Rhizosphere Engineering for Drought Tolerance in Winter Wheat

Dr. Mary Stromberger

Soil's Role in Restoring Ecosystem Services

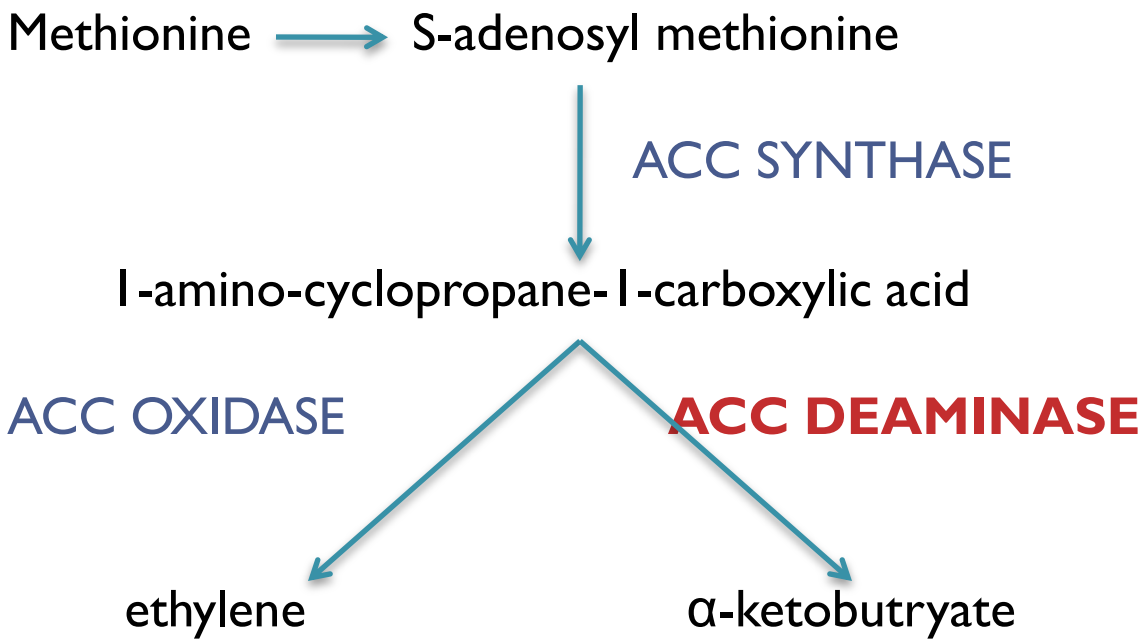
Sacramento, CA

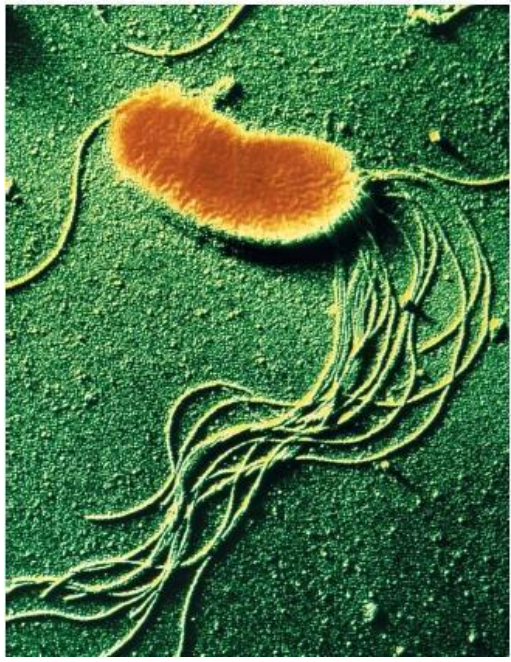
March 7, 2014

mary.stromberger@colostate.edu

Belowground interactions with ACC deaminase-positive bacteria

- Bacteria that degrade ACC, the precursor to stress ethylene





Pseudomonas

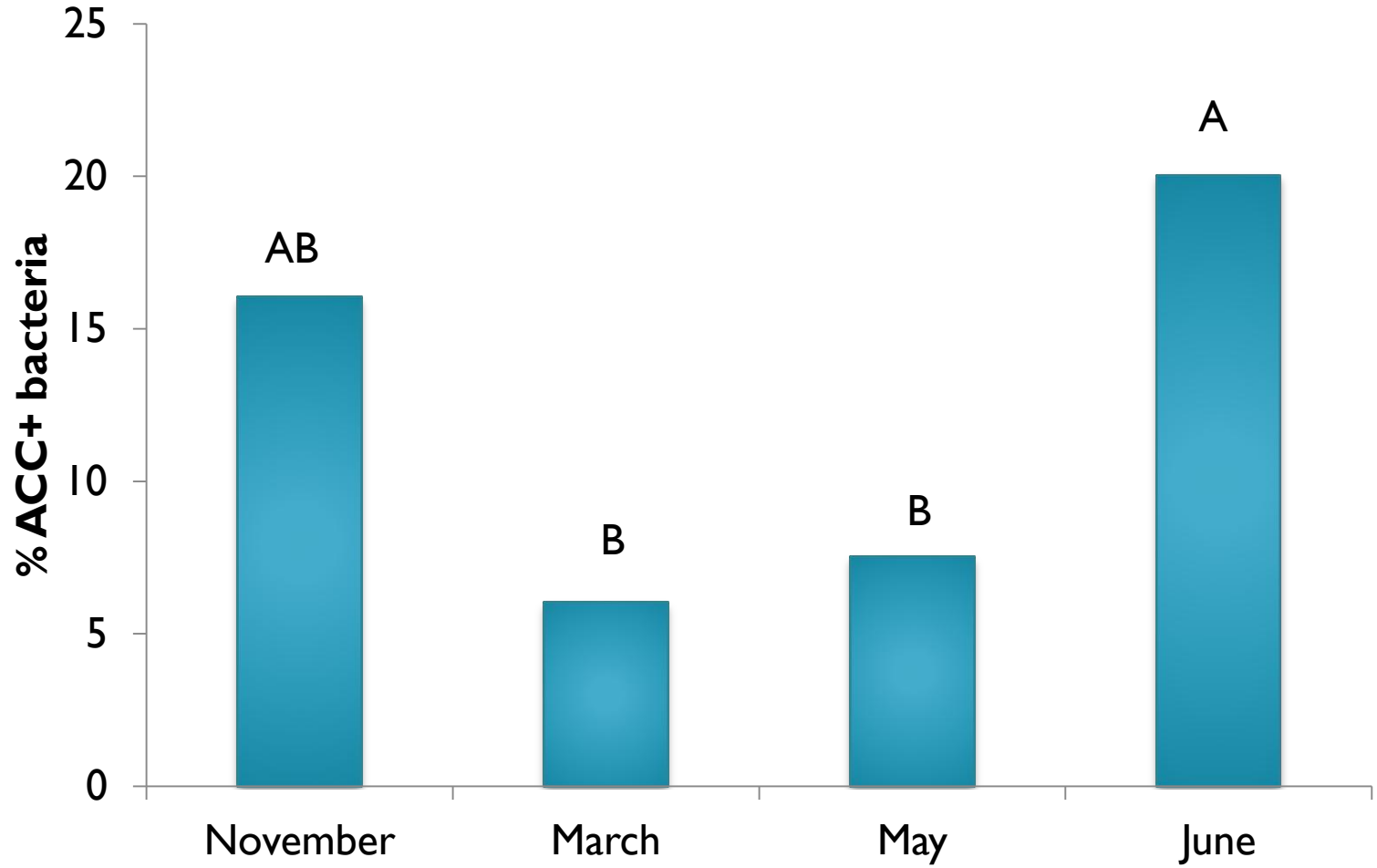
Questions?

- How abundant are they?
- What is their diversity?
- How are their abundance and diversity affected by different winter wheat varieties? By irrigation/water availability?
- Do they improve drought tolerance of winter wheat?

Field Study

- Limited Irrigation Research Farm (LIRF), Greeley, CO
- Treatment plots (3 replicate blocks)
  - 4 wheat varieties (Baca, Hatcher, Ripper and RonL)
  - 3 irrigation treatments (full, limited, and dryland)
  - 4 sampling events (November, March, May and June)
- Abundance and diversity of ACC+ bacteria
  - Total heterotrophs on 10% TSBA
  - ACC+ bacteria on DF agar
  - Diversity by sequencing DNA

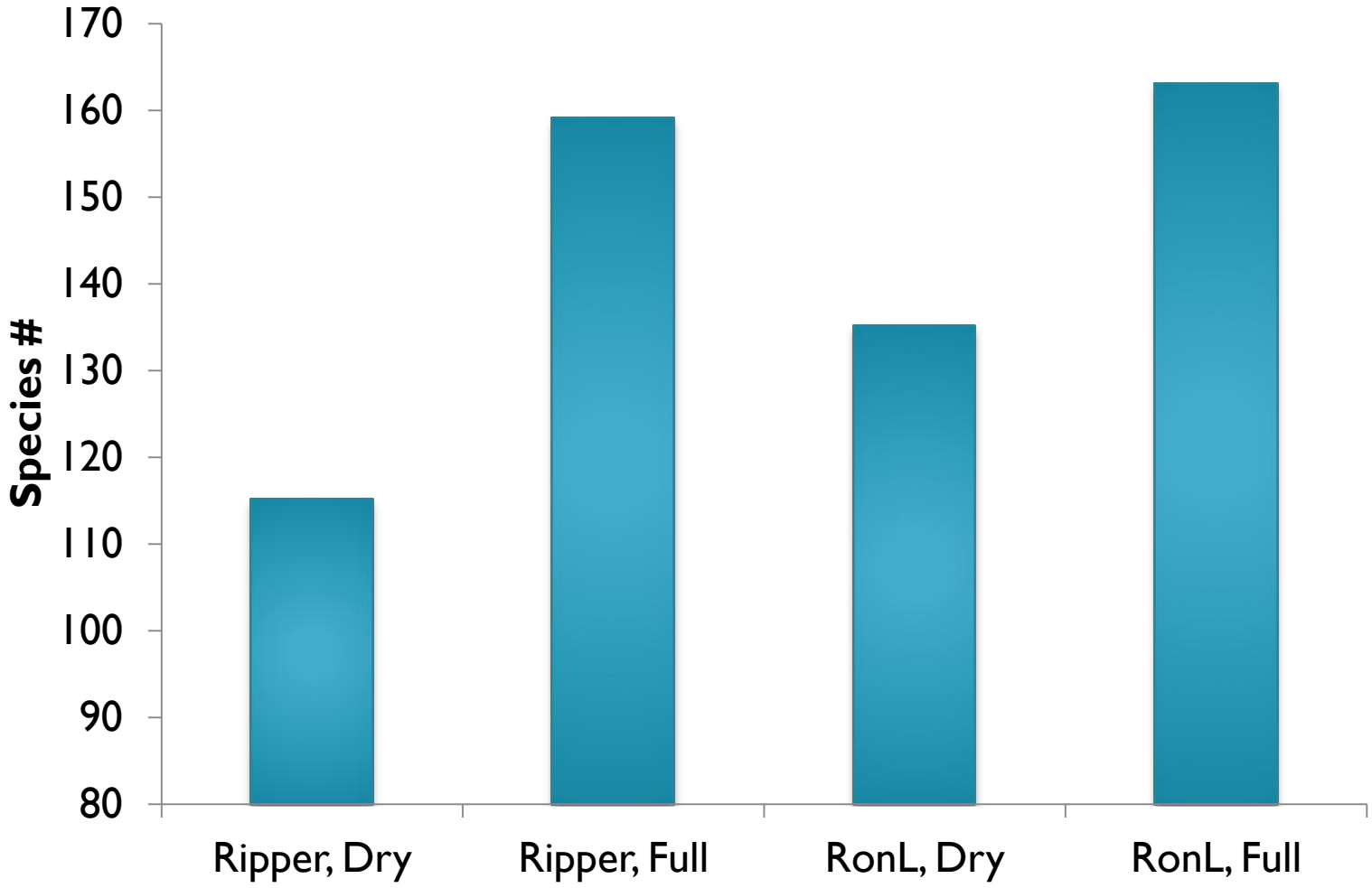
Relative abundance of ACC+ bacteria

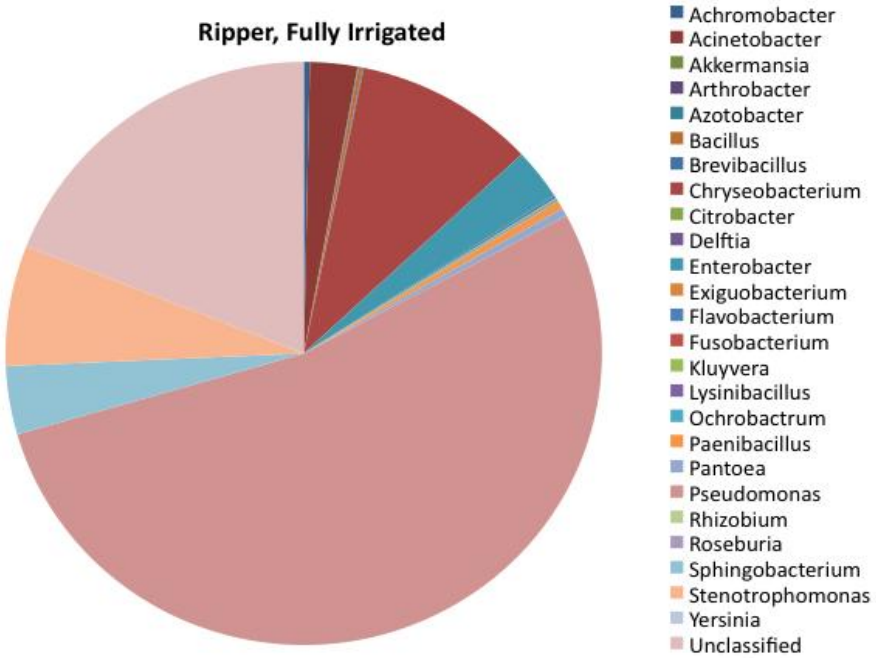


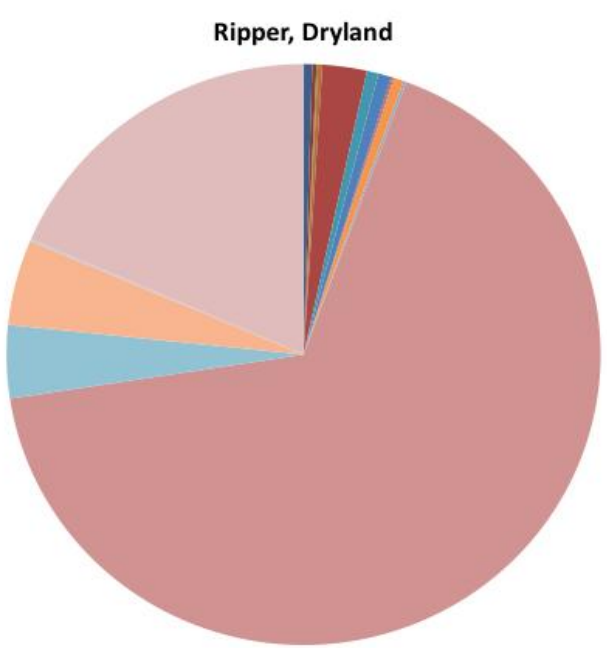
% ACC+ bacteria (flowering stage)

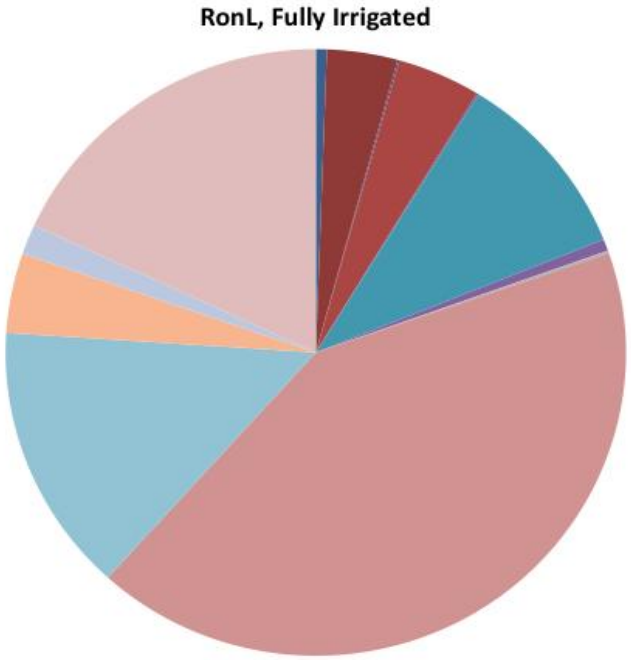
Wheat variety	Irrigation Treatment		
	Full	Limited	Dryland
Baca	1.2 a A	4.1 b A	6.9 b A
Hatcher	1.3 a B	13.5 a A	6.9 b B
Ripper	1.8 a B	7.7 ab AB	12.6 ab A
RonL	1.7 a C	8.0 ab B	17.6 a A

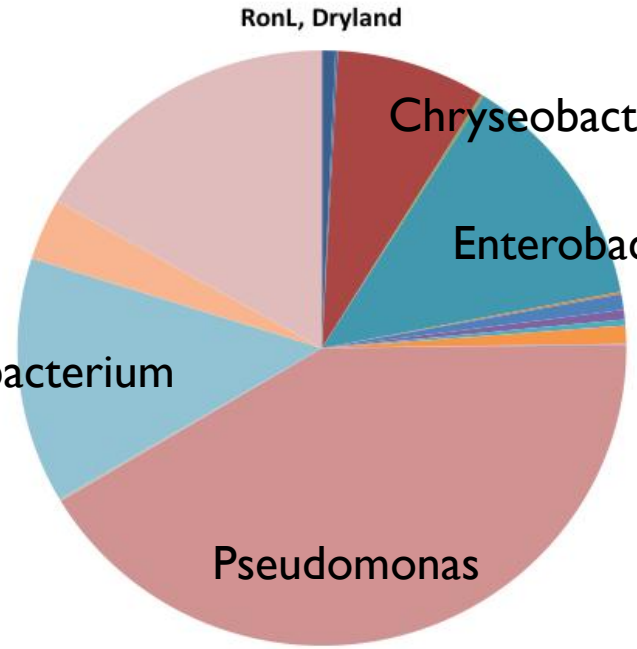
Richness of ACC+ bacteria




Ripper, Fully Irrigated
Achromobacter
Acinetobacter
Akkermansia
Arthrobacter
Azotobacter
Bacillus
Brevibacillus
Chryseobacterium
Citrobacter
Delftia
Enterobacter
Exiguobacterium
Flavobacterium
Fusobacterium
Kluyvera
Lysinibacillus
Ochrobactrum
Paenibacillus
Pantoea
Pseudomonas
Rhizobium
Roseburia
Sphingobacterium
Stenotrophomonas
Yersinia
Unclassified

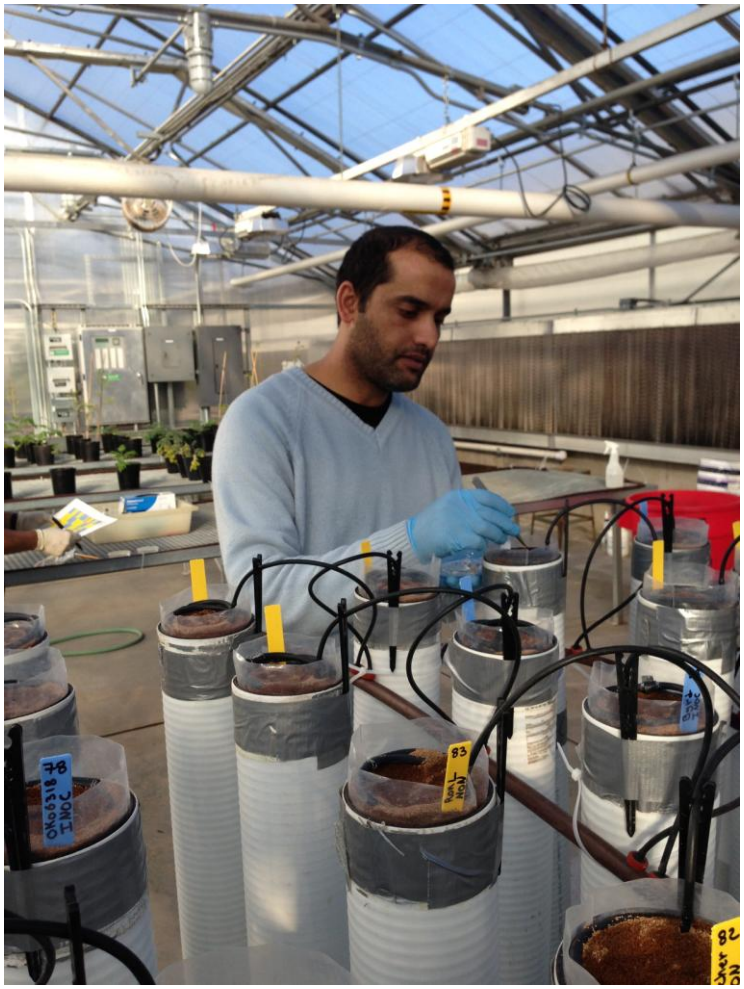

Ripper, Dryland

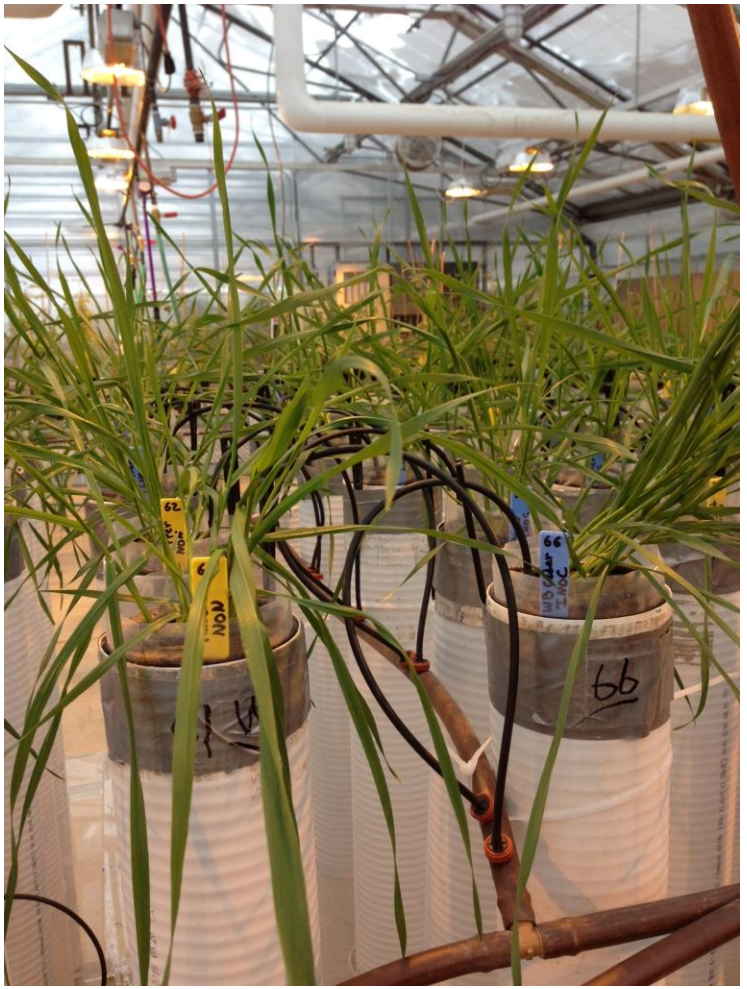

RonL, Fully Irrigated


RonL, Dryland
Chryseobacterium
Enterobacter
Sphingobacterium
Pseudomonas

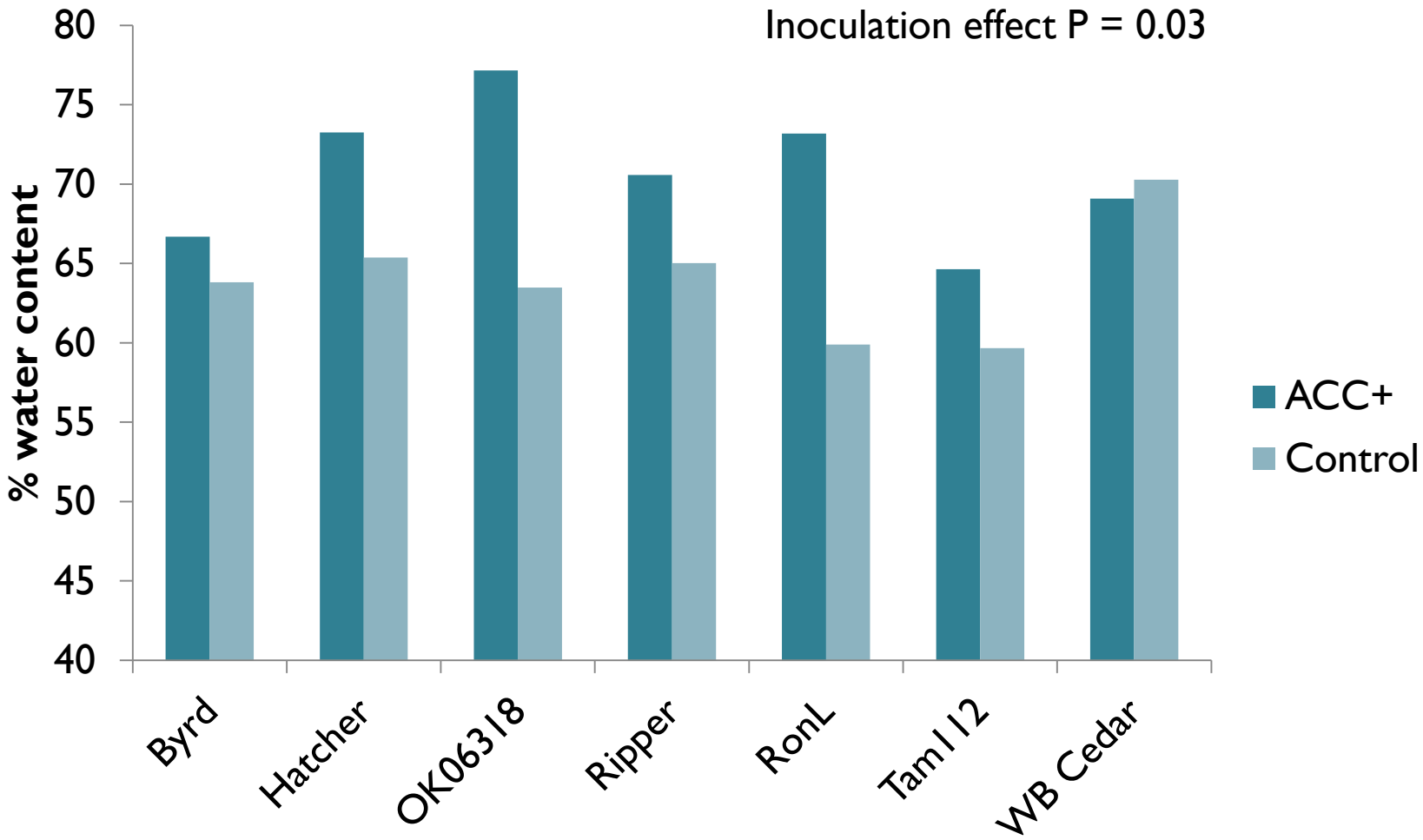
Greenhouse Studies

Cultivar × Inoculation × Water Stress interaction

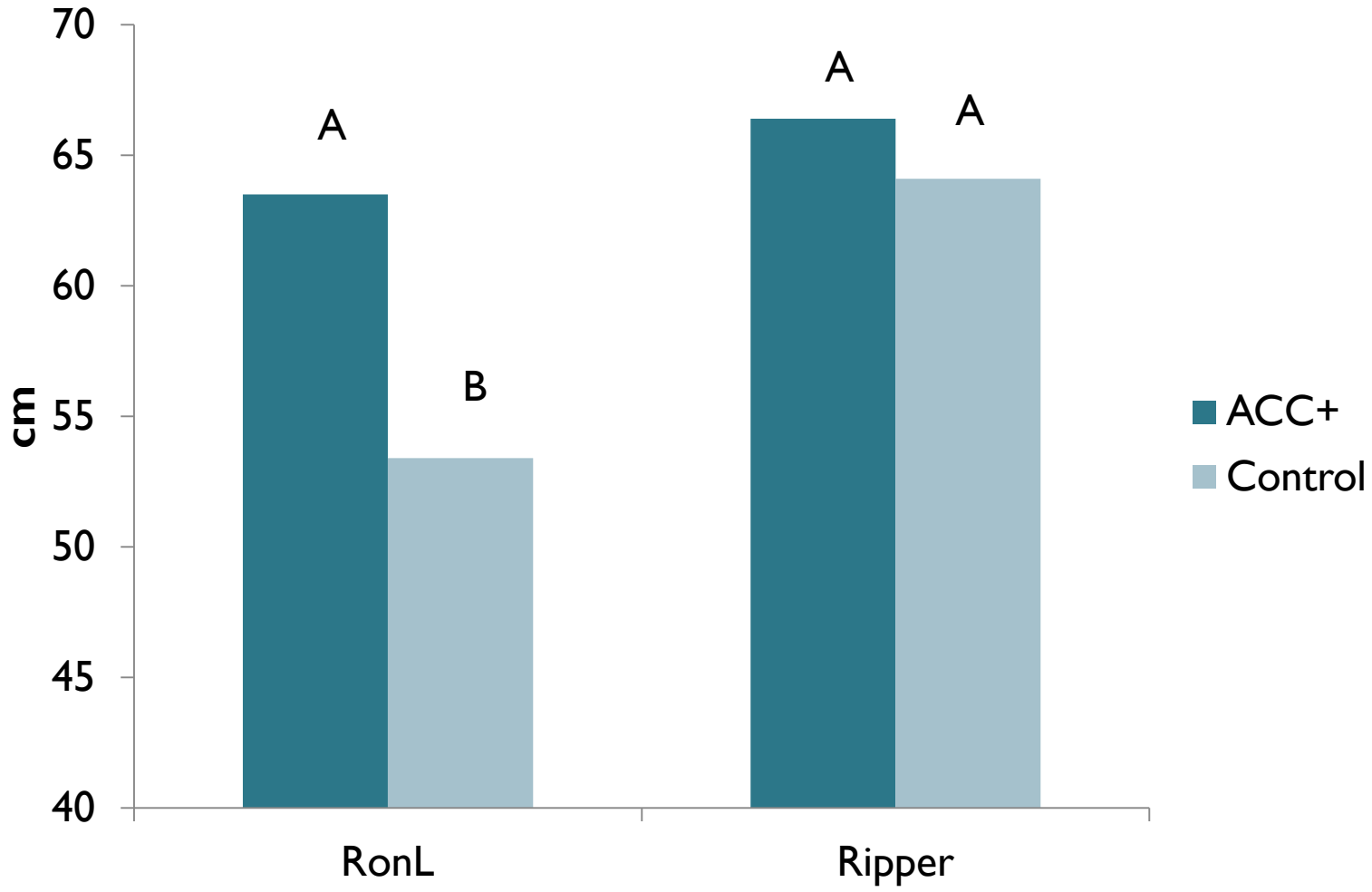




Leaf relative water content



Stem height



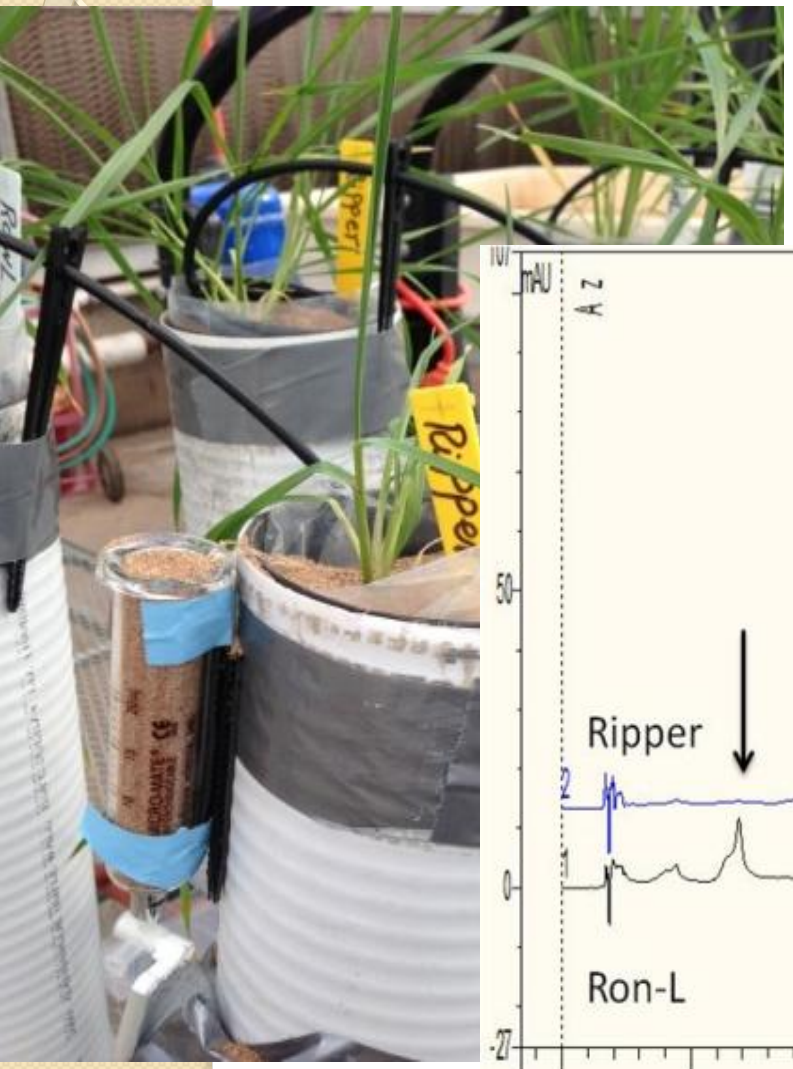
Aboveground biomass (g per pot)

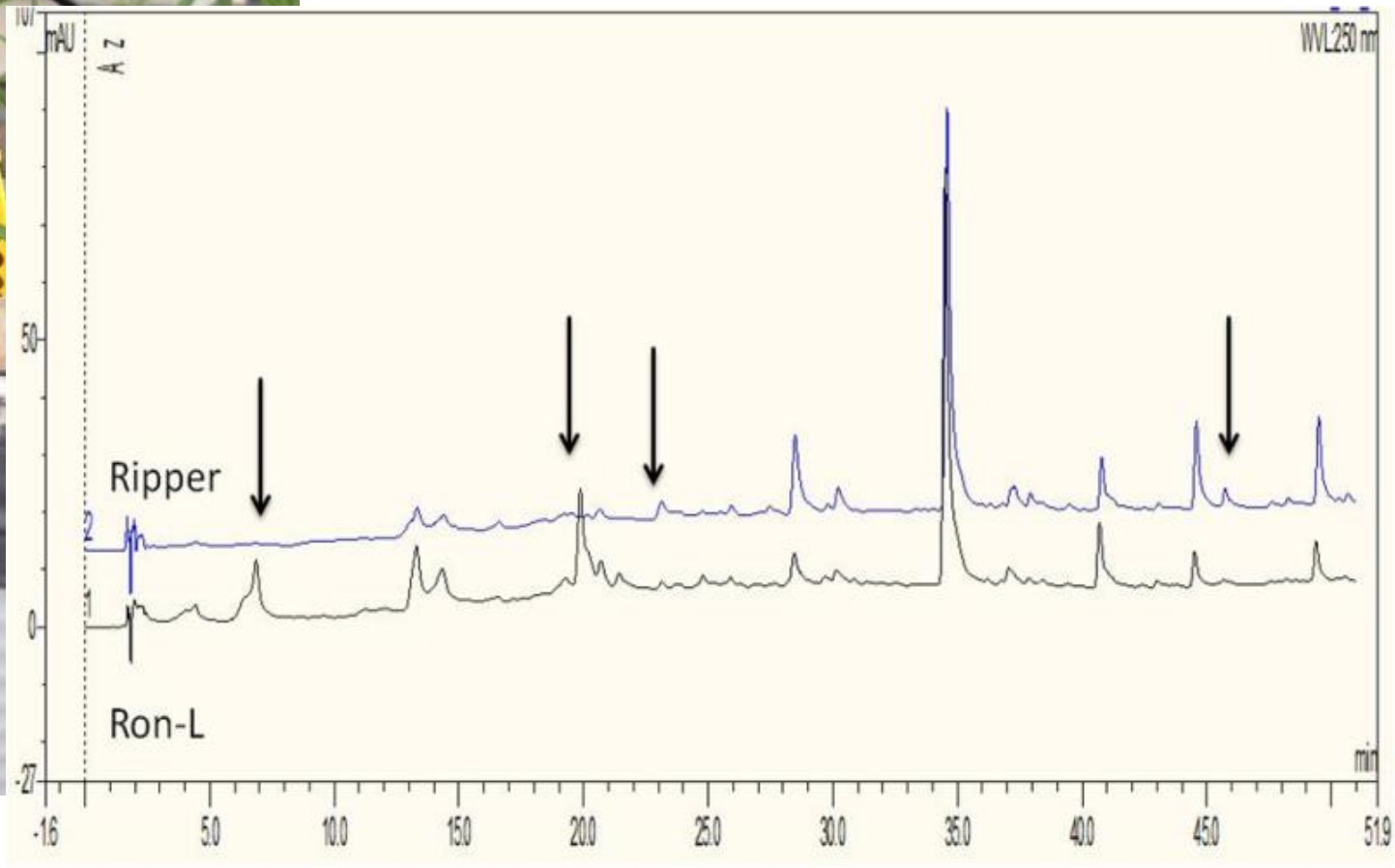
Variety × Water Stress	Inoculum Treatment	
	Control	ACC+
Ripper		
Wet	18.9a	20.4a
Dry	11.3b	7.8b
RonL		
Wet	7.7a	12.0a
Dry	3.8b	6.3a

Major findings

- ACC+ bacteria are abundant in CO soil
- Abundance and species composition varies with different wheat varieties
- Some varieties are more responsive to inoculation than others
  - Greater leaf relative water content
  - Greater productivity
  - Different root exudate chemicals?

Metabolomics of Root Exudates





On-going Research and Goals

- Identify the mechanisms by which different cultivars respond to drought
- Identify root exudate(s) that recruit and enrich ACC+ bacteria
- Identify genetic marker(s) associated with root exudates and ACC+ bacteria
- Breed new drought-tolerant cultivars that combine multiple drought tolerance traits

Acknowledgments

- Scott Reid
- Ibrahem Abduelafez
- Asma Elamari
- Dr. Marc Moragues
- Dr. Pat Byrne
- Dr. Tiffany Weir
- Dr. Dan Manter, USDA-ARS
- CO Ag Experiment Station
- Colorado Wheat Research Foundation