InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

X-ray vision: Novel use of CT scanner to view in situ saline response in plant roots

Presenting Author: Sara Venskaitis

Co-Authors: Sarah Thacker & Bonnie Drozdowski

Outline

Introduction

CT Scanners, Roots, and Study Aims

Methodology

Setup, Growth, and Scanning

Results

Traditional Methods vs. CT Scanner

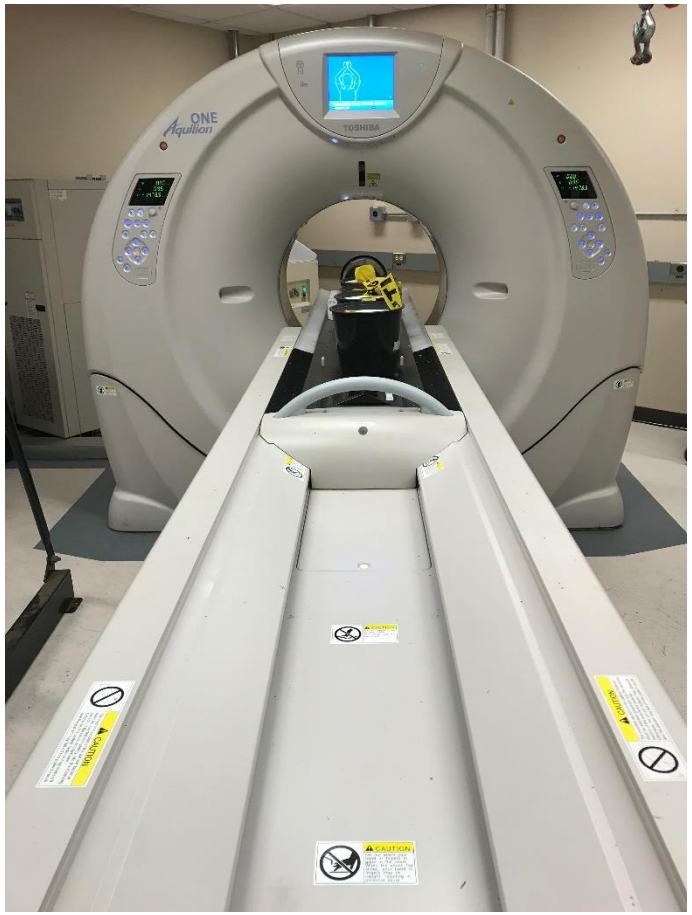
Evaluation and Applications

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

CT Scanners

- Formerly CAT Scanners
- Many X-rays in rapid succession and in 3D
- Extensive medical applications
  - *Bone and organ tissue are easily distinguishable on scans*

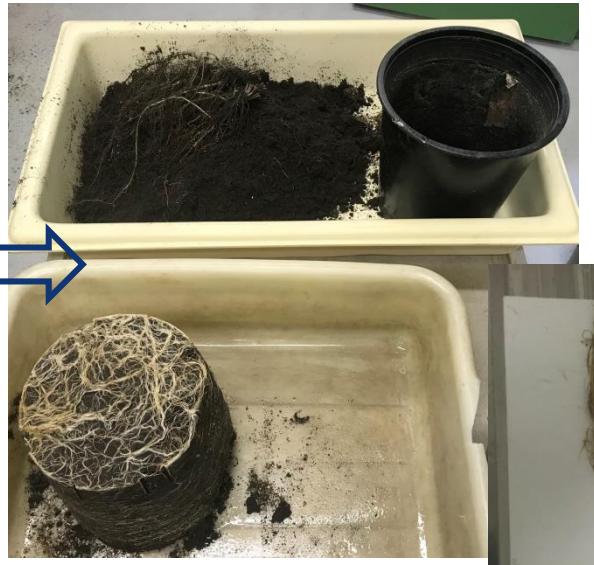
→What about plant roots vs. soil?

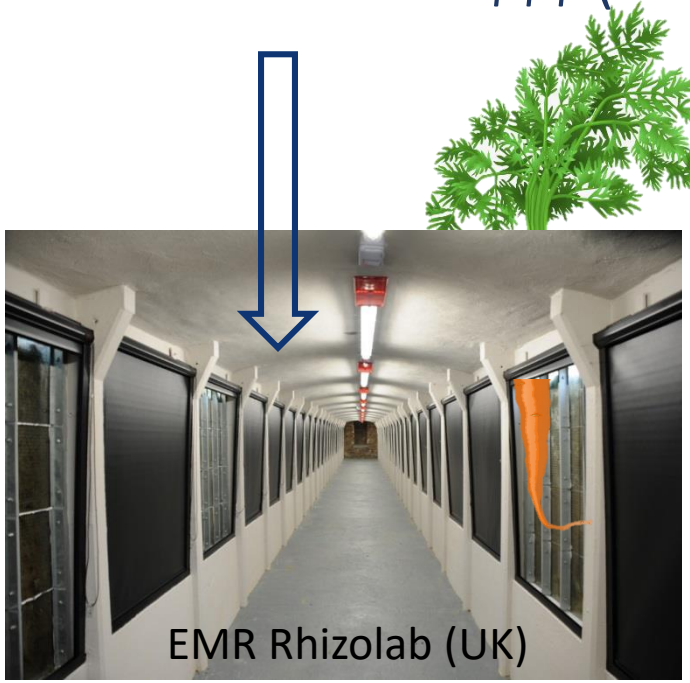


InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

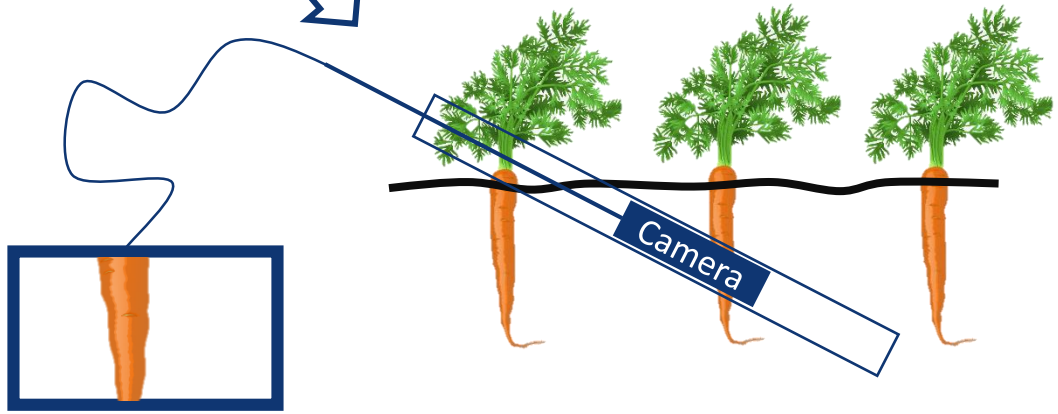
Studying Roots

- Traditional Methods:
  - Dig up the plants (root washing)
  - Mad science and $$$ (rhizotron)





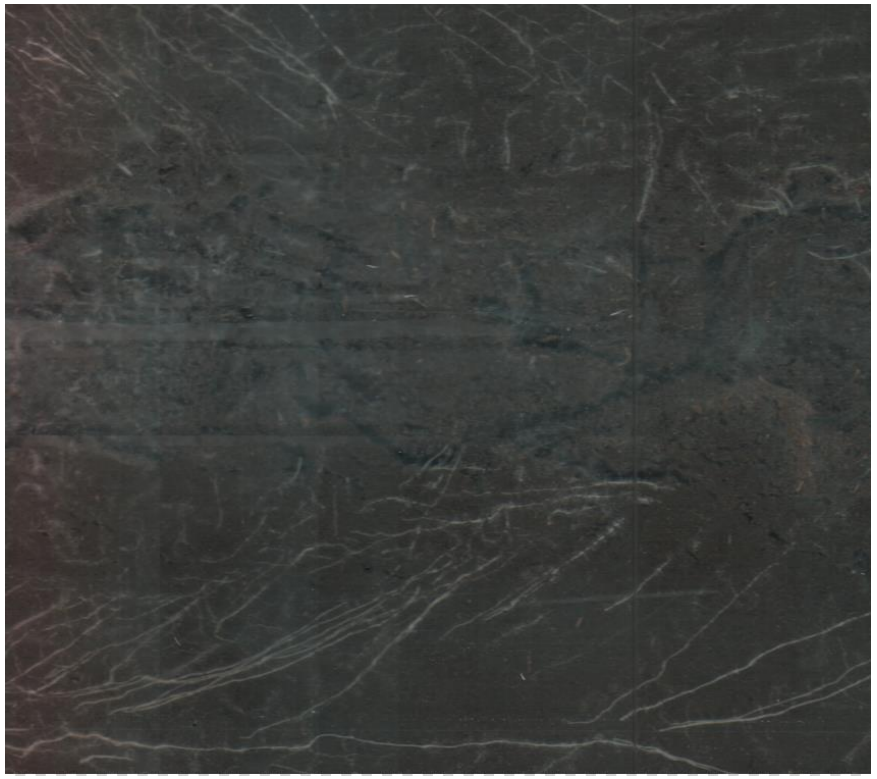
Minirhizotron



InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Studying Roots

- Issues with Traditional Methods:
  - No root architecture (root washing)
  - 2D snapshot of part of the roots (rhizotron)



InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Soil Contaminants

- As a byproduct of industry
  - Oil and Gas
  - Agriculture
- Mechanisms
  - Interfere with natural pathways
- Surrogate contaminant
  - Well-studied effects
  - NaCl

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Choice of Study Species

- Require a species that is sensitive to contaminants, root depth spans typical agricultural soil depth, and an important Albertan crop species
- Alfalfa (*Medicago sativa*)
  - Deep rooting (3.7m max)
  - Salt sensitive
  - One of Alberta's top 9 most prevalent crops

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

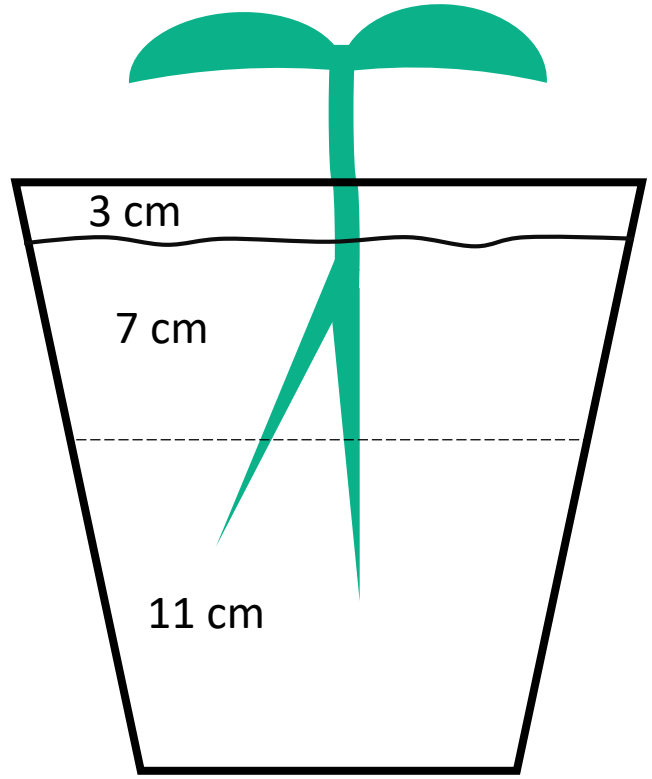
Smith, B., Christenson, Drozdowski, B., & Thacker, S. 2018. *Agronomic receptor evaluation for direct soil contact*. Prepared by Millenium EMS Solutions Ltd. and InnoTech Alberta Inc. for Petroleum Technology Alliance.

Aims of the Study

1. Establish **measurable differences in growth** outcomes from traditional methods
2. Confirm data from **CT Scan accurately reflects data** from traditional methods
3. Determine if there are **morphological/architectural differences in roots** in response to saline conditions, as viewed with the CT scanner

Experimental Setup

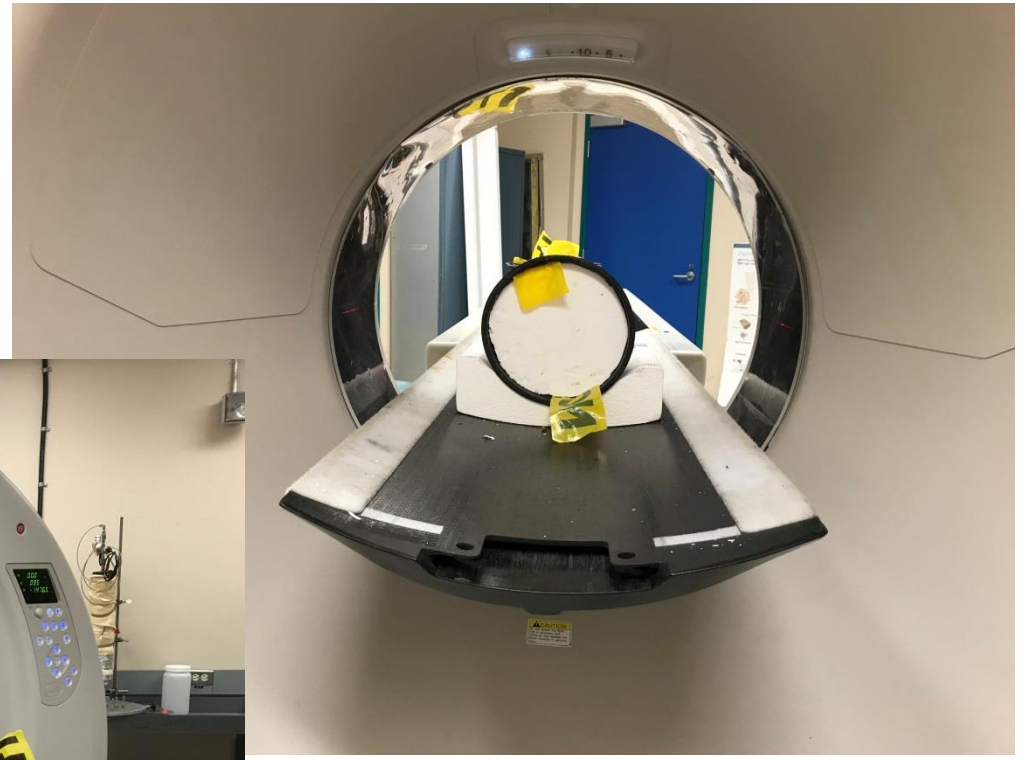
- Soil: sandy loam
- Pots: 2 gallon (7.5 L)
- Seeds: common alfalfa, 5 plants/pot
- Conditions: greenhouse grown for 3 months
- Treatments: 3 (medium EC, high EC, and control)
- Regular monitoring to assess height growth and growth stage
  - Assess treatment differences and plan for harvest

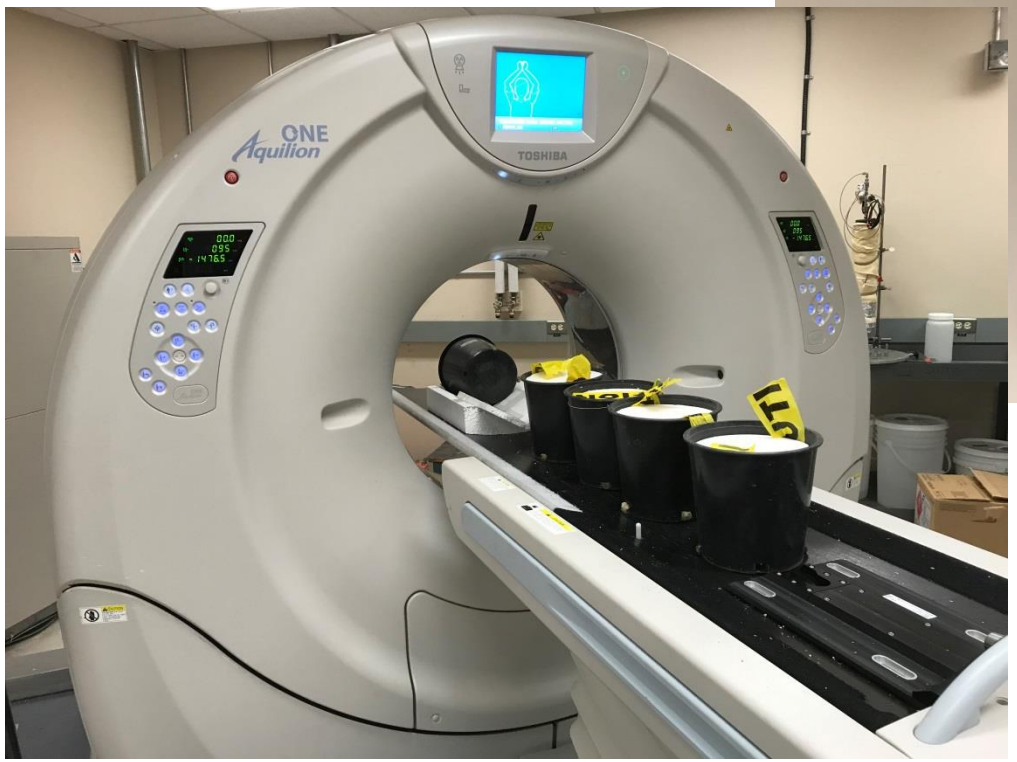


InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Scanning Phase

- Aboveground biomass harvest
- CT scan
- Root washing





InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Scanning Phase

- Aboveground biomass harvest
- CT scan
- Root washing
- CT scan interpretation and data extraction

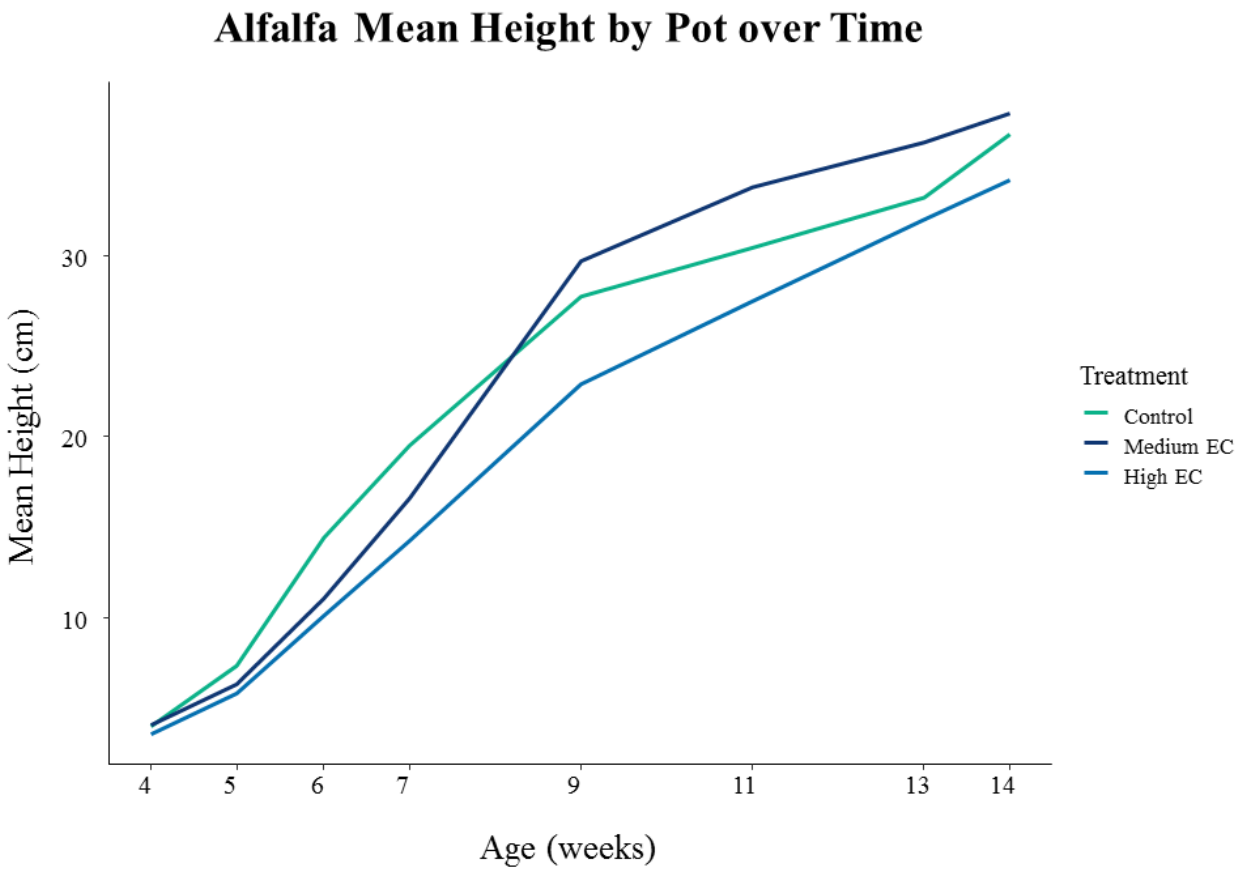
InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

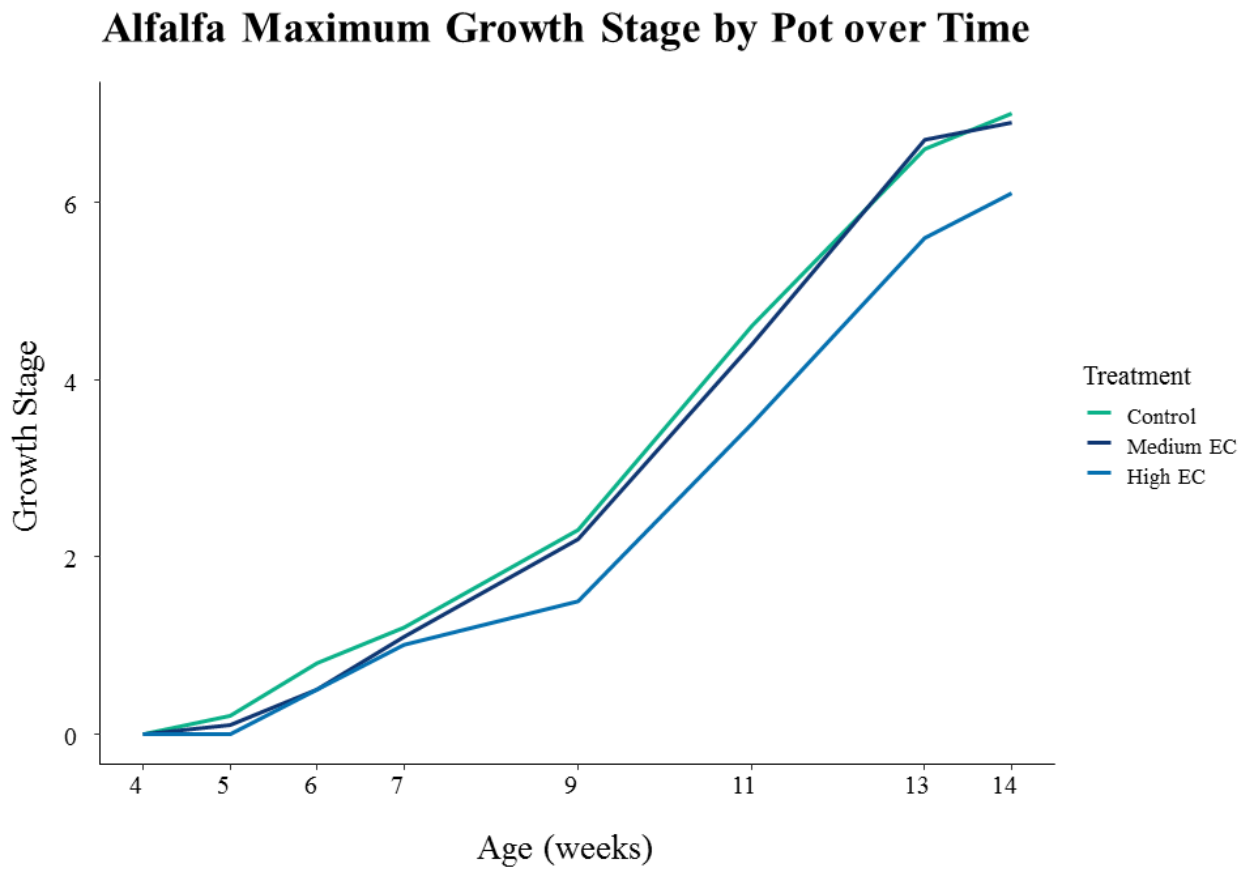
Traditional Measures

- Biomass
  - Positive regression between root biomass and final soil EC
- Height
  - Negative regression between height and final soil EC
  - Height growth over time higher in the medium EC vs. the high EC
- Growth Stages
  - Negative regression between growth stage and final soil EC
  - Growth stage progression over time faster in control and medium EC than high EC
- Root Length
  - Negative regression between root length and final soil EC

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Height and Growth Stage





InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

CT Scanner vs. Traditional Measures

- No significant relationships between volume or surface area and traditional measures

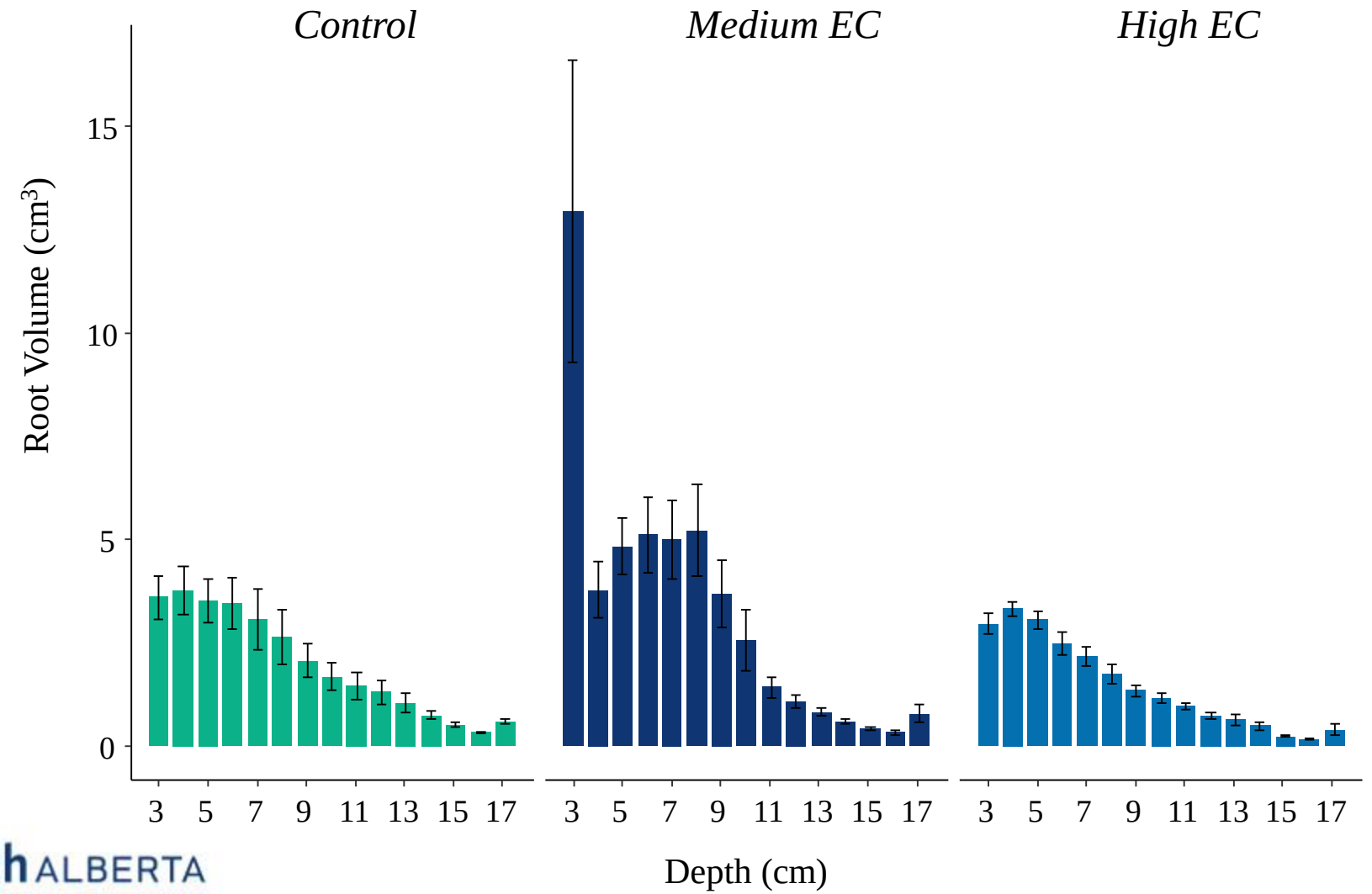
?

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

CT Scanner Outcomes

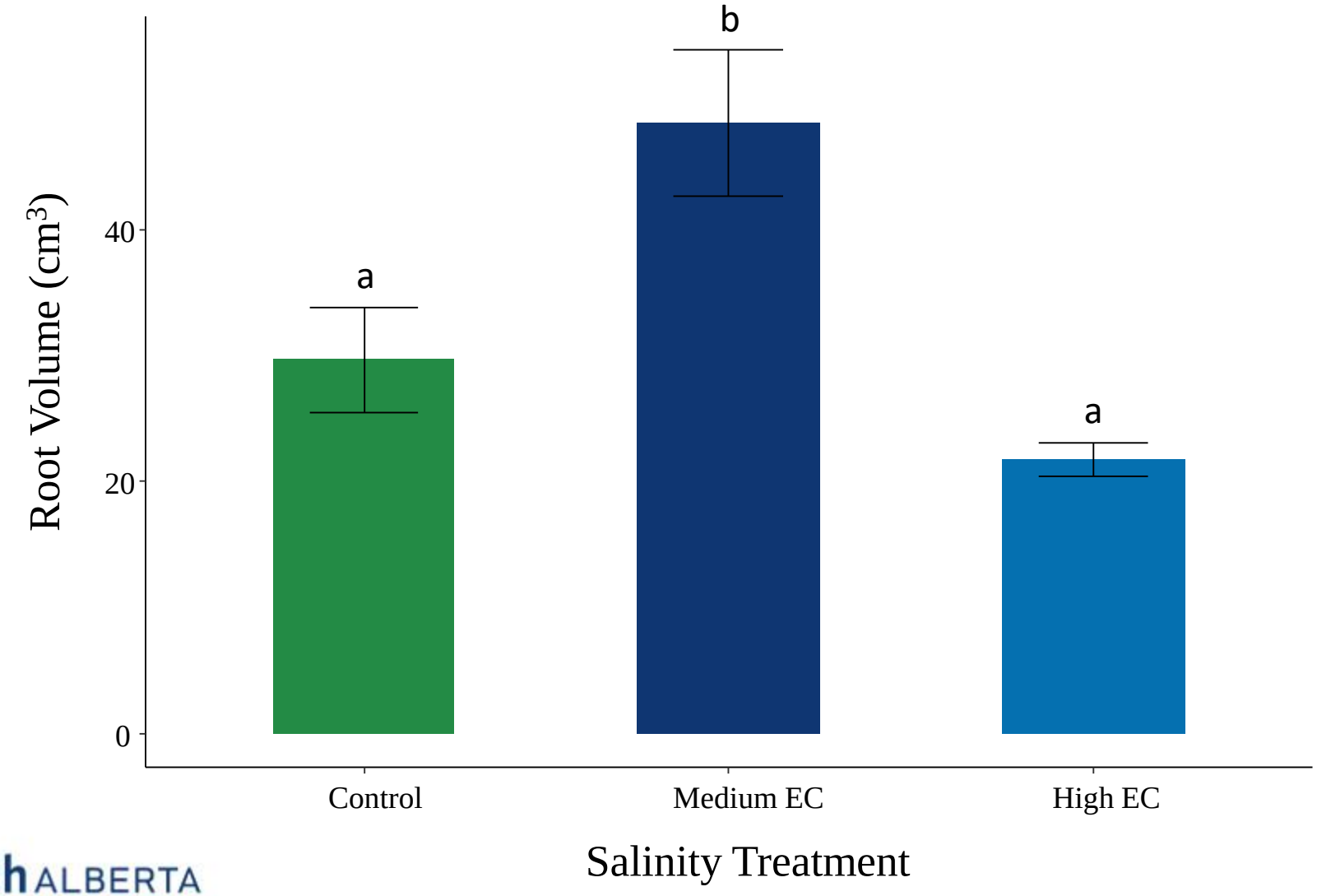
- Roots by depth
  - Root volume and surface area decrease with depth, but no increase in this rate as roots hit saline soil
- Root Volume
  - Medium EC root volume significantly greater than control or high EC
- Root Surface Area
  - Medium EC root surface area significantly greater than control or high EC

Root Volume and Depth



InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Root Volume and Salinity



InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Success of the Technology

- Needs Improvement:
  - No correlation between traditional methods and the CT scanner

  →Refine our technique
- Areas of Promise:
  - Changes in root volume at depth clearly noticeable
  - Volume models useful for visualization

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Most Relevant Applications

- Future greenhouse/growth chamber experiments investigating root growth in situ
  - Examine other contaminants
  - Additional plant species (agriculture and forestry)
  - Determine how roots interact with contaminants at depth
- Validate regulatory guidelines (e.g. COPCs)
- Apply knowledge of plant root architecture to future reclamation plans
- Avoid destructive sampling, especially for long-term studies

Next Steps

- Second Experiment
  - Very high EC
  - Test limits of CT Scanner re: soil type
- This research is part of a larger study
  - Determining an exclusion depth for contaminants of potential concern for future regulatory purposes
  - Will apply this technology to alfalfa growing in 2m columns

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

Thank You!

Acknowledgements:

Mike London

Andrew Underwood

Marshall McKenzie

Phil Chong

Jeff Newman

Annette Schieck

Rebecca Wu

Jackie Warawa

Partial internship funding provided by the Graduate Student Internship Program

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

UNIVERSITY OF ALBERTA