



Understanding the Effects of Elevated CO₂ on Soybean Performance and Seed Nutrient Concentration

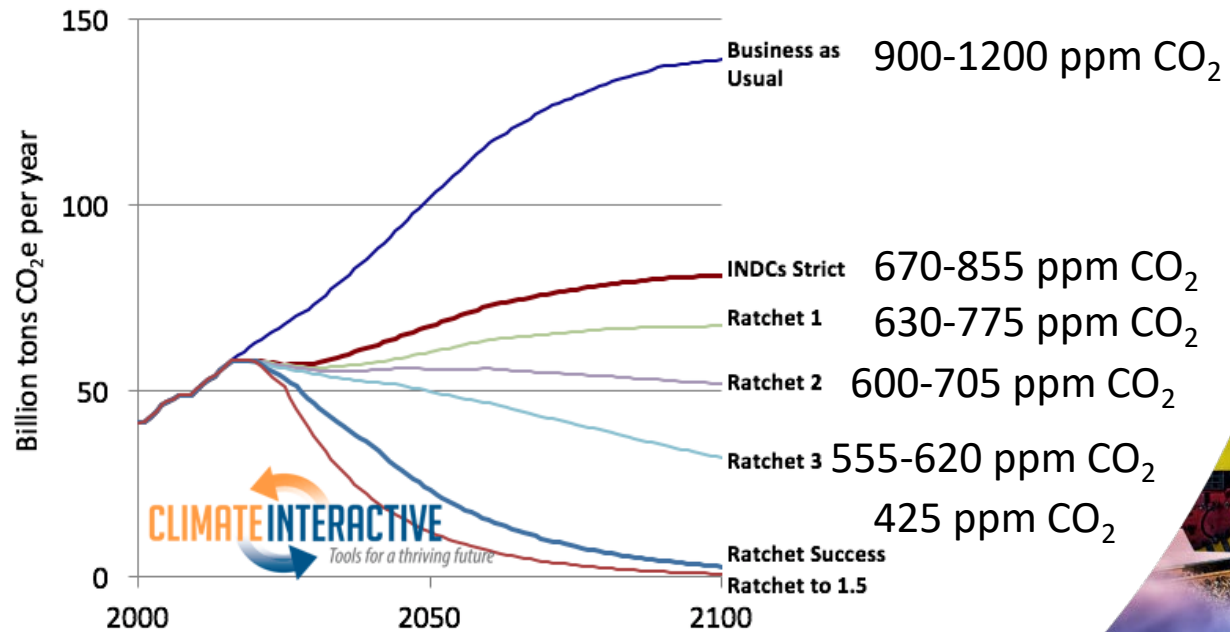
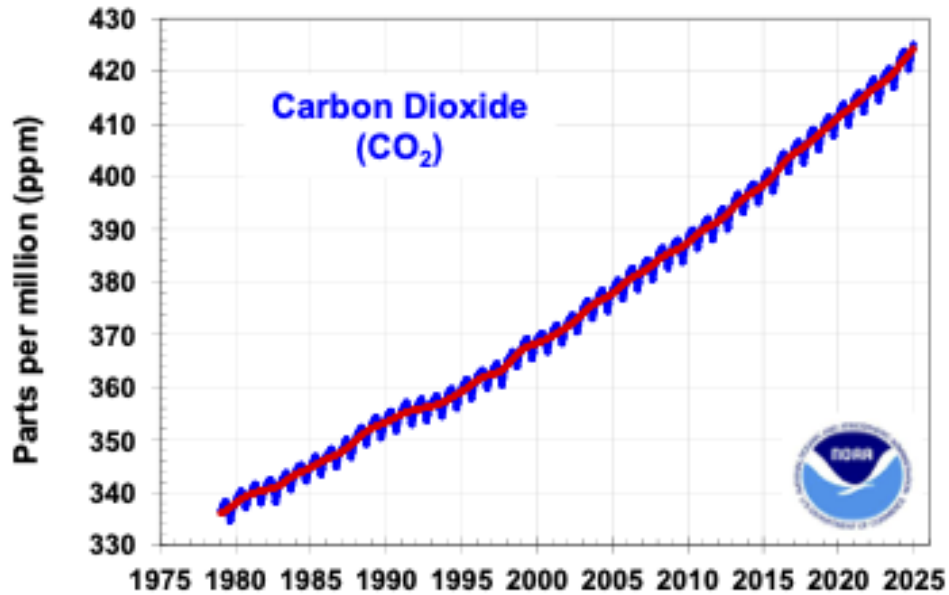
Alvaro Sanz-Saez

Associate Professor, Auburn University

February 17th, 2026



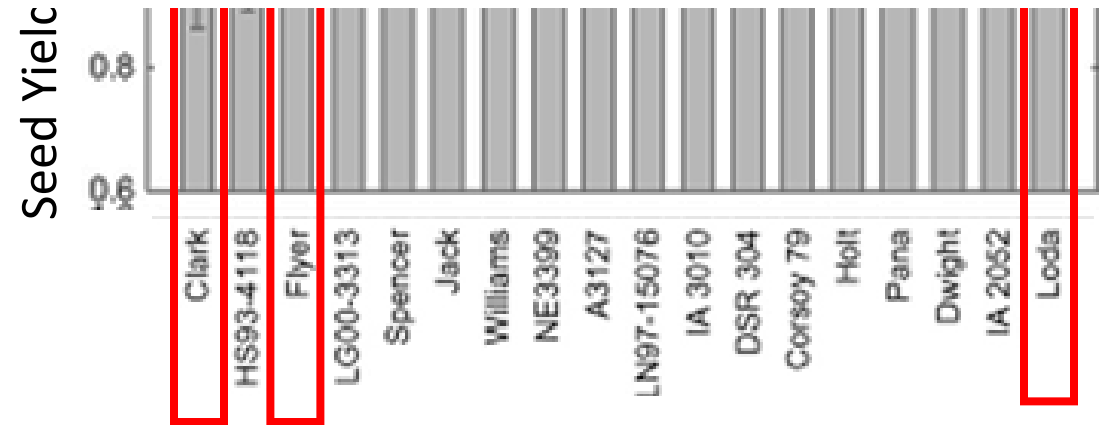
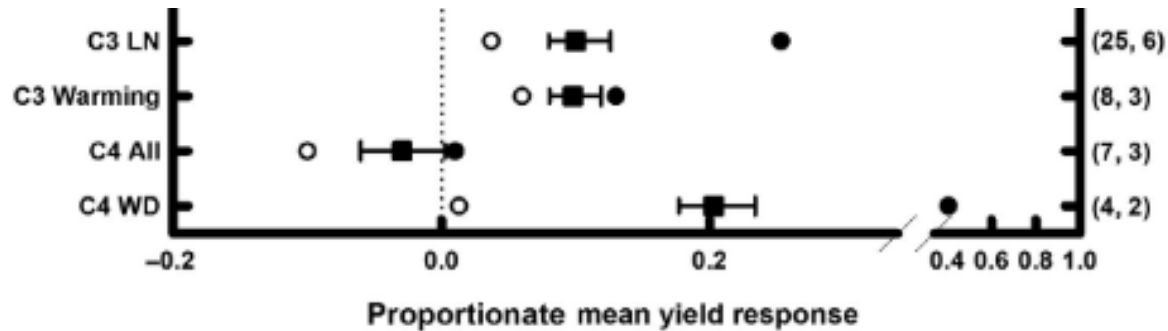
Atmospheric CO₂ Trends



Yield Effects on Major Crops

Yield Effect on Soybean is Cultivar Dependent

What does this have to do with seed mineral nutrient concentration?





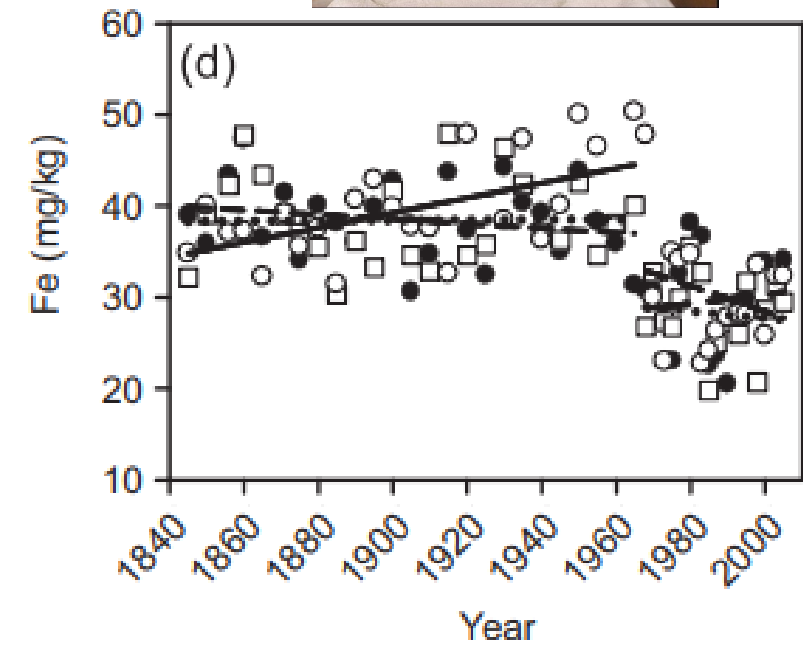
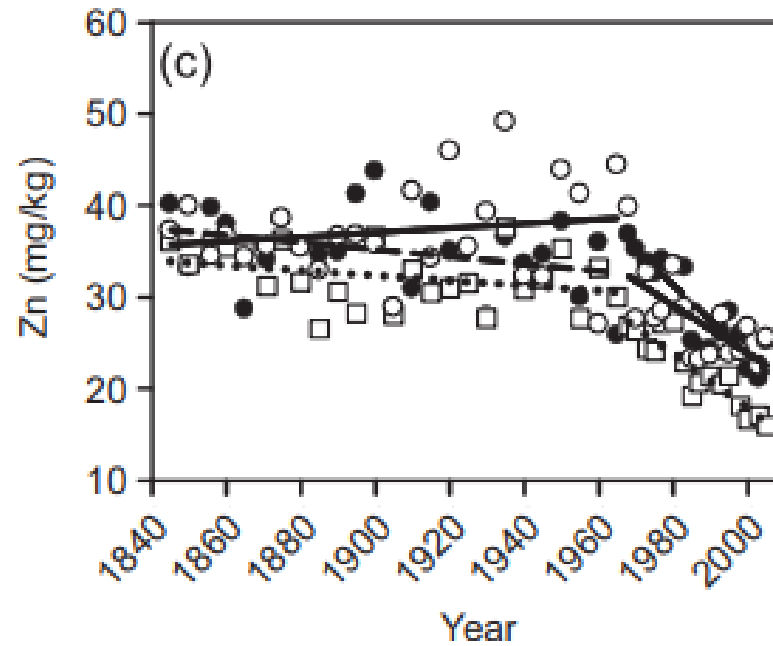
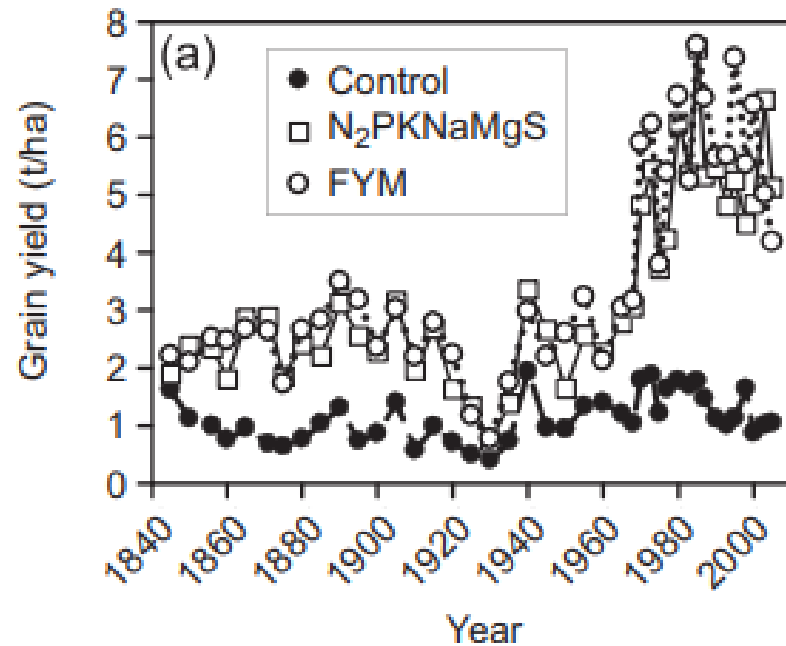
The Breeders Dilemma

The breeder's dilemma—yield or nutrition?

Cindy E Morris & David C Sands

The emphasis of traditional crop production on yield is counter-productive for human nutrition.

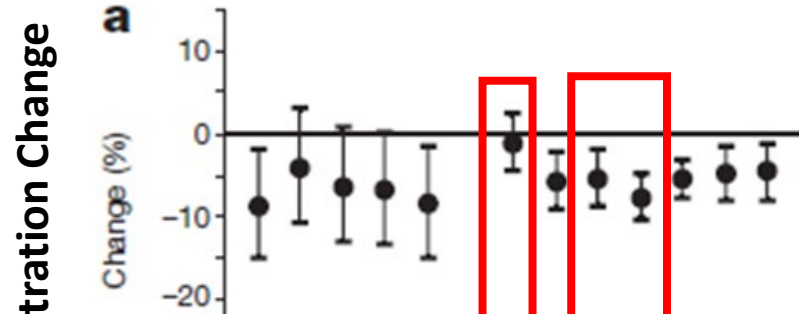
NATURE BIOTECHNOLOGY VOLUME 24 NUMBER 9 SEPTEMBER 2006



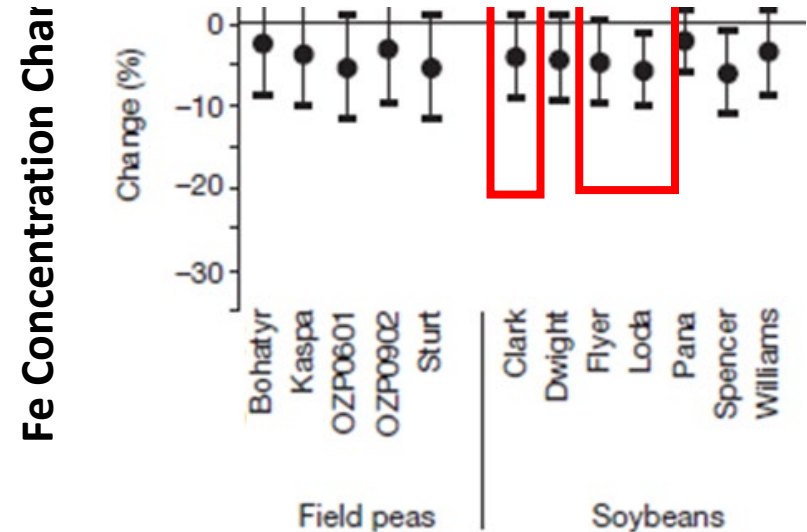
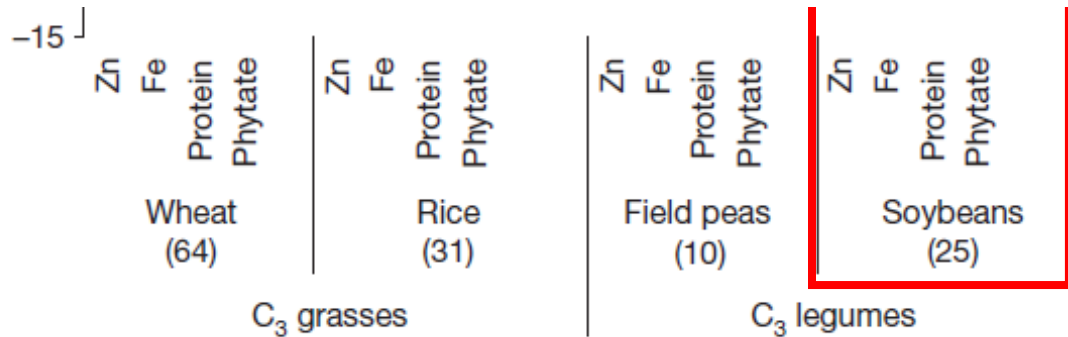


Effect of Elevated CO₂ on Seed Mineral Nutrition

15
10



What are the mechanisms of the observed mineral reduction?



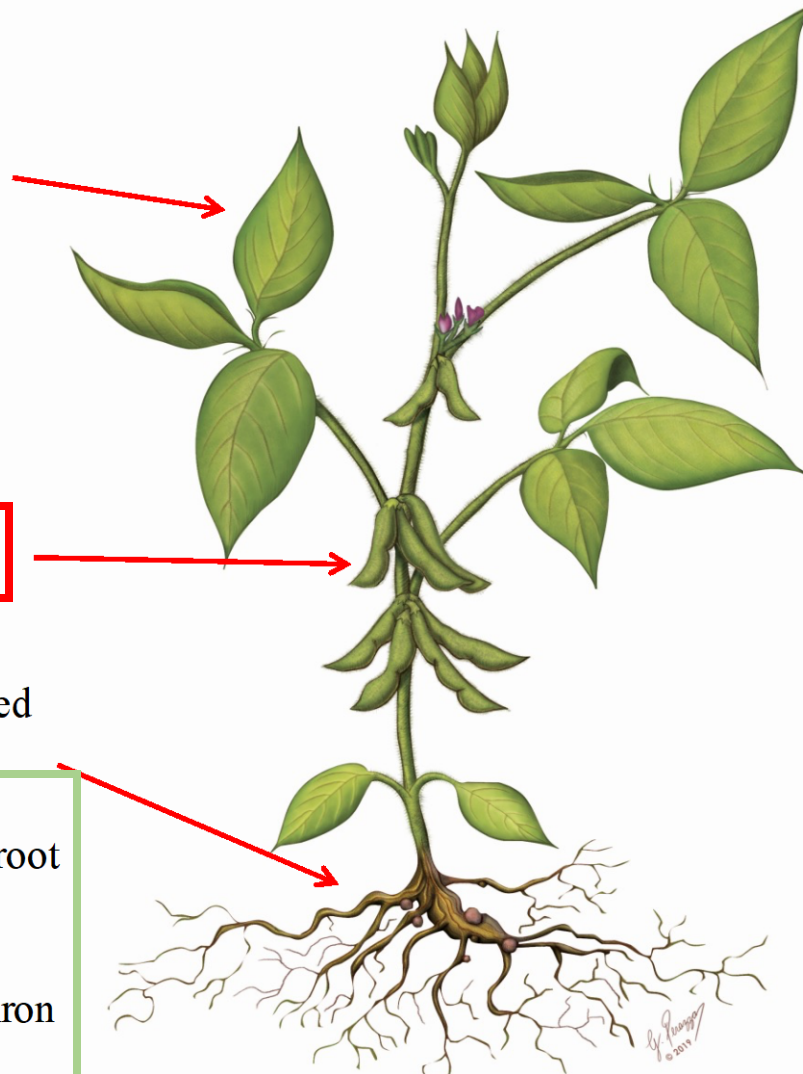


Effect of Elevated CO₂ on Seed Mineral Nutrition

Strategies to understand plant nutrient responses to elevated [CO₂]

Hypotheses

- (1) Lower transpiration
- (2) Down-regulation of photosynthesis
- (3) Altered requirements for minerals due to changes in enzymes/organic complex requirements
- (4) Mineral dilution
- (5) Inhibition of nitrate assimilation by decreased photorespiration
- (6) Reduction in mineral absorption through the root and changes in root architecture
- (7) Alteration of zinc and iron transporters



Dr. Courtney Leisner



Dr. Lisa Ainsworth



Dr. Ivan Baxter





Effect of Elevated CO₂ on Seed Mineral Nutrition



National Soil Dynamics Lab
Auburn, AL



Ravneet Kaur



Mary Durstock



Dr. Steve Prior

CO₂ Treatments

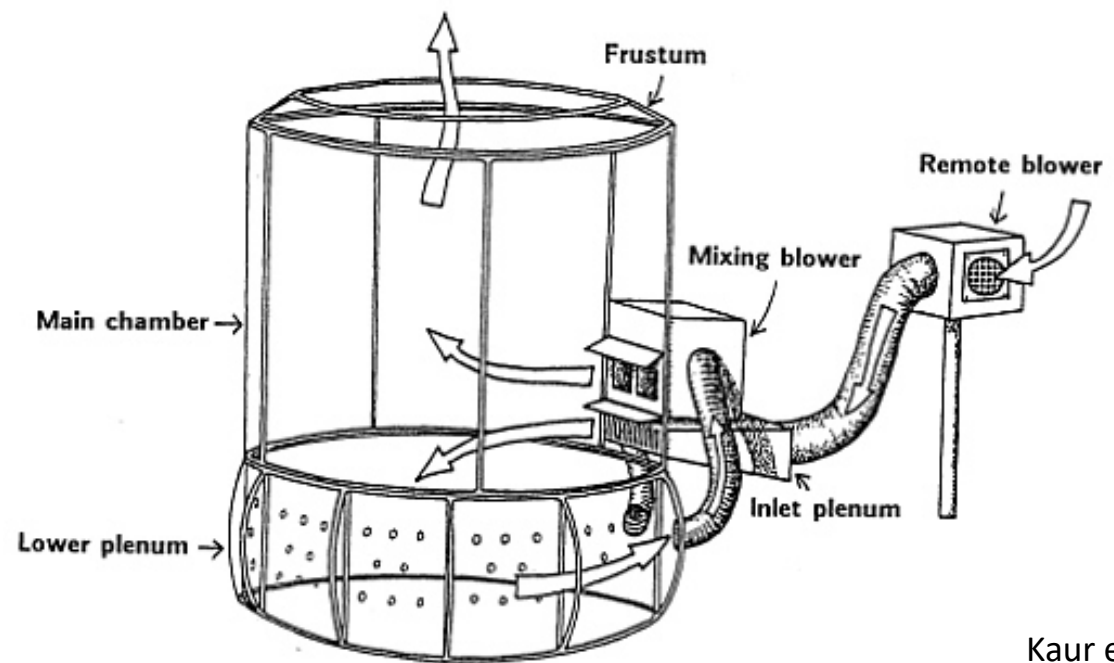
- Ambient CO₂ (410 ppm)
- Elevated CO₂ (610 ppm)

Cultivars

- Clark (=Y, =Zn, =Fe)
- Flyer (=Y, -Zn, =Fe)
- Loda (+Y, -Zn, -Fe)

Measurements

- Photosynthesis
- Biomass and yield
- Mineral Content
- Root Dry Weight

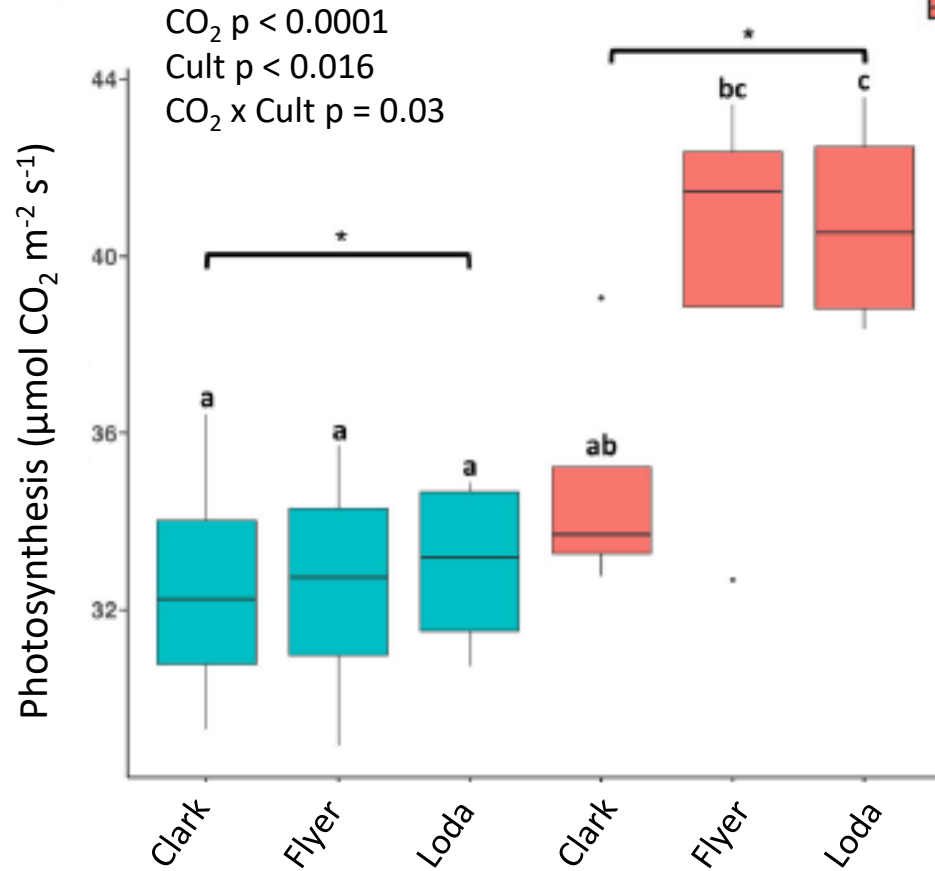




Nutrient Dilution has a Role in Decreased Nutrient Concentration

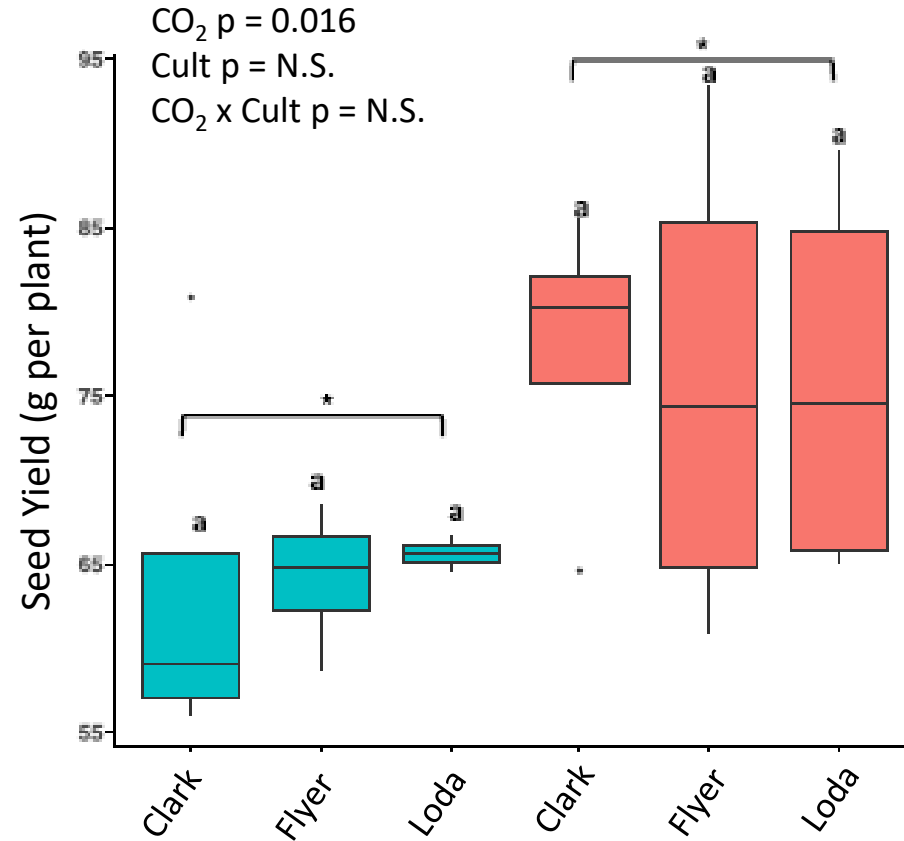
Photosynthesis at Seed Filling

Treatment
■ Ambient
■ Elevated



Seed Yield at maturity

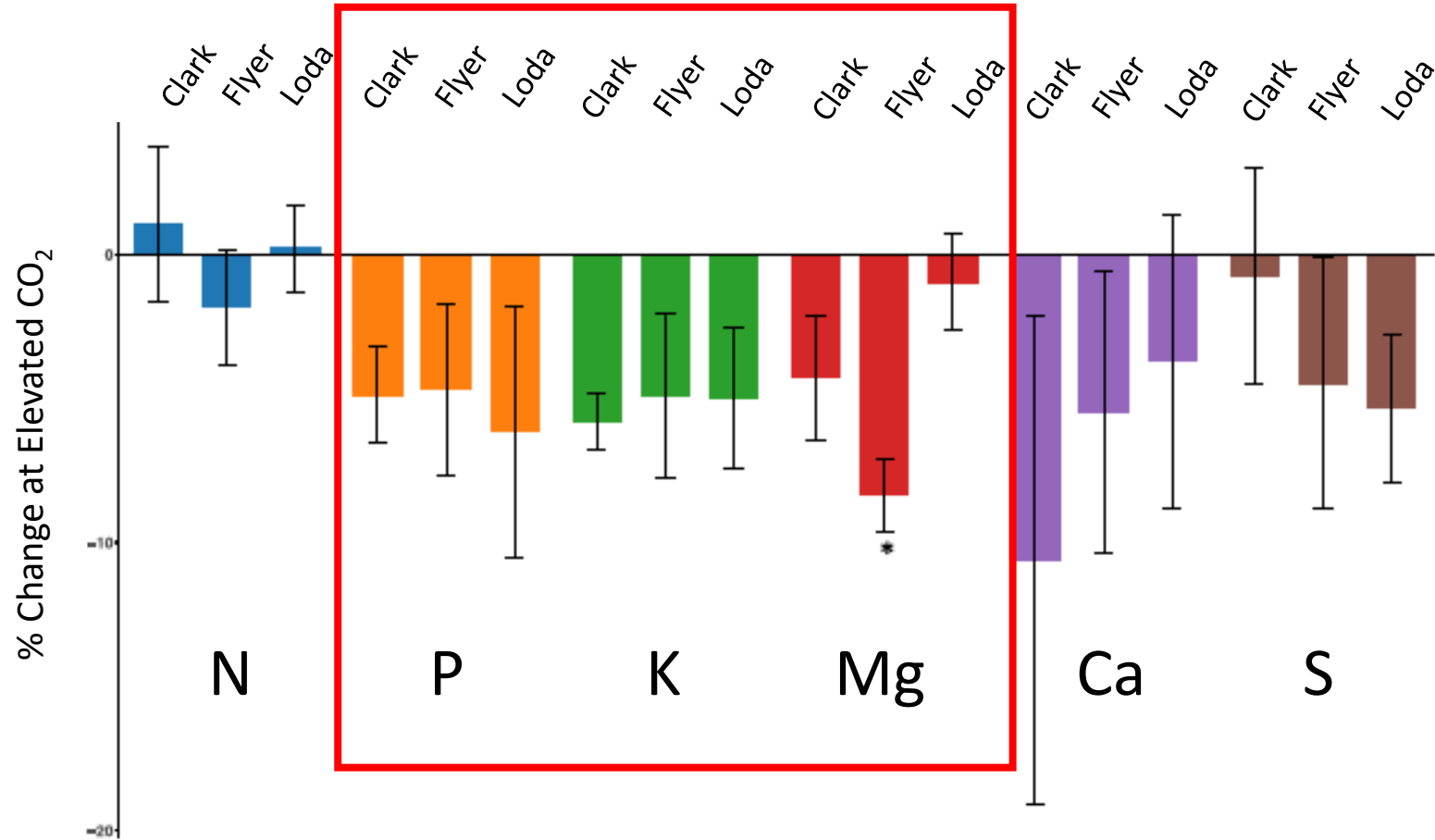
Treatment
■ Ambient
■ Elevated





Nutrient Dilution has a Role in Decreased Nutrient Concentration

% Change in Seed Nutrient Concentration

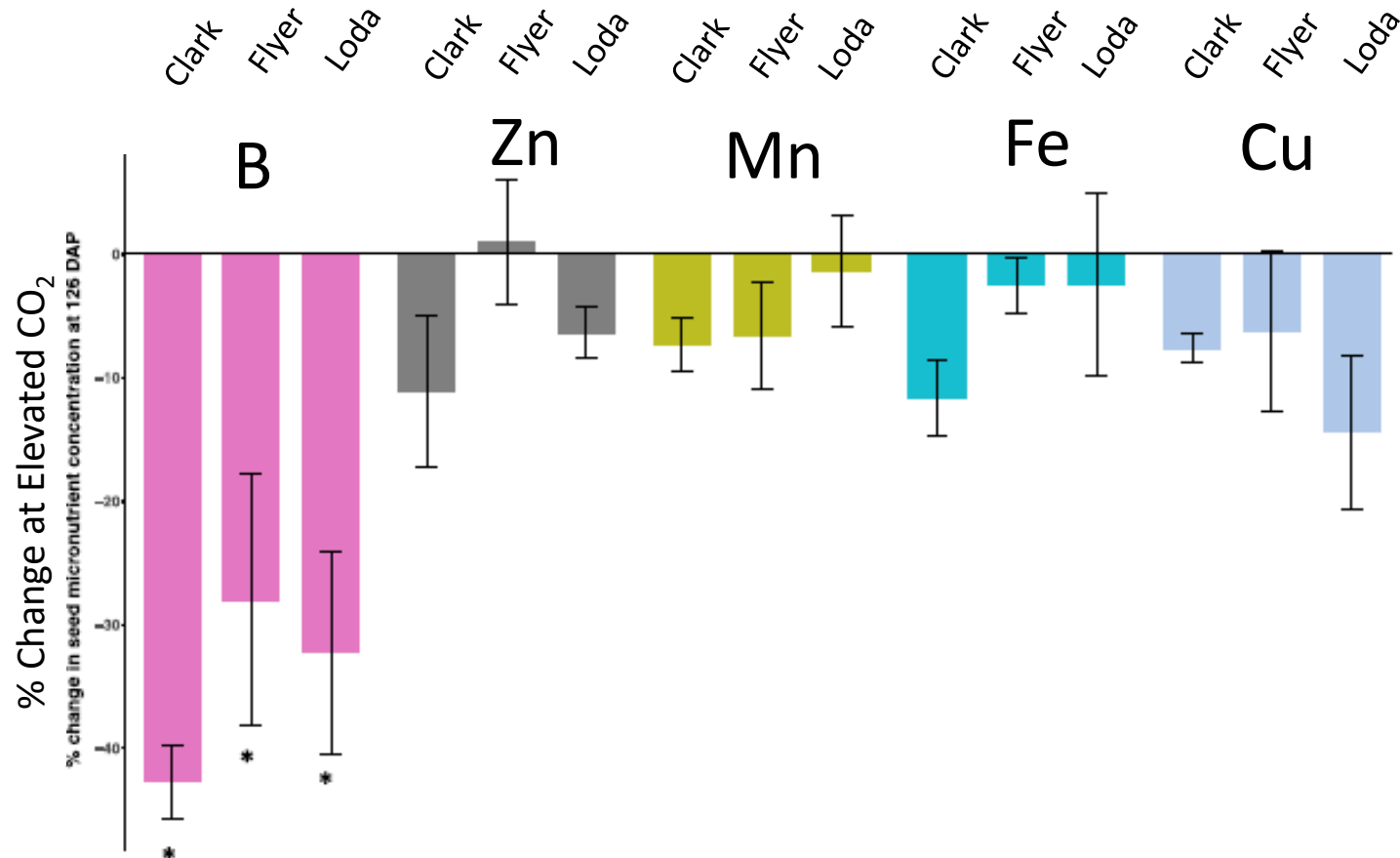


<i>p</i> value	N	P	K	Mg	Ca	S
CO ₂	0.922	0.044	0.0232	<0.001	0.134	0.178
Cultivar	0.015	0.006	<0.0001	<0.0001	<0.0001	<0.0001
CO ₂ x Cultivar	0.453	0.876	0.828	0.022	0.311	0.354



Nutrient Dilution has a Role in Decreased Nutrient Concentration

% Change in Seed Nutrient Concentration

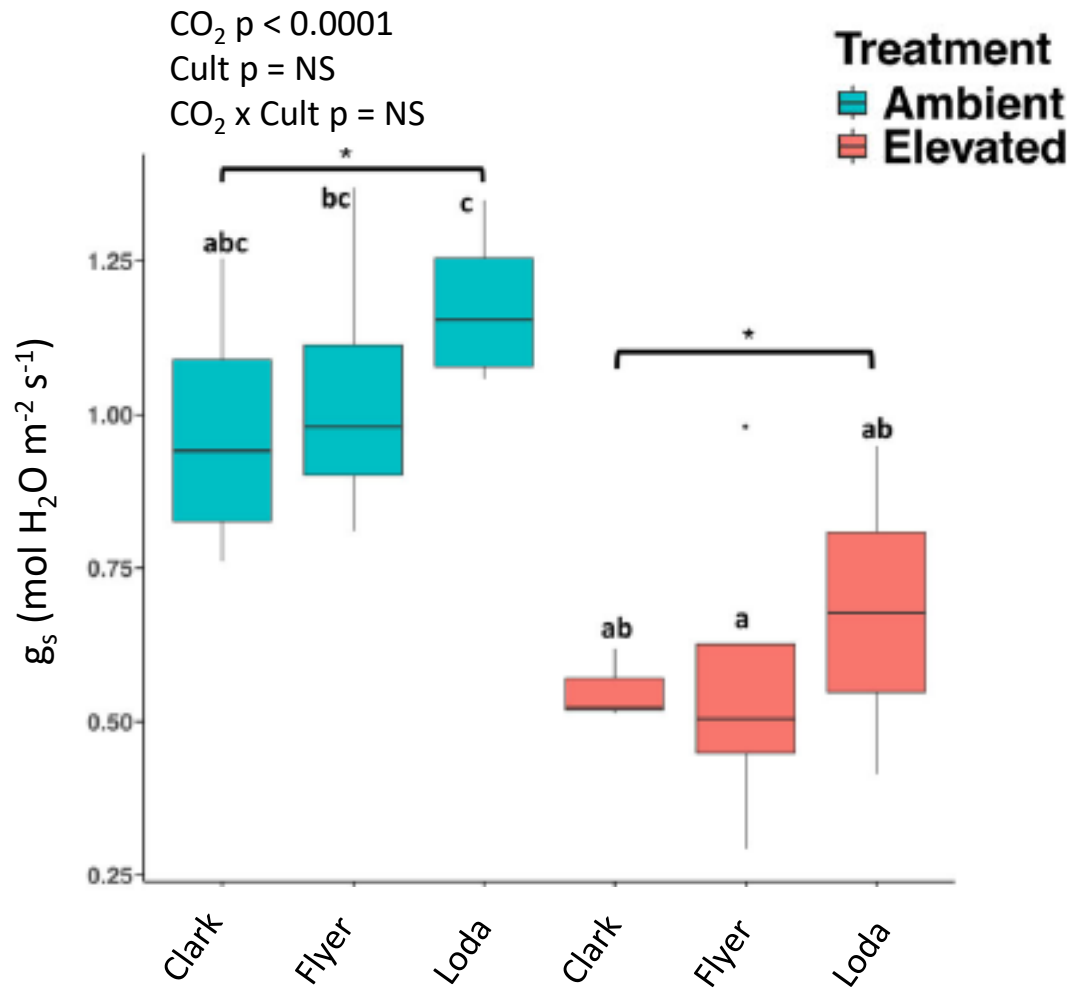


<i>p</i> value	B	Zn	Mn	Fe	Cu
CO ₂	<0.0001	0.086	0.041	0.083	0.012
Cultivar	<0.0001	<0.0001	0.052	0.001	0.006
CO ₂ x Cultivar	0.022	0.243	0.505	0.085	0.436

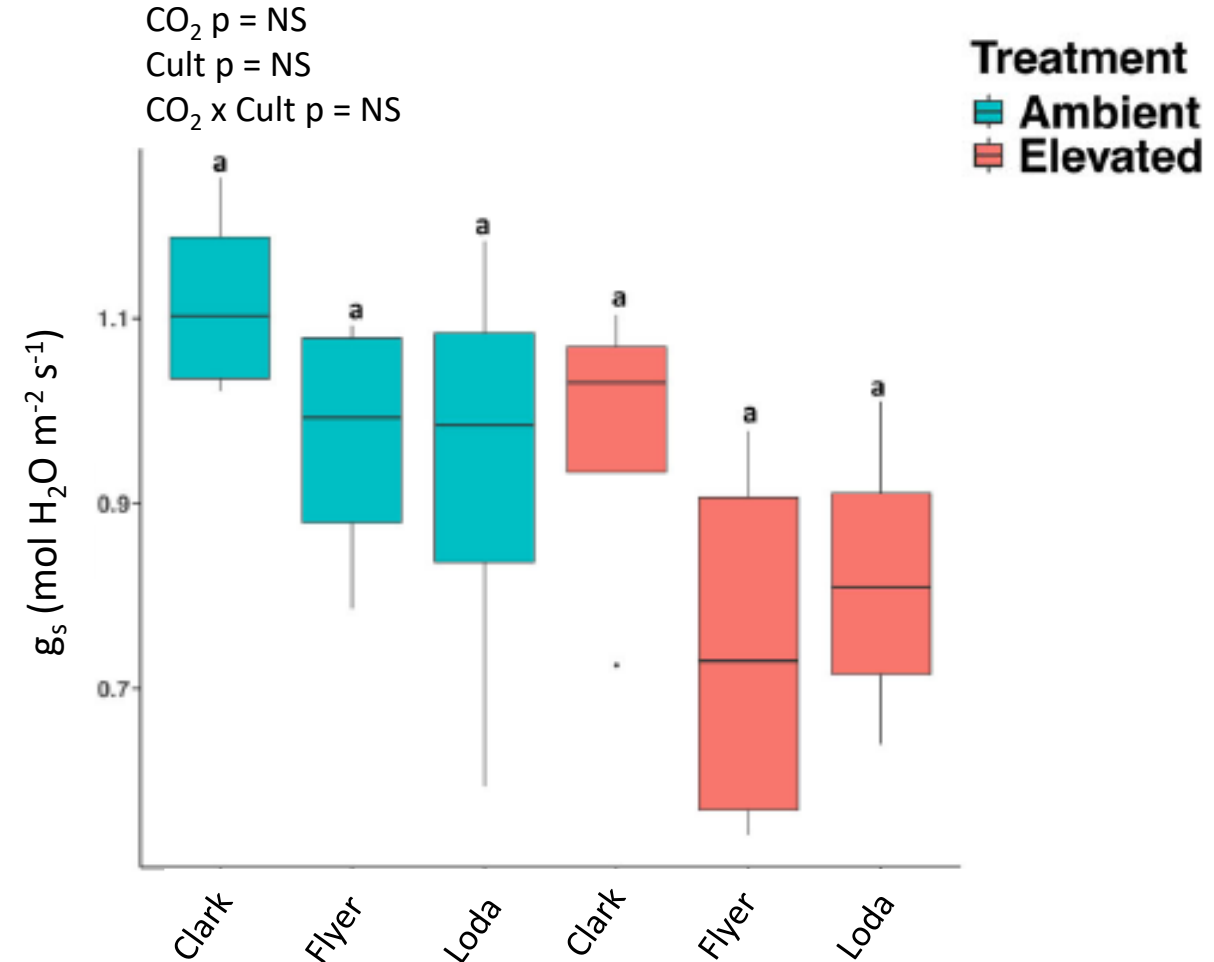


Limited Influence of Transpiration on Nutrient Concentration

Stomatal Conductance Vegetative Stage

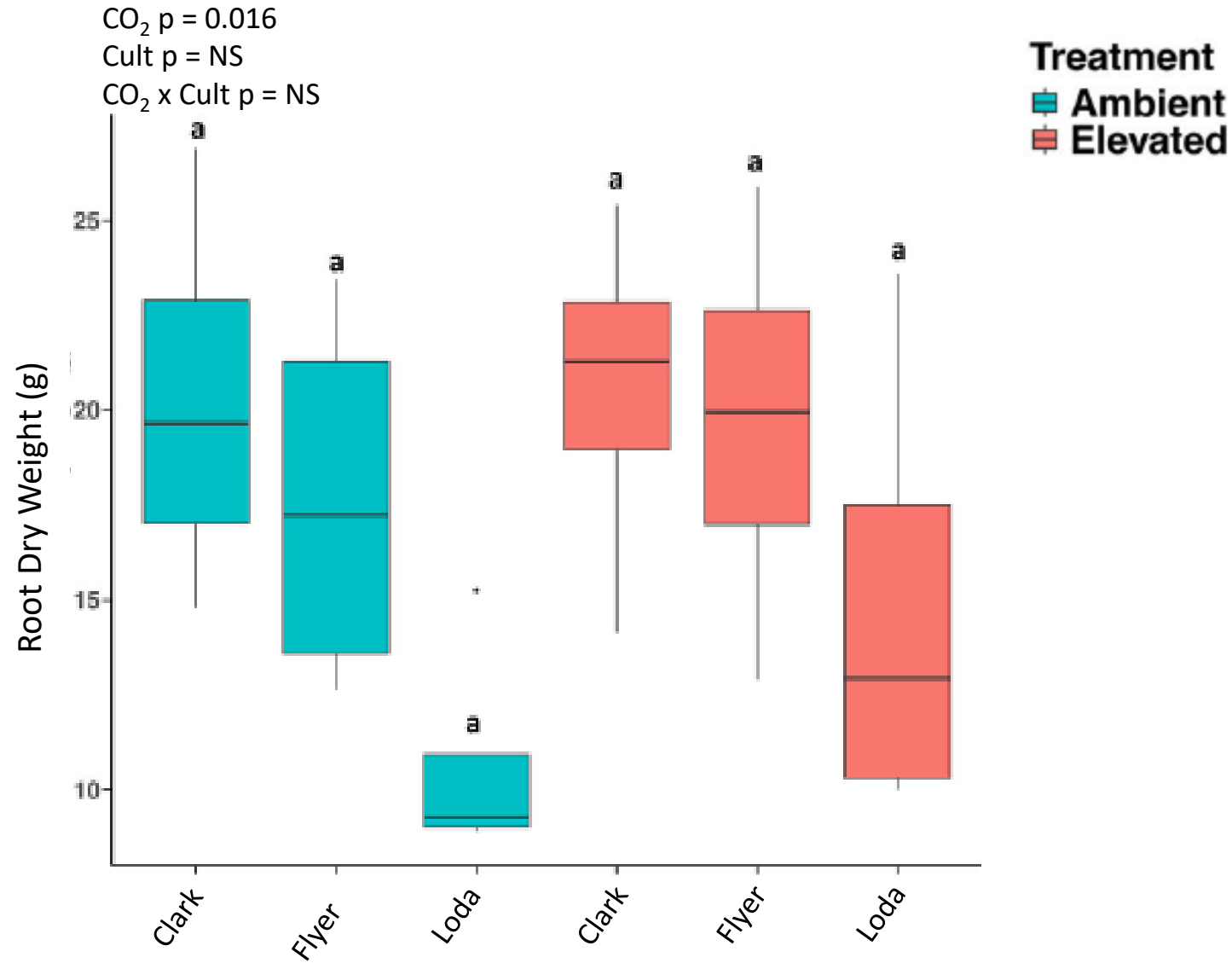


Stomatal Conductance Reproductive Stage



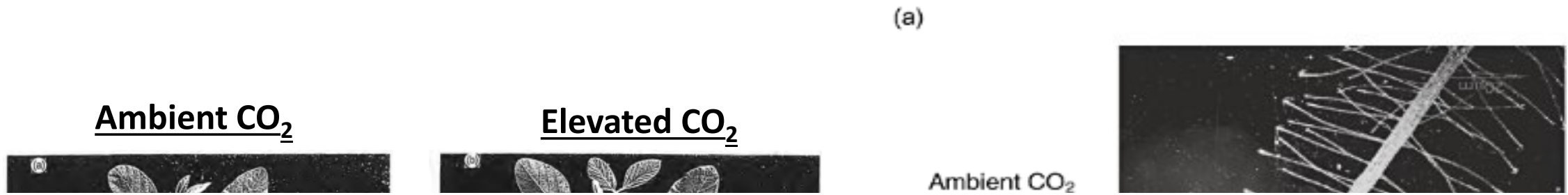


Limited Root Biomass Response May Limit Nutrient Uptake





Literature Points that Elevated CO₂ Enhance Root Growth



There is no report of cultivar variation in root traits under elevated CO₂

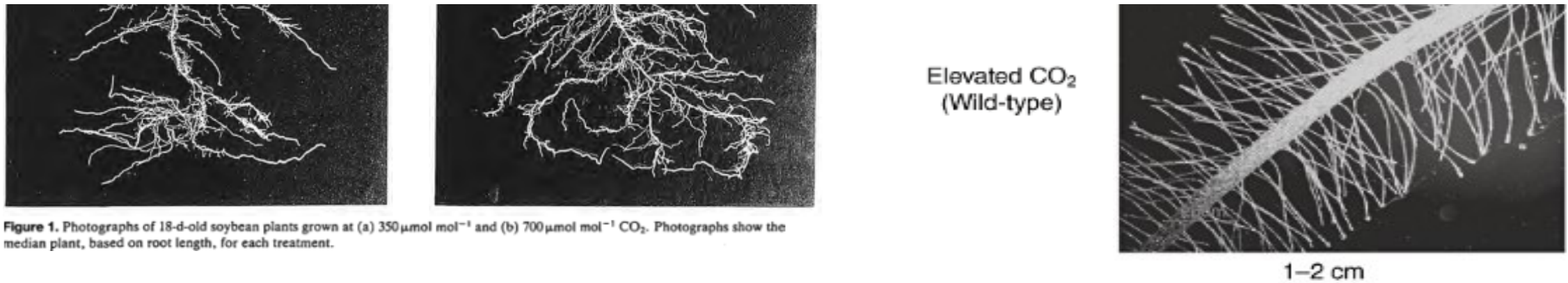


Figure 1. Photographs of 18-d-old soybean plants grown at (a) 350 $\mu\text{mol mol}^{-1}$ and (b) 700 $\mu\text{mol mol}^{-1}$ CO₂. Photographs show the median plant, based on root length, for each treatment.



Studying Root Cultivar Variation to Elevated CO₂

- **Conditions:** Growth Chamber
- **Soybean cultivars:** PI398223, HS93-4118, Loda, Clark and Spencer.
- **CO₂ Treatments:**
 - 420 ppm (ambient)
 - 620 ppm (elevated)
 - 820 ppm (elevated)



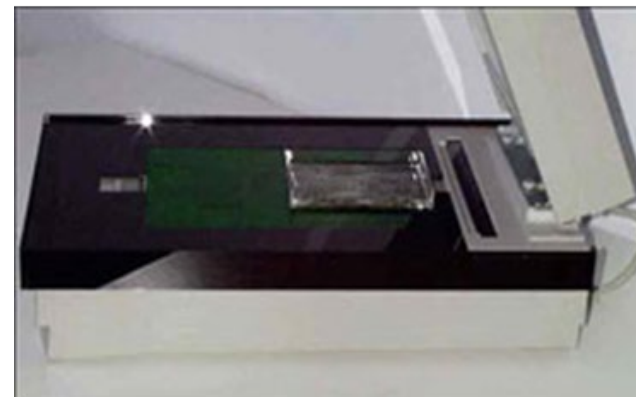
Sharmin Sultana
Auburn University
szs0438@auburn.edu



➤ Root Analysis Techniques

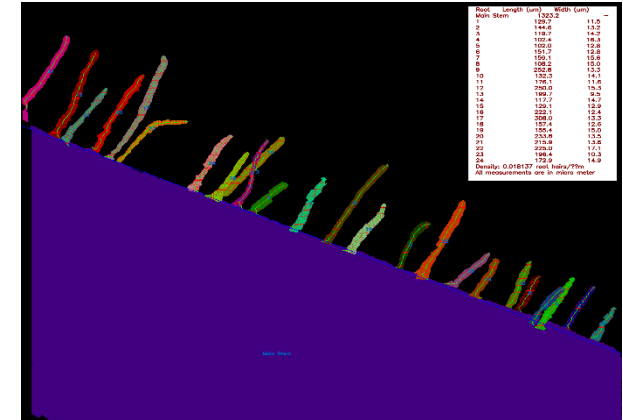
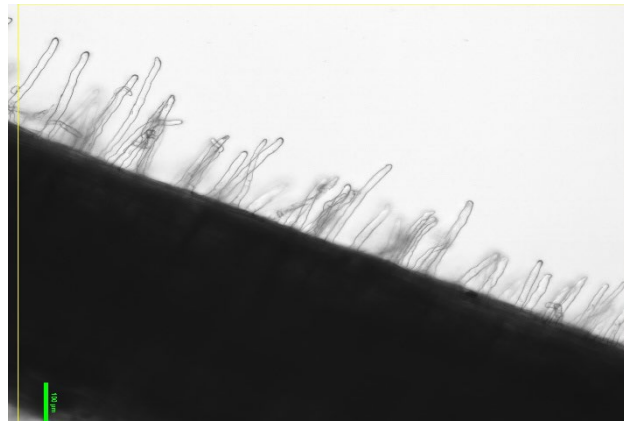
Root Scanning:

Employed flatbed scanner (Winrhizo, SEIKO EPSON CORP.) for root imaging.





Studying Root Cultivar Variation to Elevated CO₂



Microscopic images
Nikon Eclipse Ti2

Annotation of root hair parameters
CVAT for root hair annotation and AI model creation

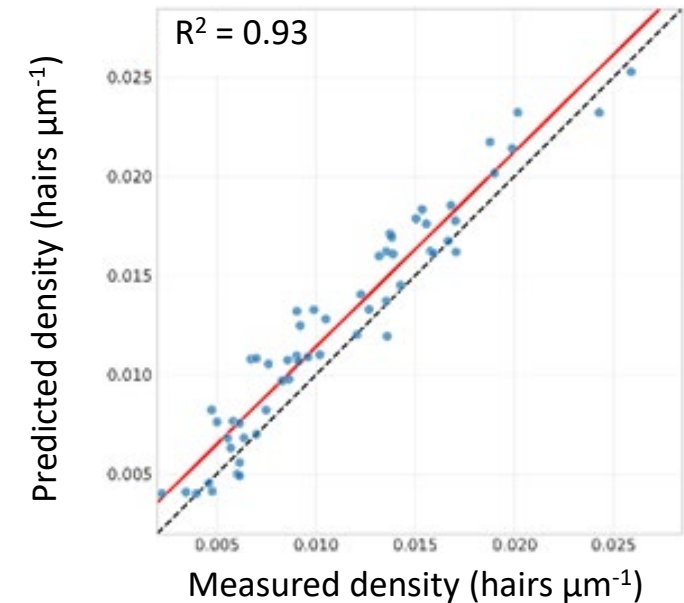
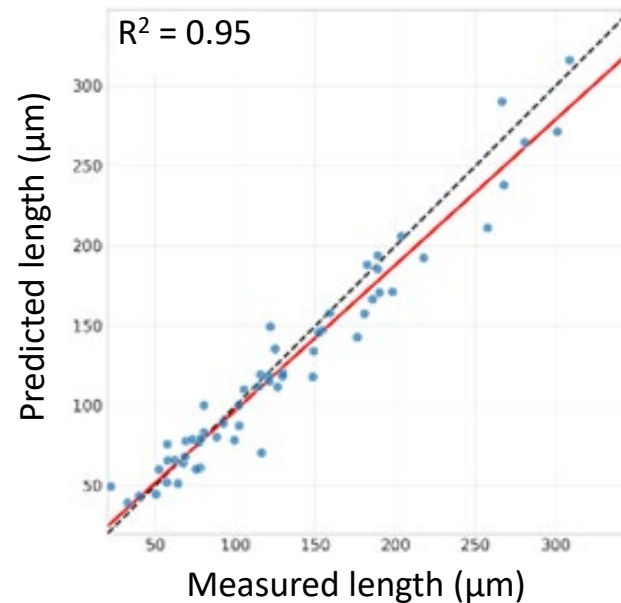
Root Hair Length



Dr. Tanzeel Rehman

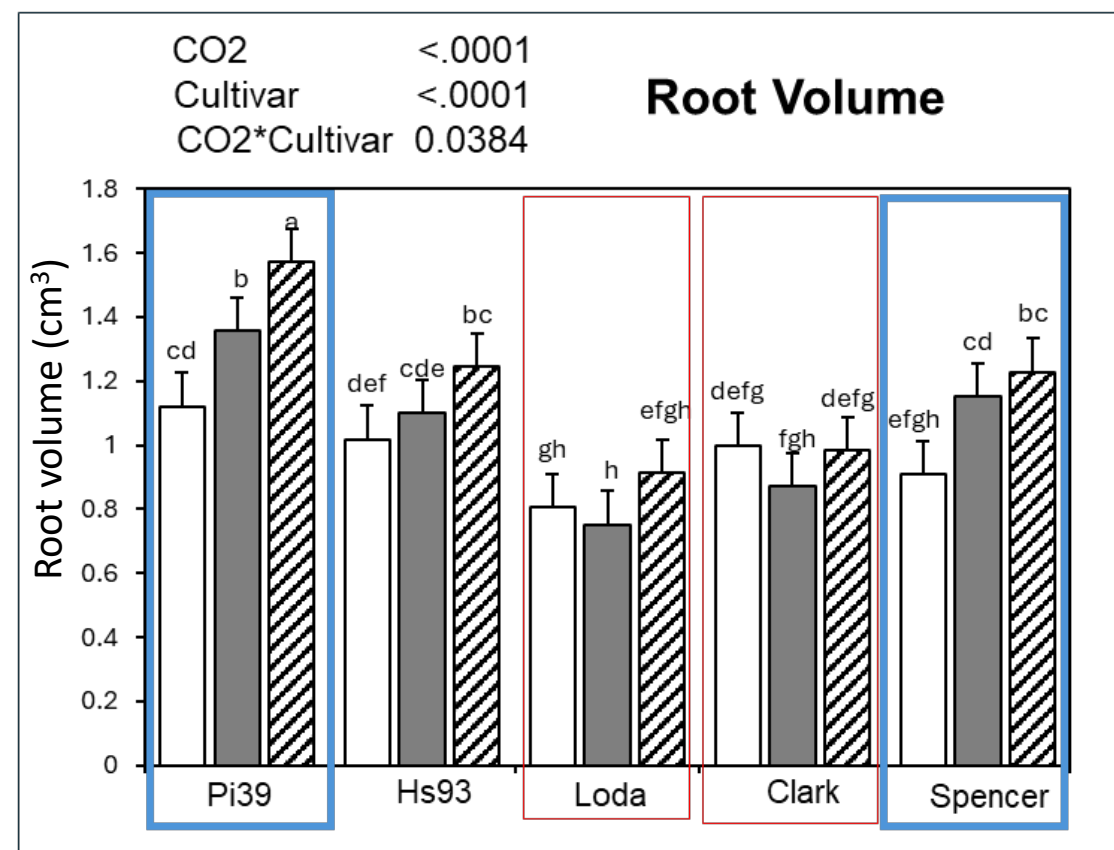
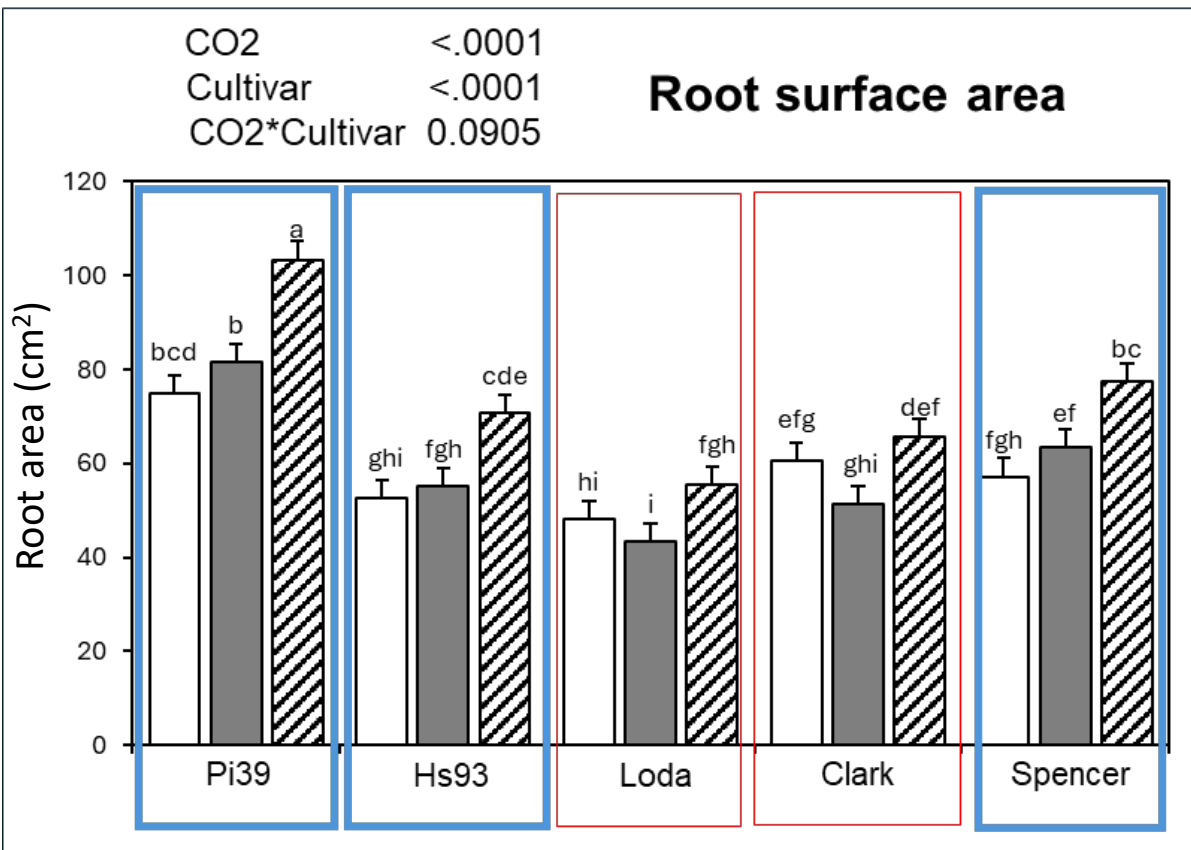
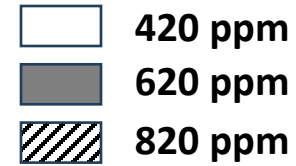


Muhammad Waseem



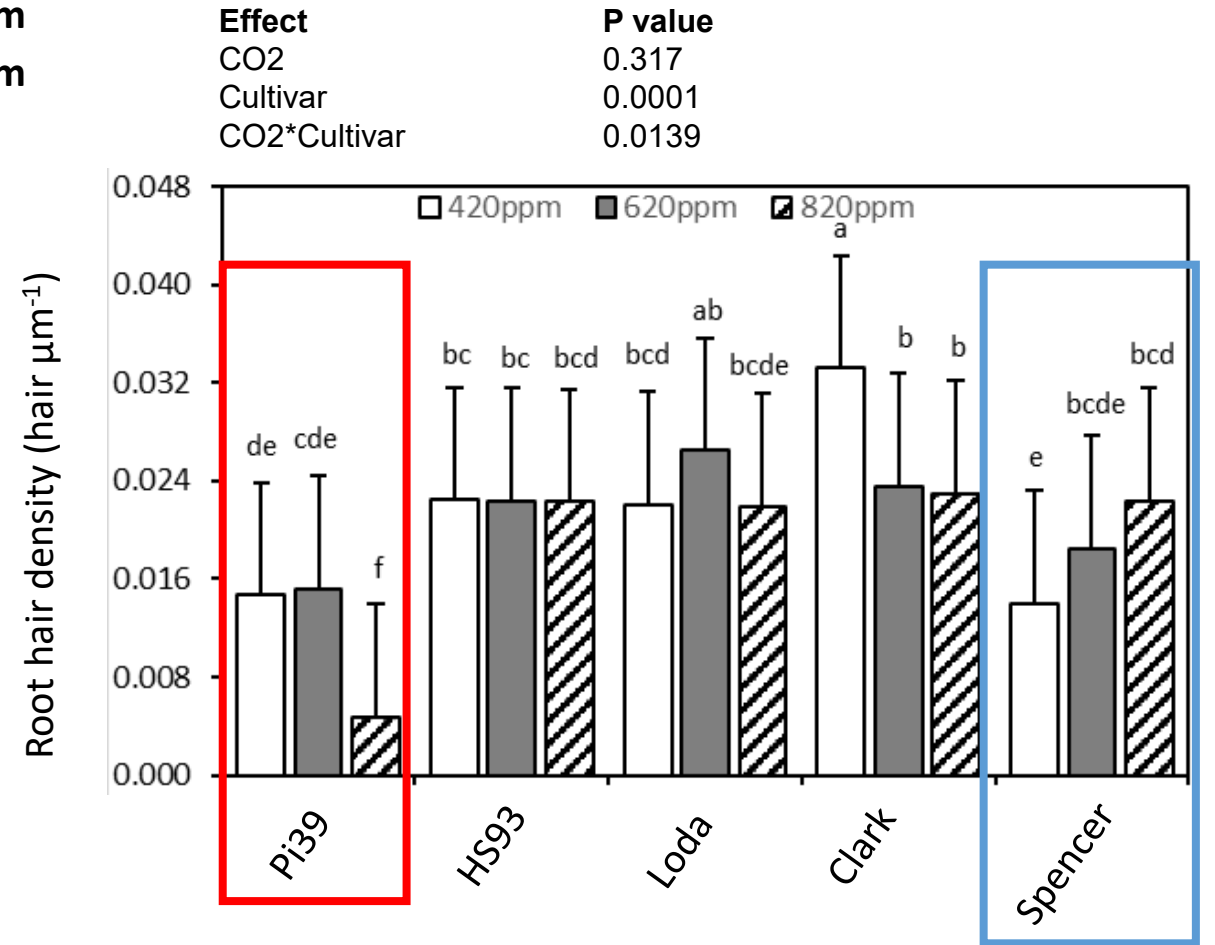
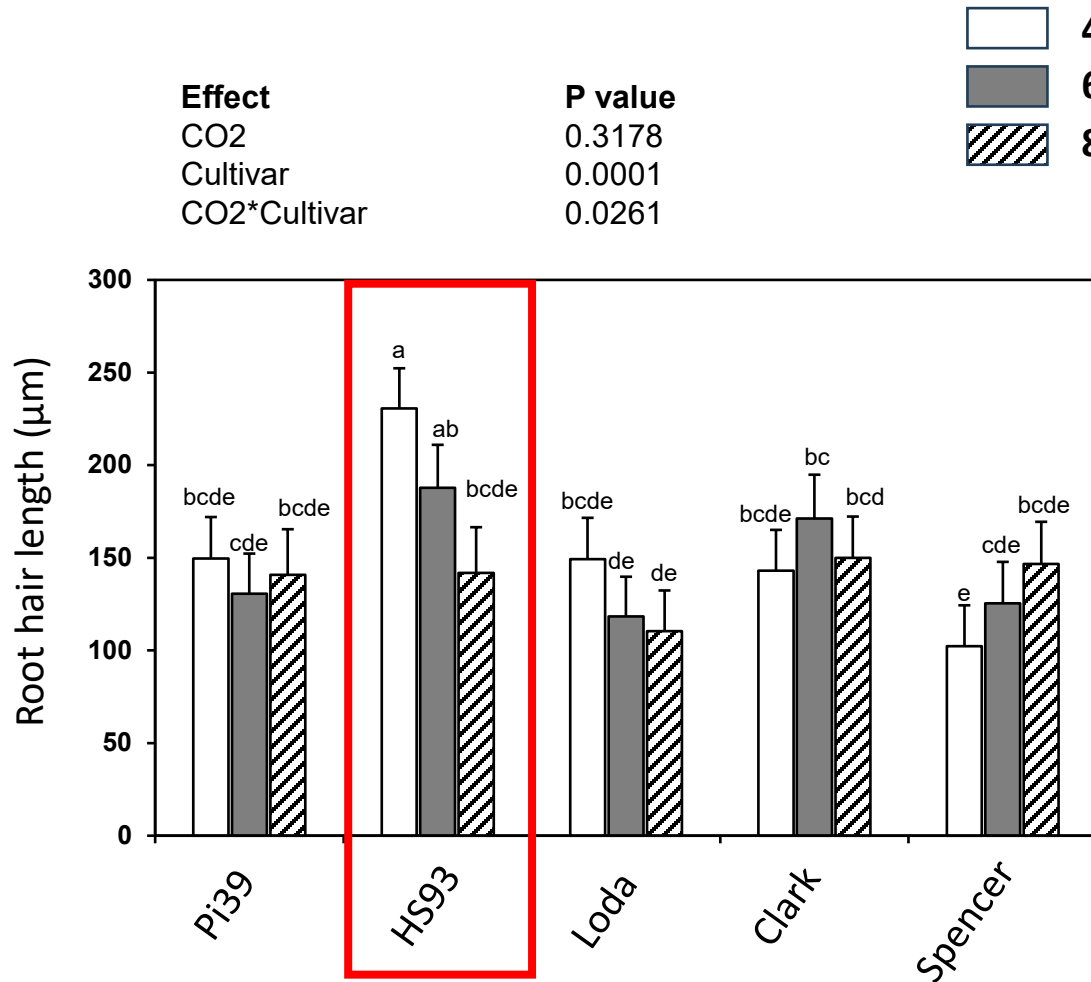


There is cultivar variation in root architectural traits





There is cultivar variation in root hair traits





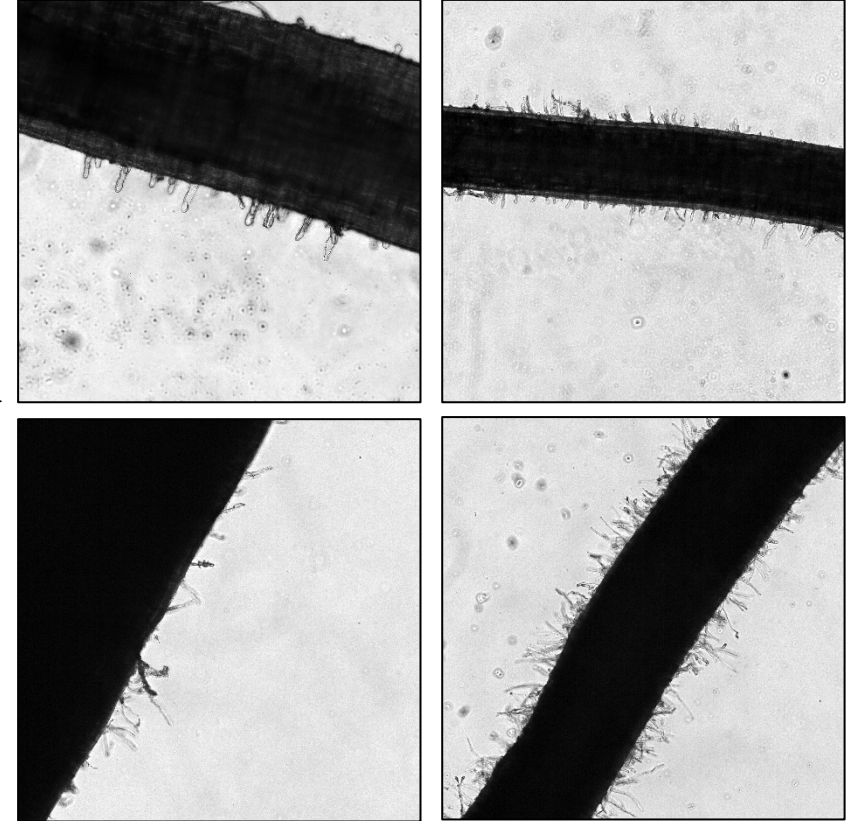
Measuring root hairs in real soil



Growth Chamber Experiment



Rhizobox Trial Setup



Root Hairs Visualized in soil



Acknowledgements



Dr. Courtney Leisner



Ravneet Kaur



Dr. Lisa Ainsworth



Mary Durstock



Dr. Ivan Baxter



Muhammad Waseem



Dr. Tanzeel Rehman



Sharmin Sultana



Dr. Steve Prior



United States Department of Agriculture
National Institute of Food and Agriculture

CONTACT: Alvaro Sanz sanz@auburn.edu