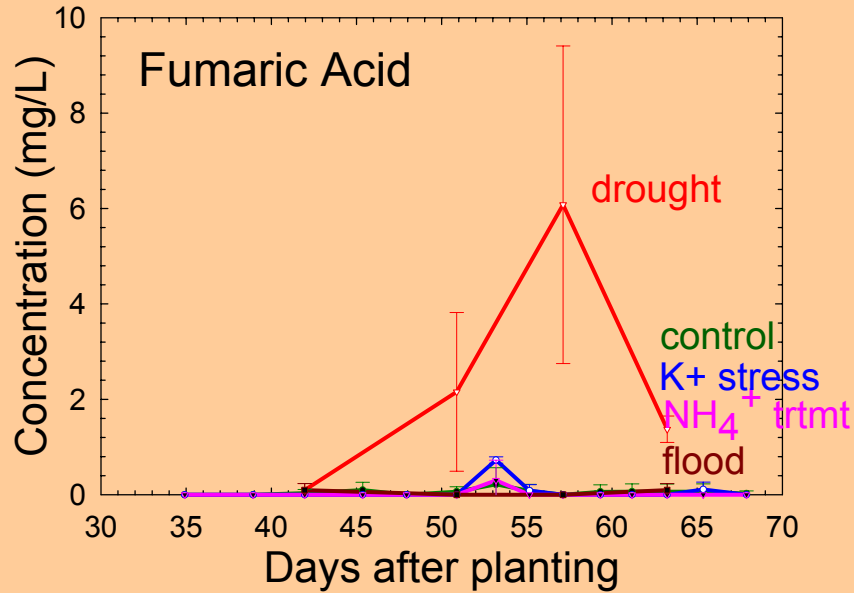
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100 %

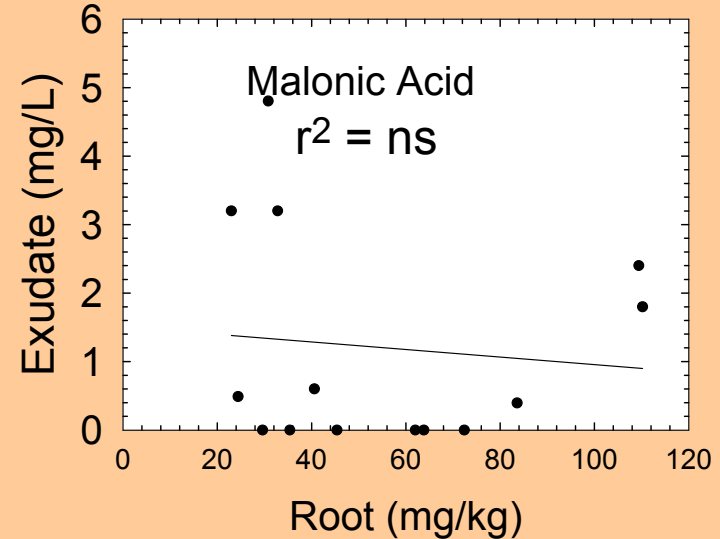
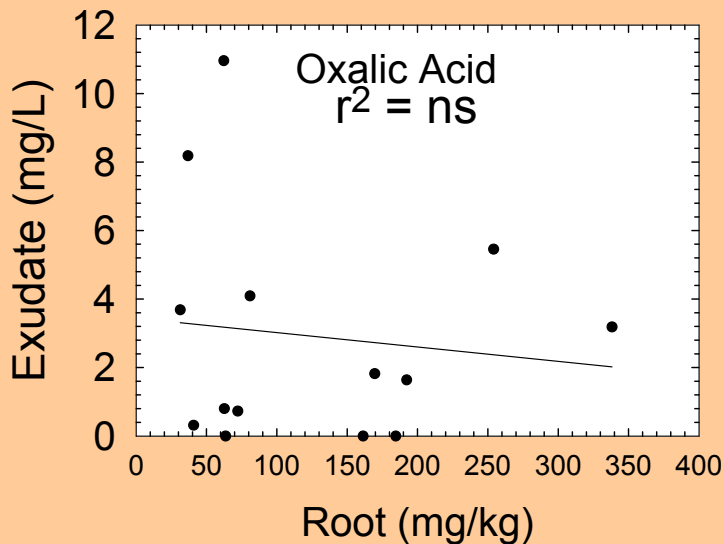
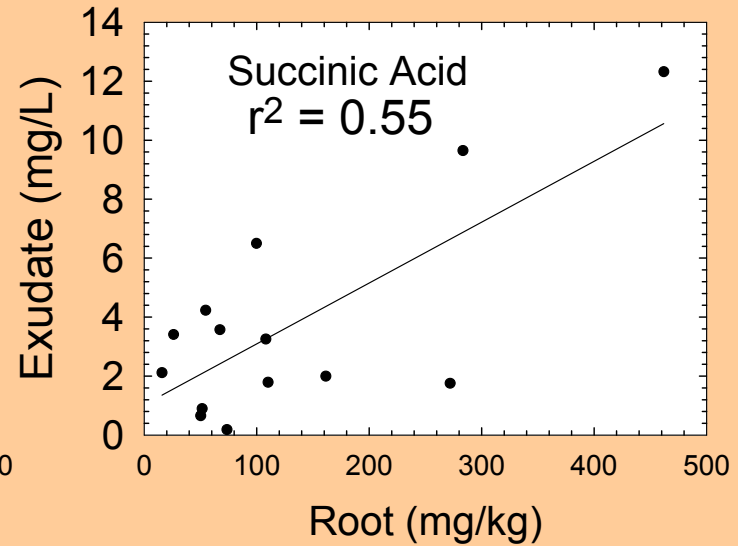
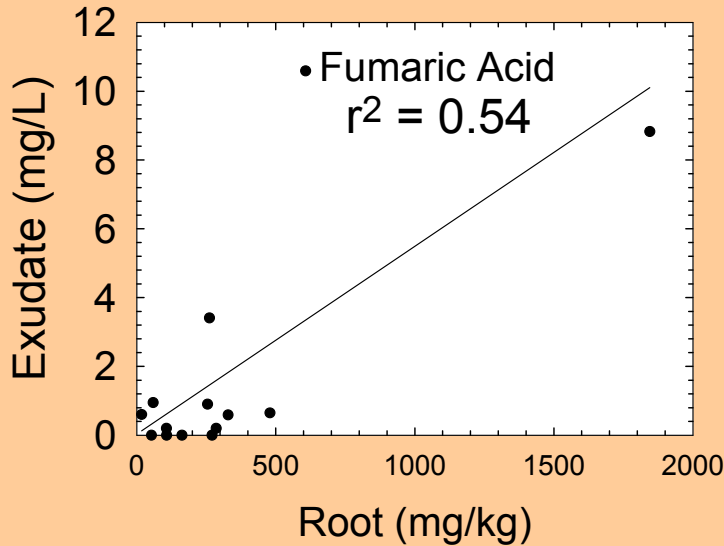
Based on the distribution of carbon released by the roots (mostly soluble with not much left on the sand), we conclude that the exudates we're seeing are mostly compounds released directly from the root, not whole cells released from the root.

# 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.

