
Mycorrhizal colonization of four varieties of switchgrass

Marlene Tyner

GCEP SURE

Argonne National Lab

University of Michigan

Mentor: R. Michael Miller



CSiTE – Carbon Sequestration in Terrestrial Ecosystems



- Long-term, collaborative research project between Argonne, Oak Ridge, and Pacific Northwest national laboratories
 - Investigating the carbon sequestration potential of prairie grasses
 - Conducted at two switchgrass research sites in Milan, Tennessee and Batavia, Illinois
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Why should we care about carbon sequestration?

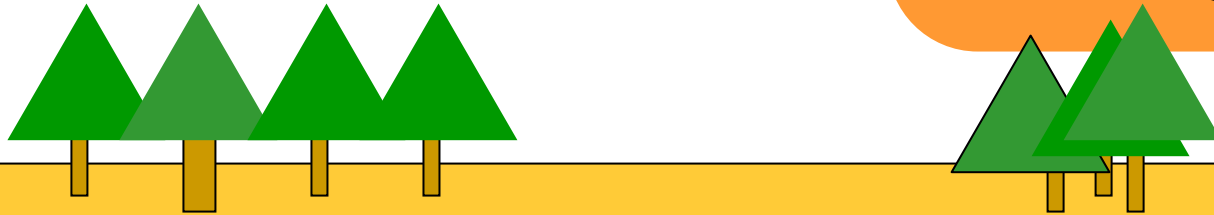
Carbon loss due to:

- Cultivation and harvesting
- Destruction of forests

~50%
lost

Terrestrial ecosystems are a great potential carbon sink to aid in mitigating global climate change

Managed terrestrial ecosystem storage potential of 2000 petagrams



Why switchgrass as a model C-sequestration system *and* potential biofuel source?

- Several varieties are able to grow in environments all over the country
- Short development phase (2-3 years)
- Can persist in areas with marginal to poor soils
- Forms an extensive root network with a huge potential for carbon sequestration if managed properly



What are mycorrhizal fungi?

- Types of fungi symbiotic with the roots of a majority of plant species
- Ecto- and arbuscular mycorrhizae are the two most common types of association
- Help roots reach out further in the soil to obtain water and nutrients such as nitrogen and phosphorus - limiting factors in many ecosystems - in exchange for carbon from the plant.

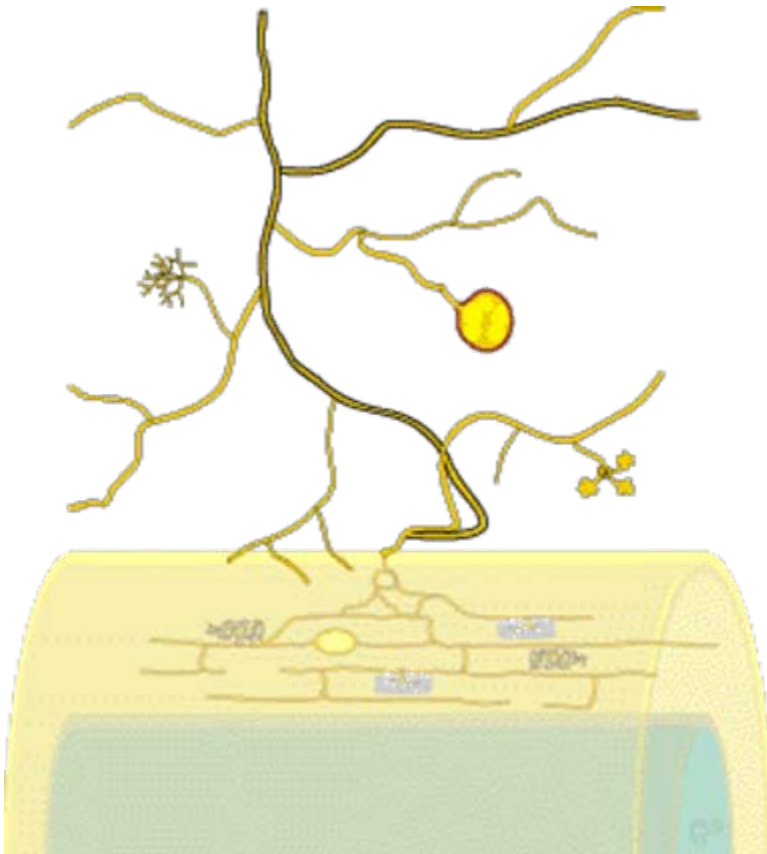
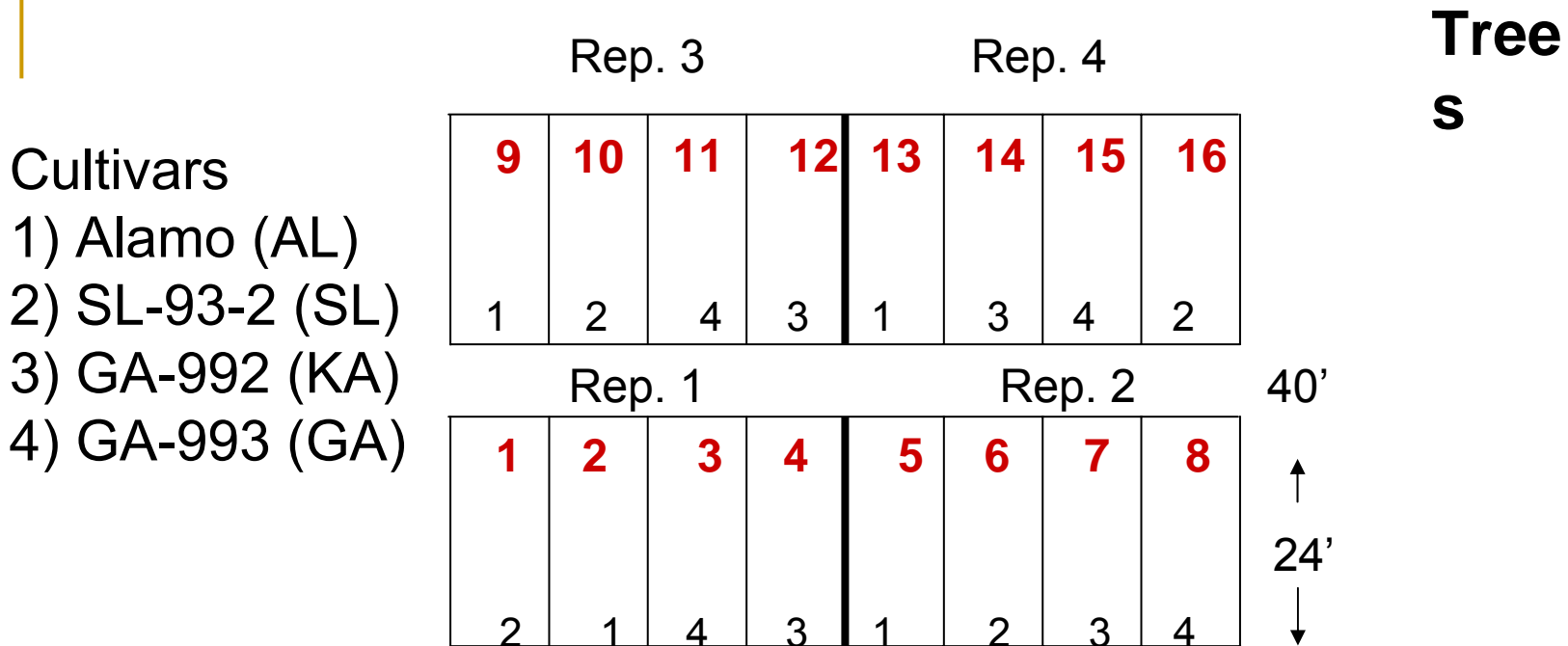


Diagram of AM fungal structures

Why are mycorrhizae interesting from a C sequestration point of view?

- Plants with more coarse roots have more mycorrhizal associations than plants with more fine roots
- Mycorrhizae degrade slower than plant detrital material, so holds carbon in soils longer (Treseder & Allen 2000, etc.)
- Roots colonized with mycorrhizal fungi are believed to live longer
- 90% of all vascular plants form mycorrhizal associations
- More mycorrhizae means a more powerful carbon sink in the soil!





Field Entrance

212 Varieties

Browning Road

Buildings

Milan Field Site – Experimental Setup

Courtesy of Personal Communication, Don Tyler, University of Tennessee

My summer research – major question

- Is there a difference in the amount of mycorrhizae found in each of the different cultivars at Milan? At different depths?

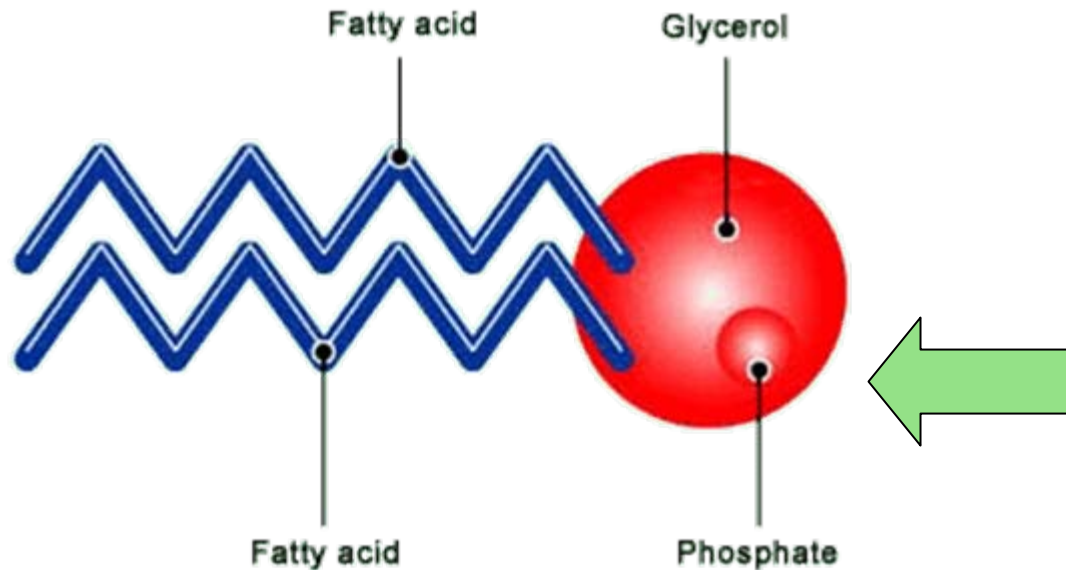


- Answering using both fatty acid analysis and observed colonization data



Fatty Acid Analysis

- Phospholipids and neutral lipids make up cell membrane lipid bilayers
- Specific to groups of microbes

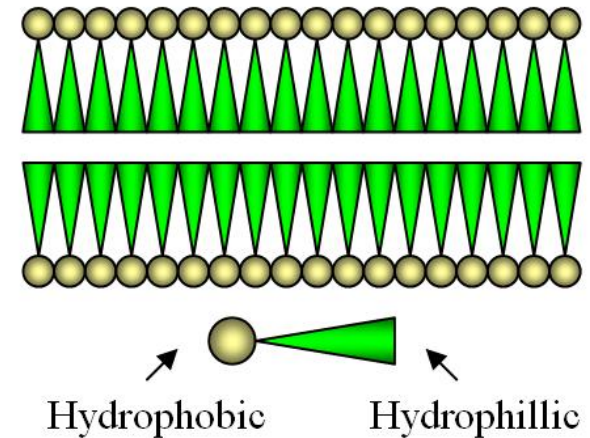


Phosphate group makes lipid polar; absence of phosphate group = neutral lipid

Fatty Acid Analysis

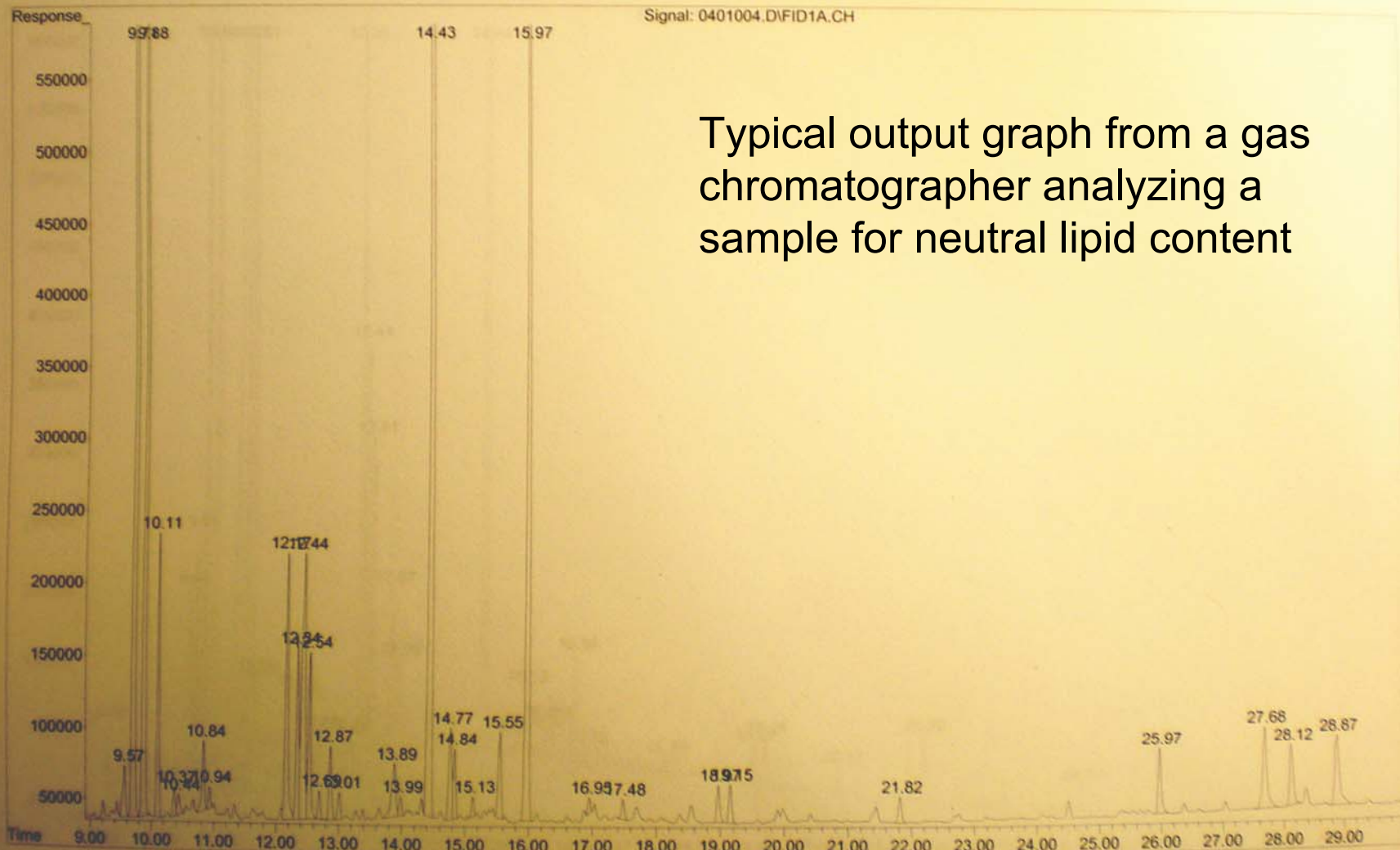
Basic lipid bilayer, makes up
cell membranes →

Medical Engineer.com, 2007



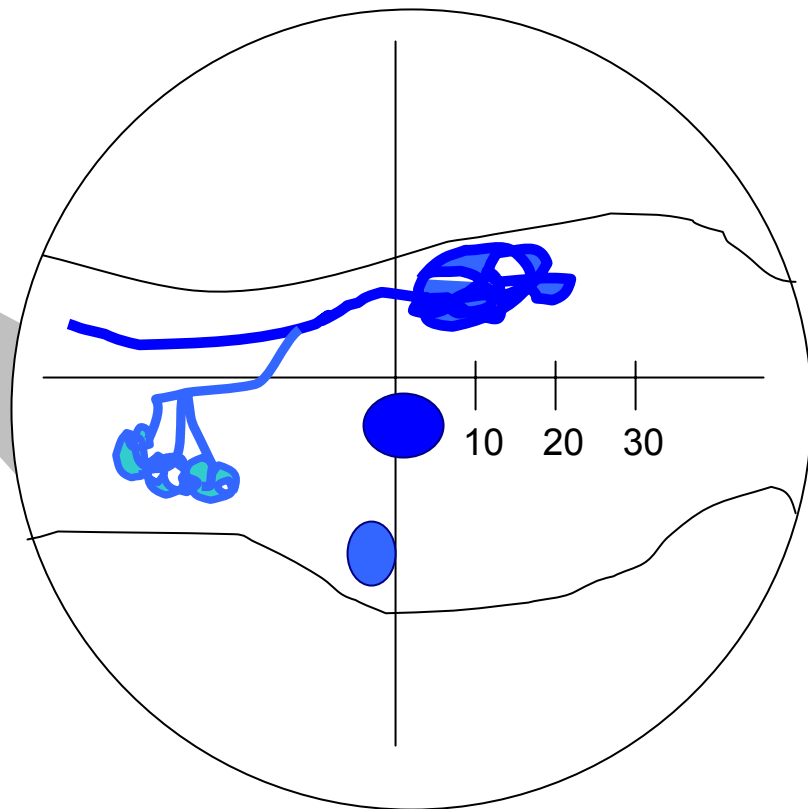
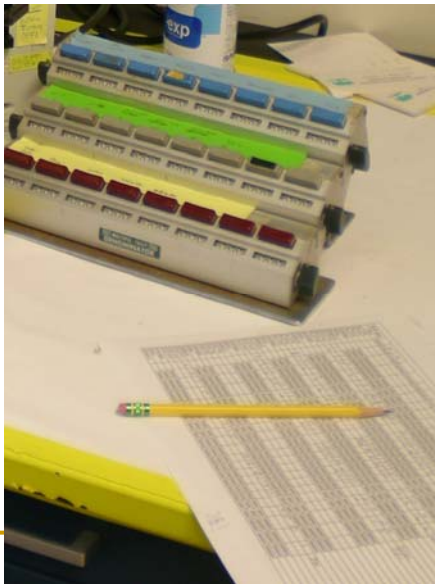
- 16:1 ω 5c is the major fatty acid associated with arbuscular mycorrhizal fungi; typical of Glomaceae family
- 20:1 ω 9 is a fatty acid characteristic of members of the Gigasporaceae family
- Phospholipid concentrations indicate biomass
- Neutral lipids indicate the form of carbon storage for these fungi

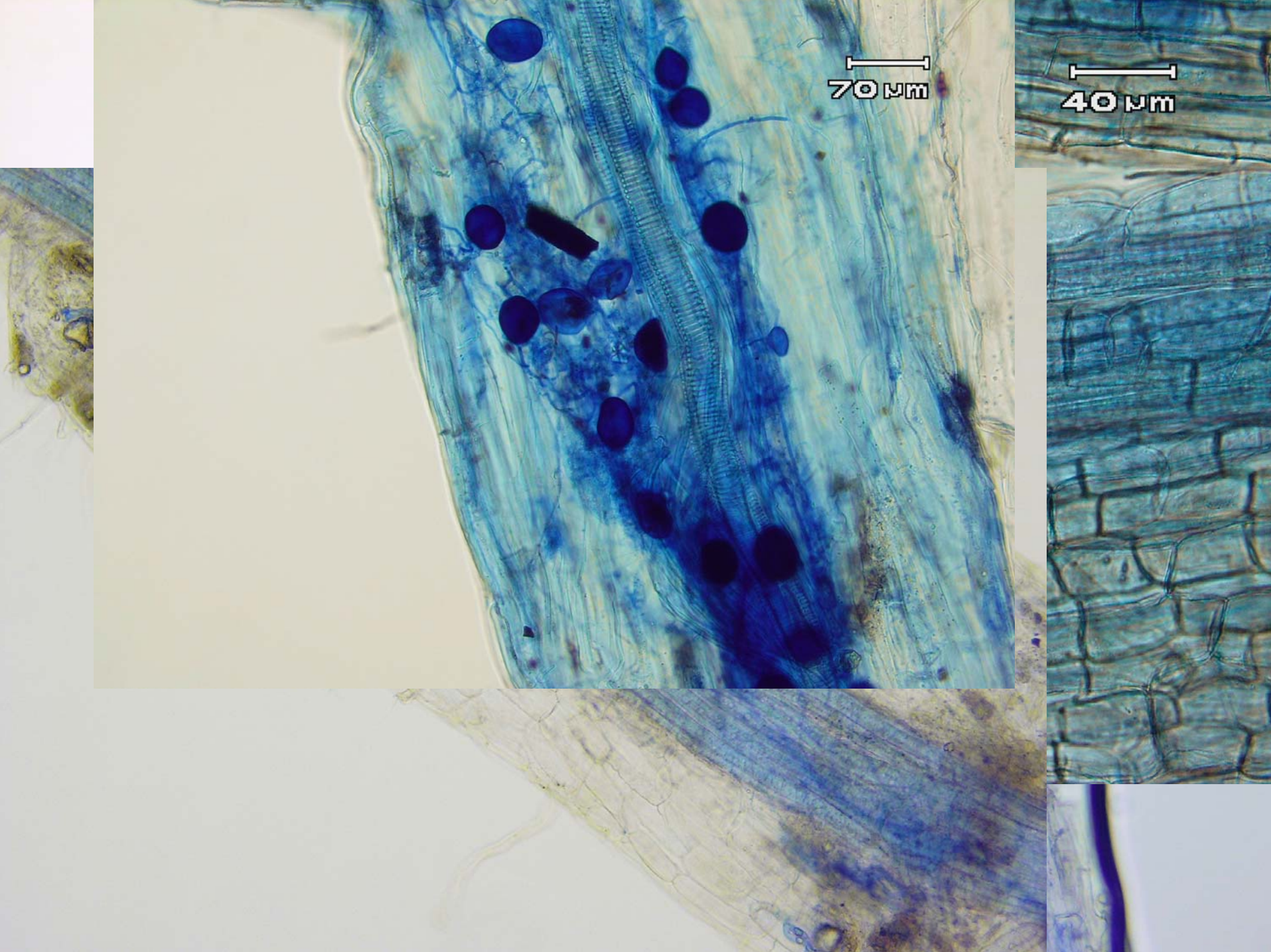
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Operator : Sharon
Instrument : Instrumen
Acquired : 23 Jul 2007 12:24 using AcqMethod PLFA_GC.M
Sample Name: 27N
Misc Info :



Observed colonization methodology

- Gridline-Intersect Method of root analysis
- Gives an estimate of total root length colonized via extrapolation from a sub-sample

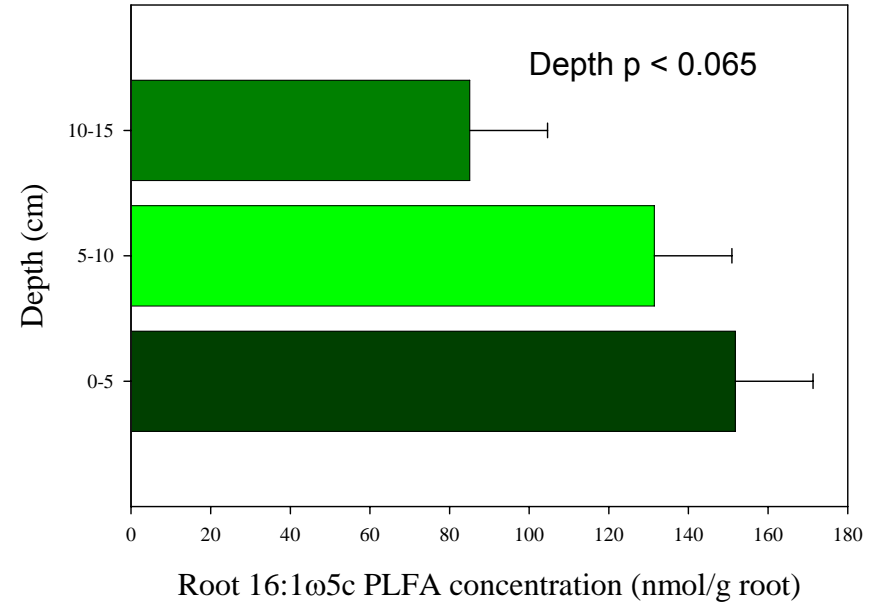
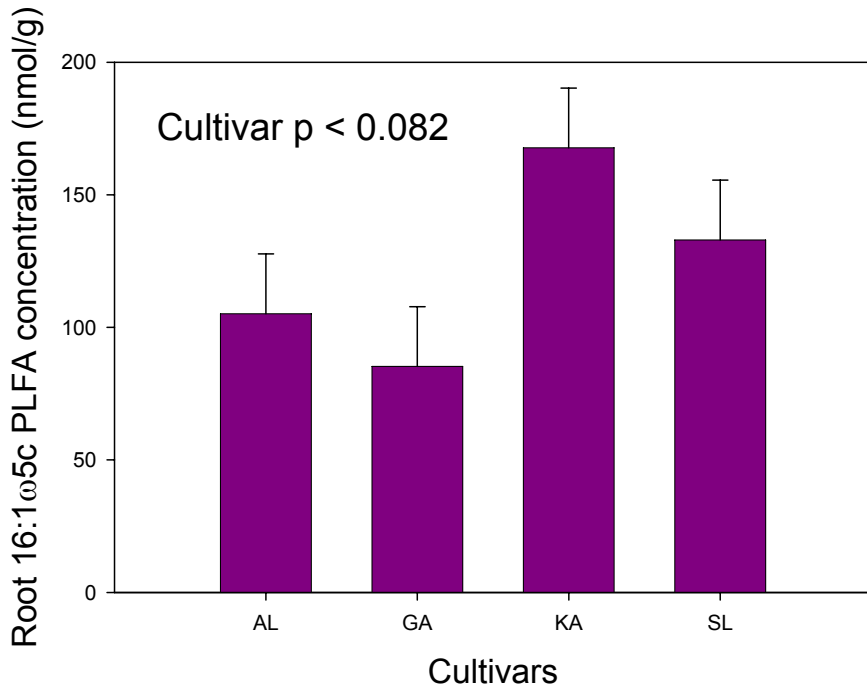




What we should expect to see

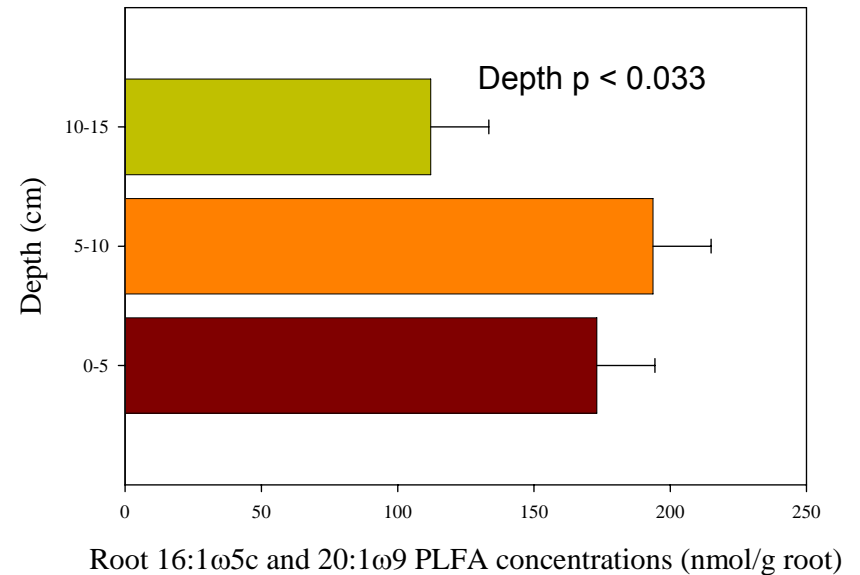
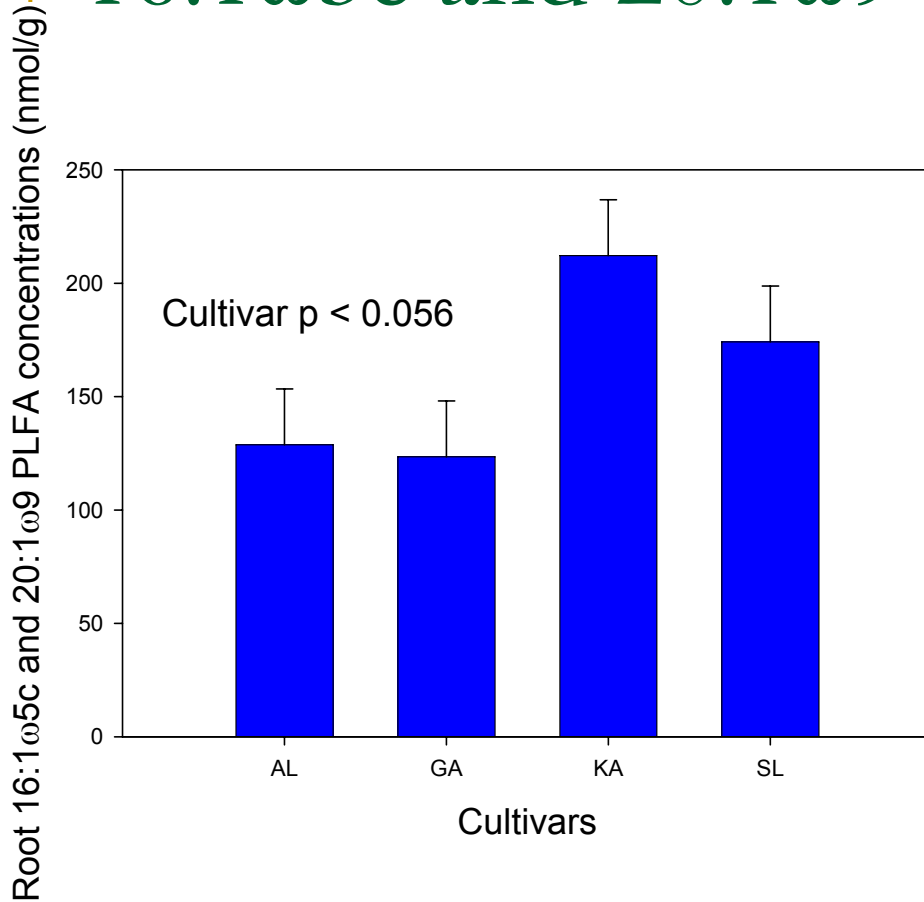
- Strong correlation between neutral lipid concentrations and presence of vesicles
→ more vesicles means more storage
 - Strong correlation between phospholipid concentrations (16:1 ω 5c and 20:1w9 specifically) and percent of total root length colonized
→ higher phospholipid concentrations indicate higher AMF biomass presence
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16:1 ω 5c PLFA concentrations



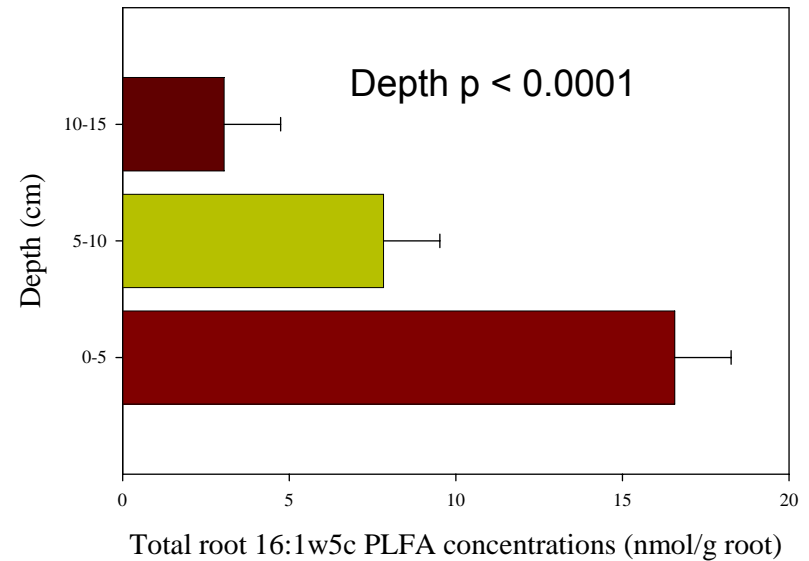
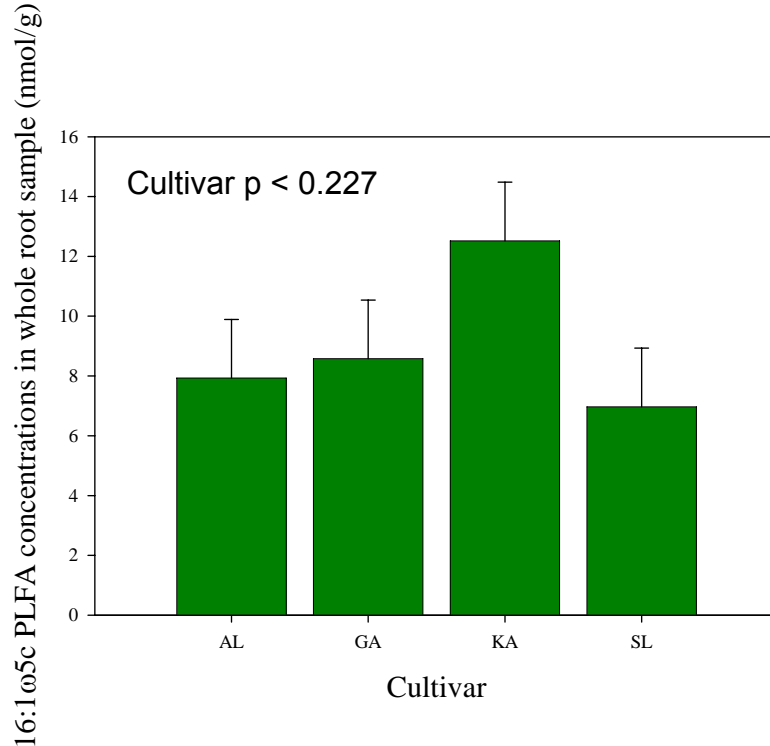
→ Significant cultivar and depth effect regarding 16:1 ω 5c PLFA concentrations in root samples

16:1 ω 5c and 20:1 ω 9 PLFA concentrations



→ Significant cultivar and depth effect regarding 16:1 ω 5c and 20:1 ω 9 PLFA concentrations in root samples

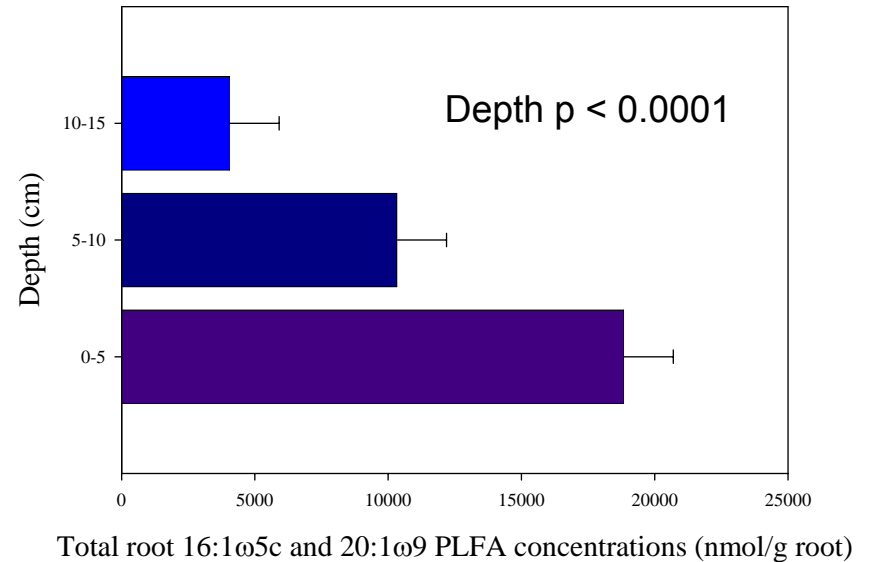
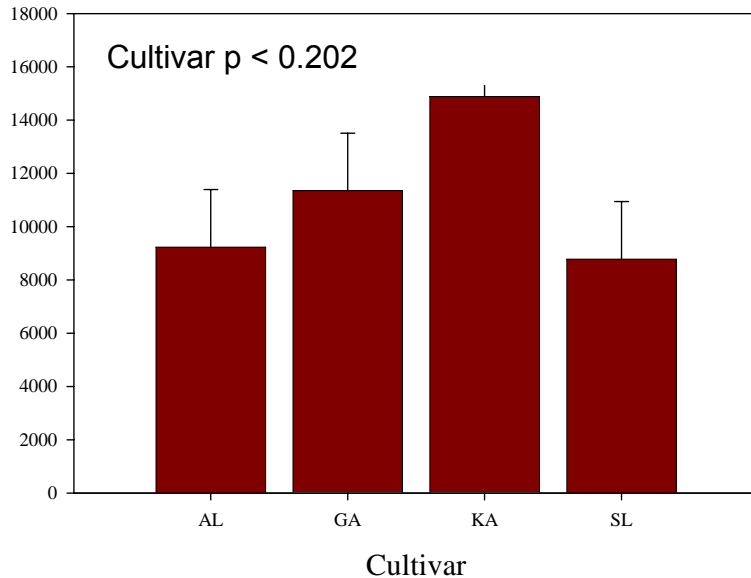
Total 16:1 ω 5c PLFA concentrations in total root sample



→ No significant cultivar effect on total 16:1 ω 5c PLFA concentrations in total root sample, but a significant depth effect

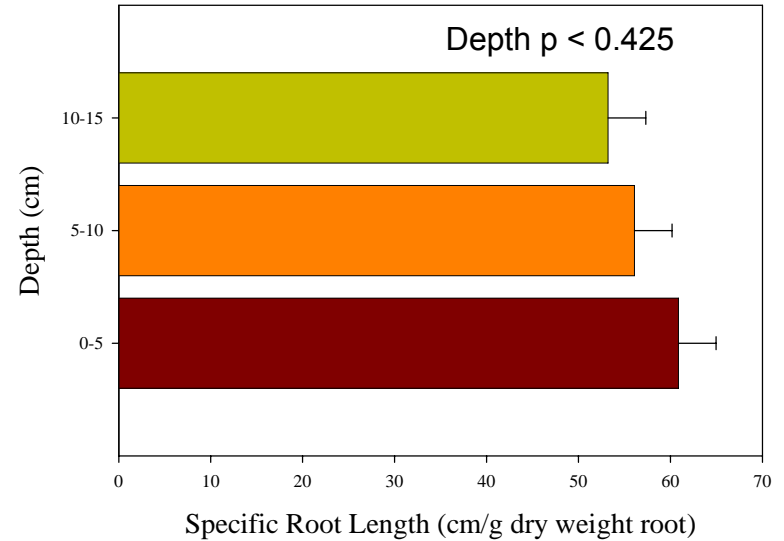
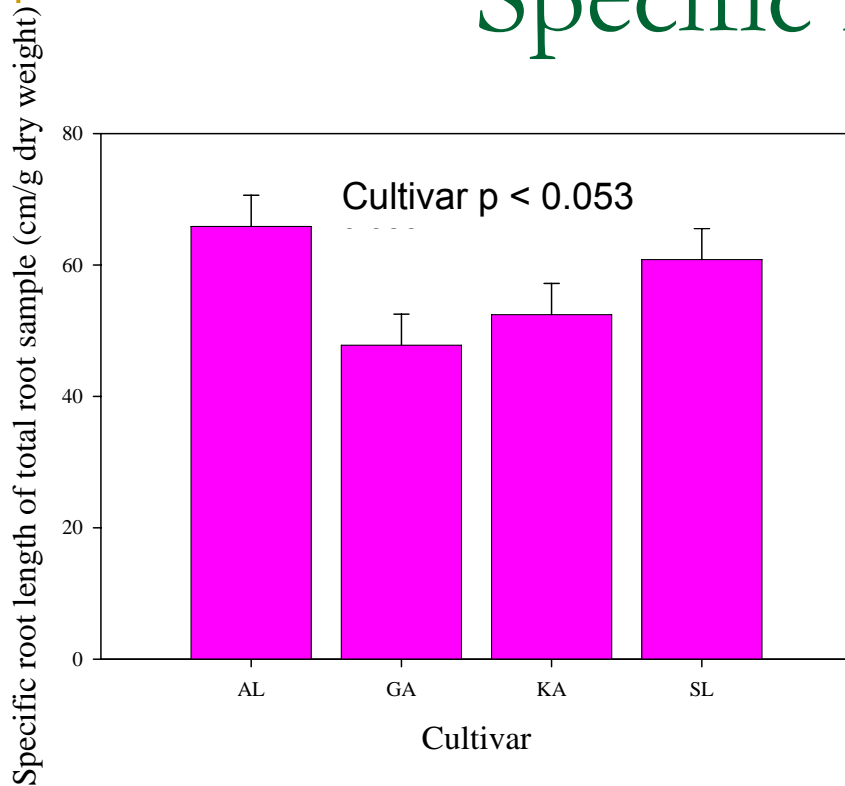
Total 16:1 ω 5c and 20:1 ω 9 PLFA concentrations in total root sample

16:1 ω 5c and 20:1 ω 9 PLFA concentrations in total root sample (nmol/g)



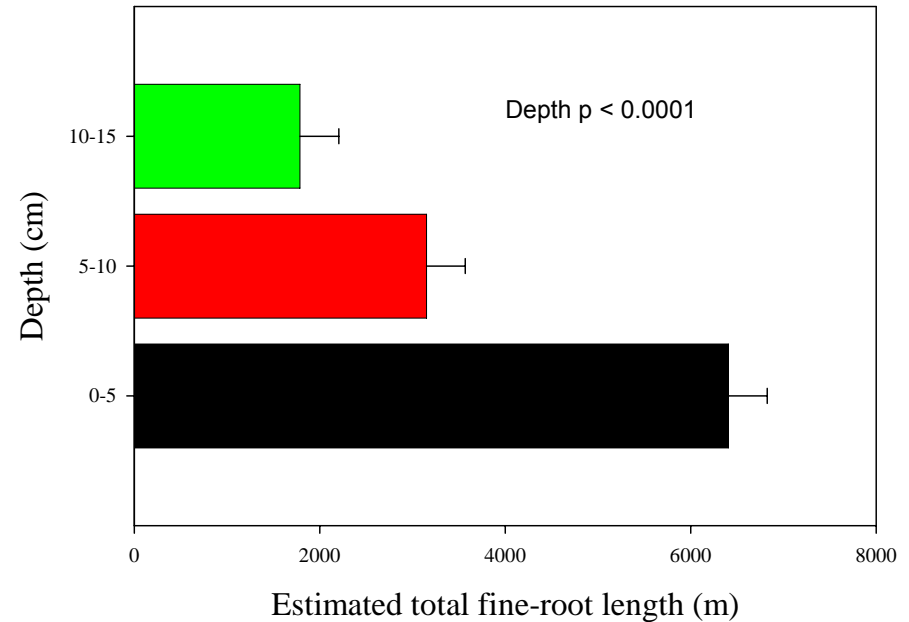
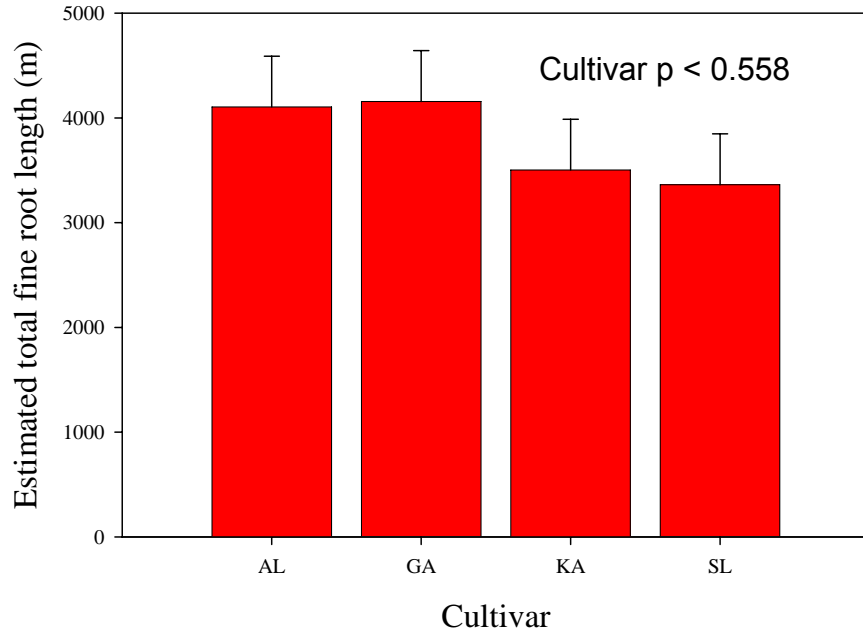
→ No significant cultivar effect on the total PLFA concentrations in the total root sample, but a significant depth effect exists

Specific root length



- Specific root length shows root architecture; shows ratio of length to mass
- Coarser roots – low srl
- Finer roots – high srl
- Significant cultivar effect, no significant depth effect

Fine-root length



→ Significant depth effect on fine root length, but no significant cultivar effect

Summary

- The Kanlow cultivar appears to have the highest AMF colonization, according to the PLFA concentrations in the root samples taken for this study
 - The AMF PLFA concentrations are highest in the 0-5 cm depth range for all cultivars
 - The Kanlow cultivar also has one of the lowest specific root length values, supporting the idea that colonization occurs more frequently in coarser roots than in finer roots
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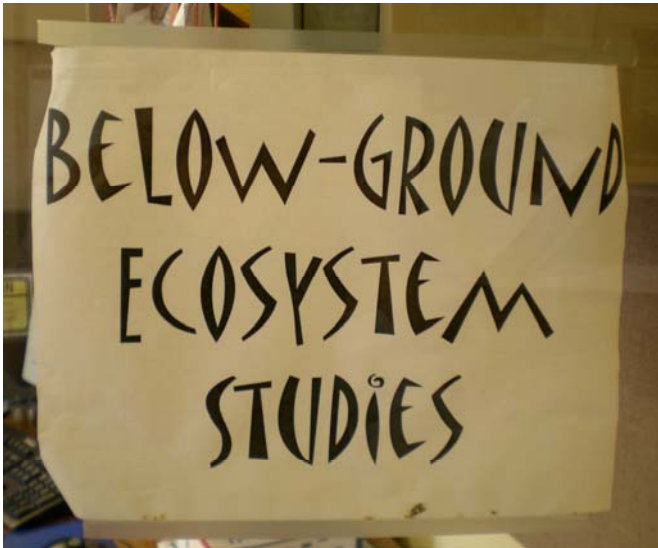
Future Work

- Correlation of PLFA data and colonization data
 - Is there a relationship between what we are seeing in the roots and what is present in the soil?
- Use of hyphal in-growth bags, to be harvested in October



Thanks!

- Department of Energy, DOE Office of Science, GCEP SURE program
 - Argonne National Laboratory
 - The Argonne group: Dr. Mike Miller, Sharon Gray, Susan Kirt, Sarah O'Brien, Kelly Gravier, and anyone else who took some time out to teach me something
- You guys rock!

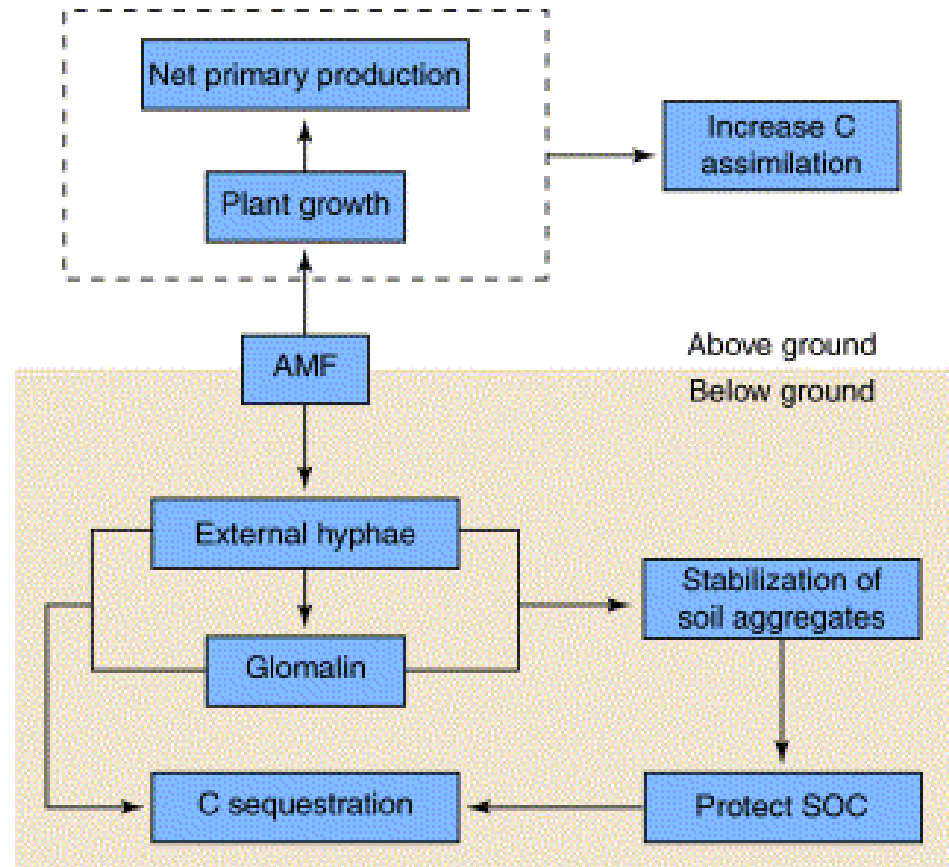


SCIENCE!



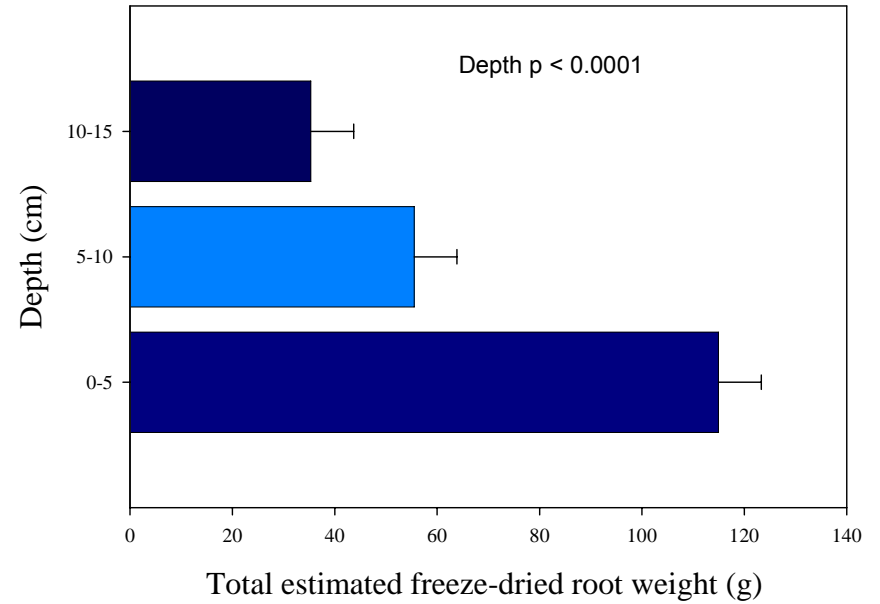
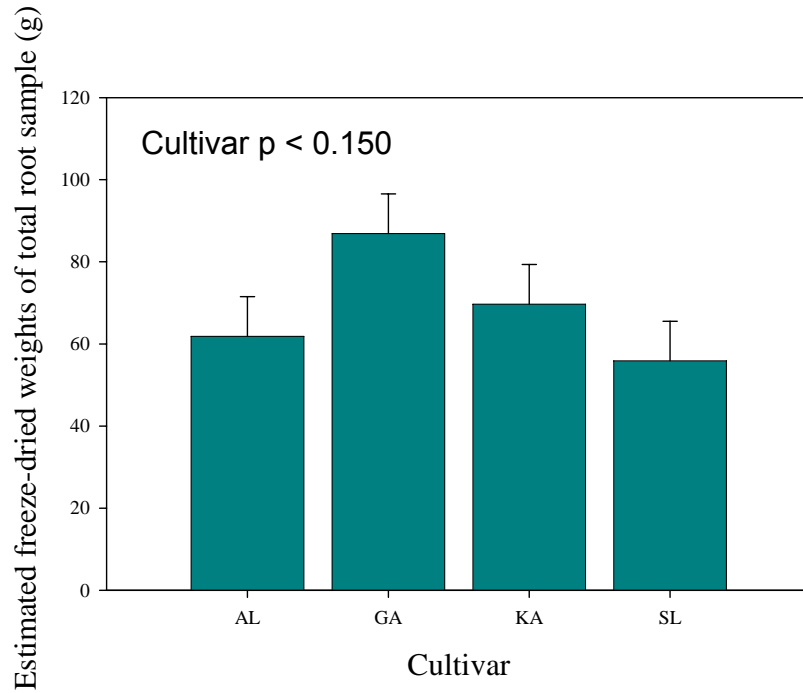
Contributions of AMF hyphae to soil carbon sequestration (Zhu & Miller, 2003)

- Influence of AMF on soil carbon sequestration
 - Nutrient effects on Host
 - Plant growth
 - NPP
 - C assimilation
 - AMF biomass
 - External hyphae
 - Chitin cell wall
 - glomalin
 - Protected SOC
 - AMF efficiency – direct access to photosynthate



TRENDS in Plant Science

Freeze-Dried Weights



RESULT