SHOOTS + ROOTS + FRUITS: APPLICATIONS FOR HANDHELD INSTRUMENTS IN PHENOTYPING STUDIES

Edwin J. Reidel, Ph.D.

November 2017

FELIX INSTRUMENTS
APPLIED FOOD SCIENCE

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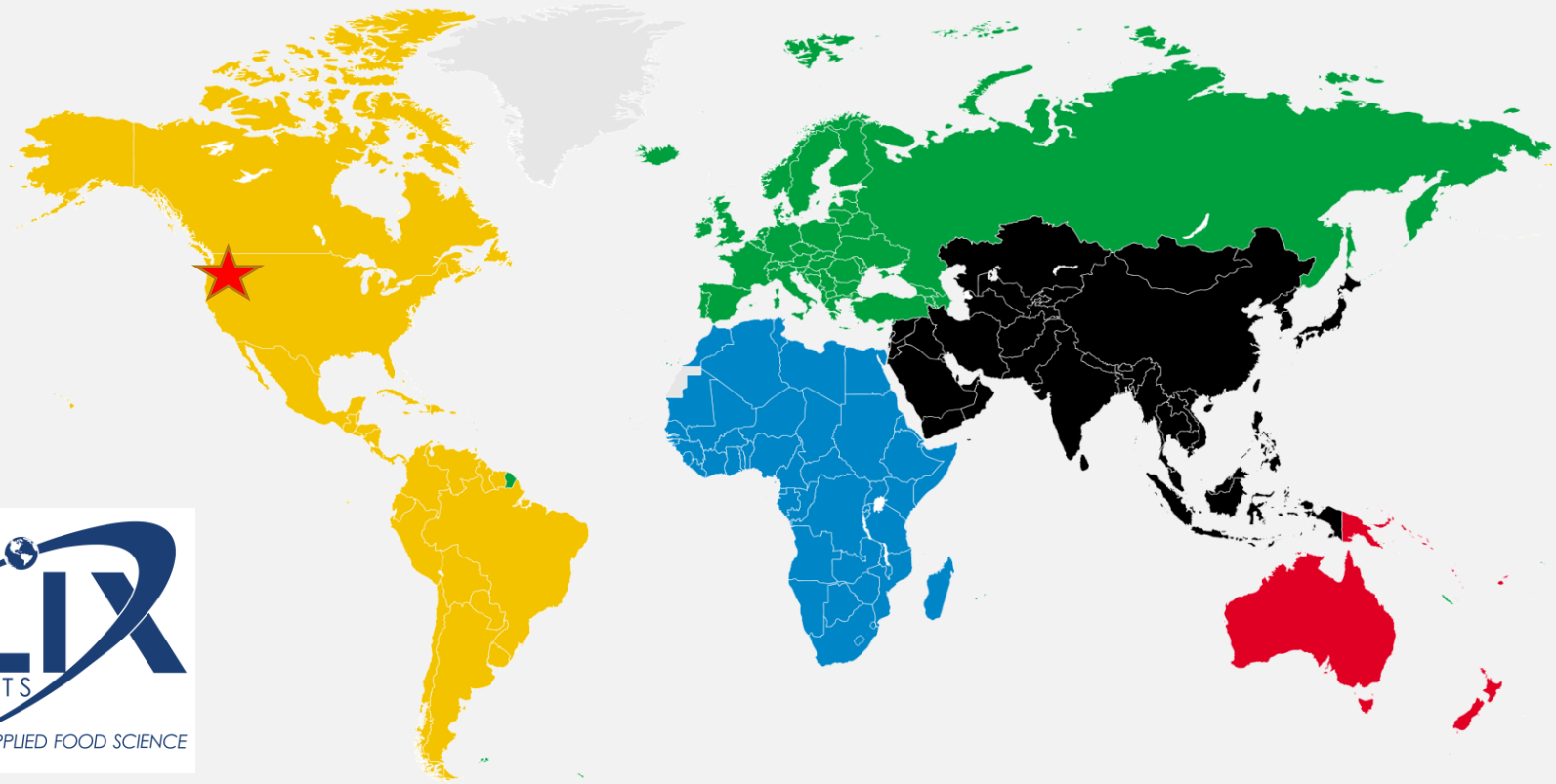
DESIGN | ENGINEER | BUILD



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All instruments built in
Camas, WA USA

FULL CID BIO-SCIENCE PRODUCT LINE

CI-110

Plant Canopy Imager

CI-202

Portable Laser
Leaf Area Meter

CI-203

Handheld Laser
Leaf Area Meter

CI-340

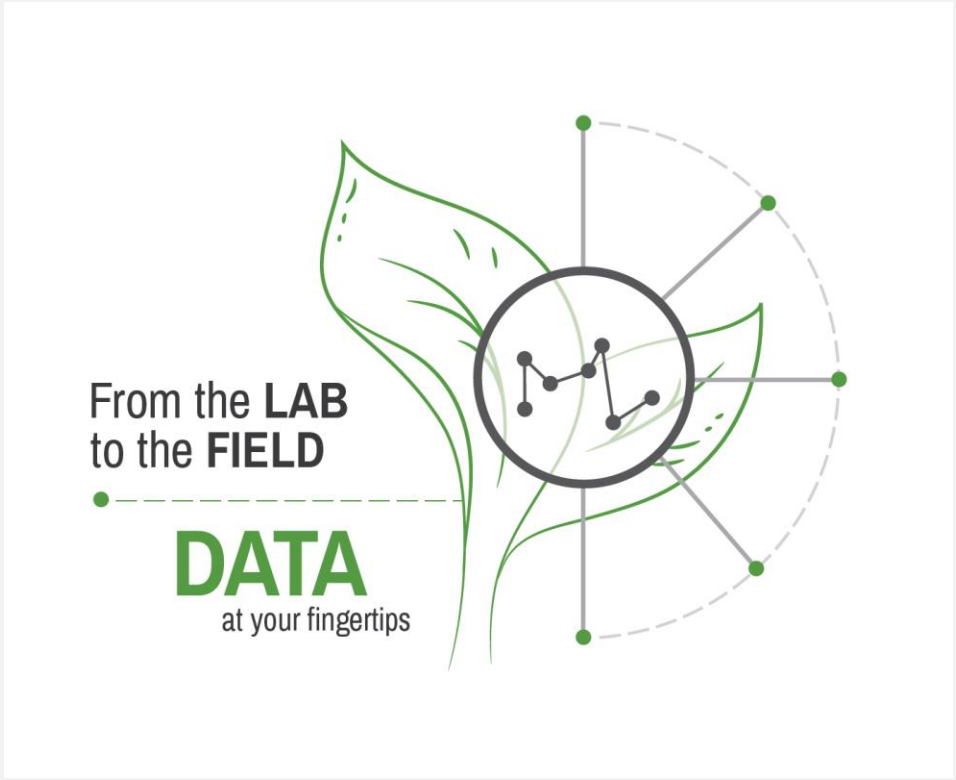
Handheld
Photosynthesis System

CI-600

In-Situ Root Imager

CI-710

Miniature Leaf
Spectrometer

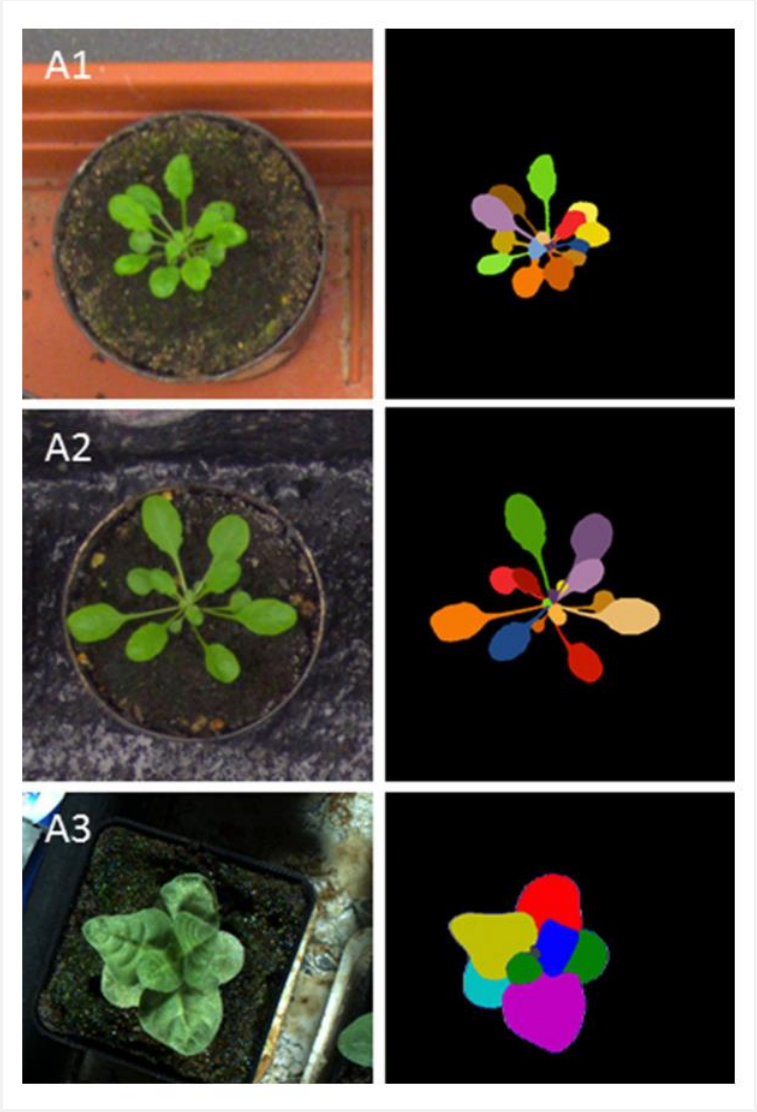


LASER LEAF AREA METERS

- Palette-style or wand-style
- Attached or detached leaves
- Leaf area, length, width, perimeter, ratio, shape-factor
- Laser-based scanning

CI-203 Handheld Laser Leaf Area Meter

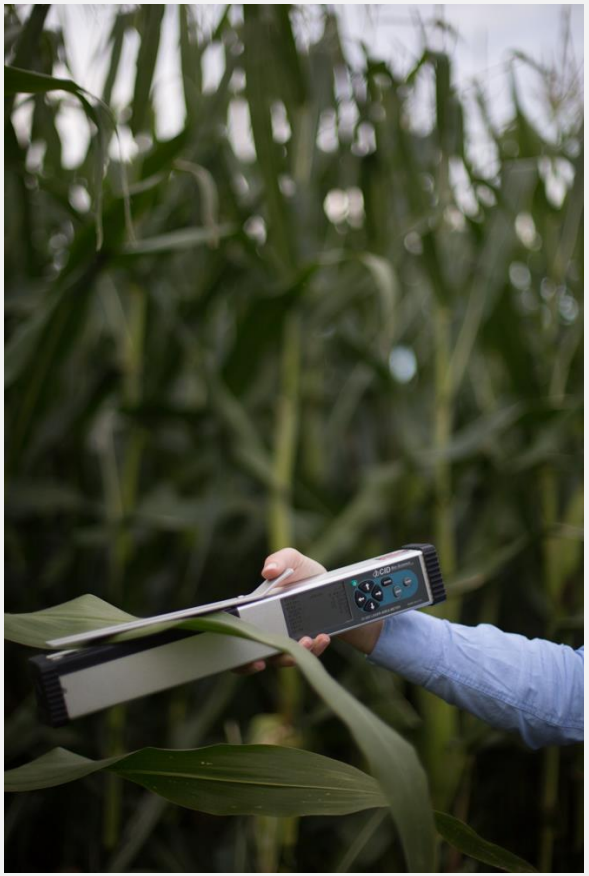
CI-202 Portable Laser Leaf Area Meter



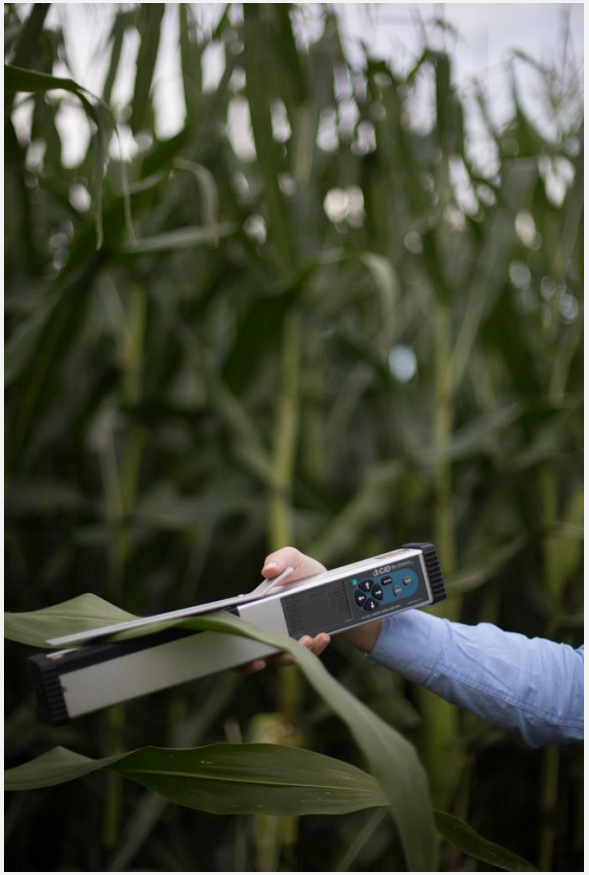
DOI 10.1007/s00138-015-0737-3

LASER LEAF AREA METERS - USES

- Validate models for digital biomass
- Destructive sampling post-harvest

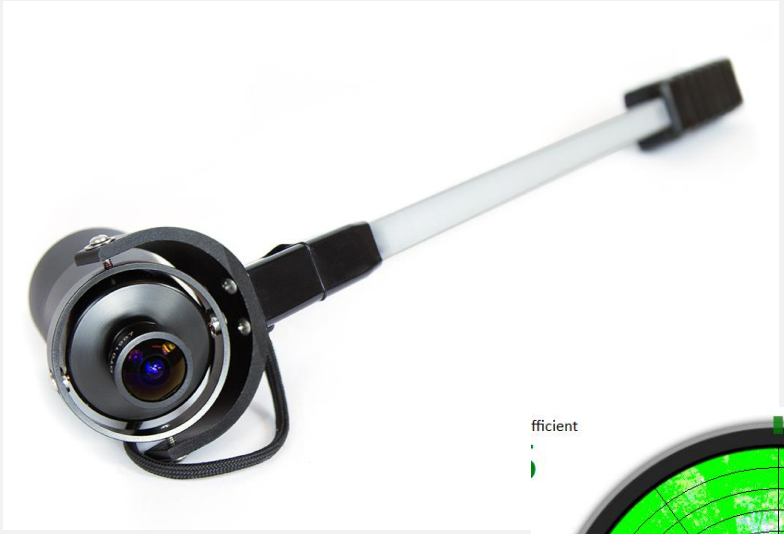


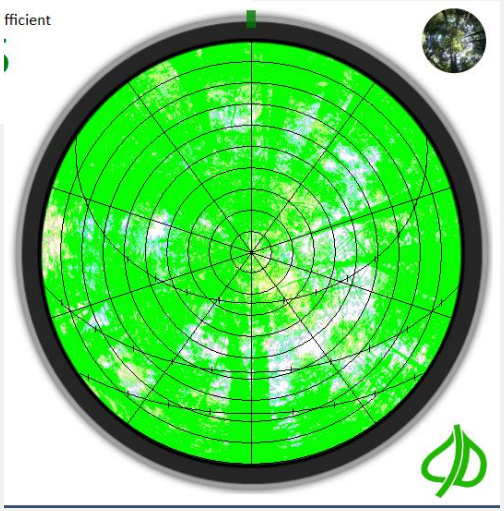
LASER LEAF AREA METERS - USES



CI-110 PLANT CANOPY IMAGER

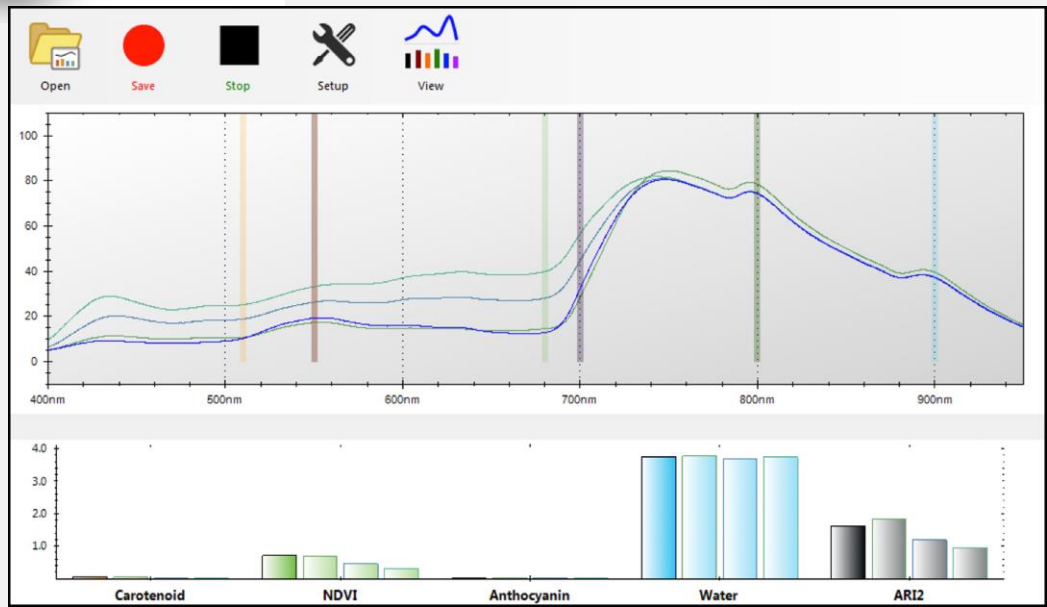
- Digital hemispherical canopy photography
- 150 degree image of canopy
- Non-destructive calculation of LAI/PAI, sunflecks, and PAR
- GPS location and compass for image collection and site-mapping
- User-selectable range zenith & azimuth angles
- Otsu Method or Entropy Crossover Technique





CI-710 MINIATURE LEAF SPECTROMETER

- 400-950 nm measurement range
- Measures Absorbance, transmittance, reflectance
- Pre-loaded with vegetation & pigment indices
- Programmable user-interface for custom indices



https://doi.org/10.1016/j.cj.2014.09.004

CI-710 CASE STUDY

Epicuticular wax

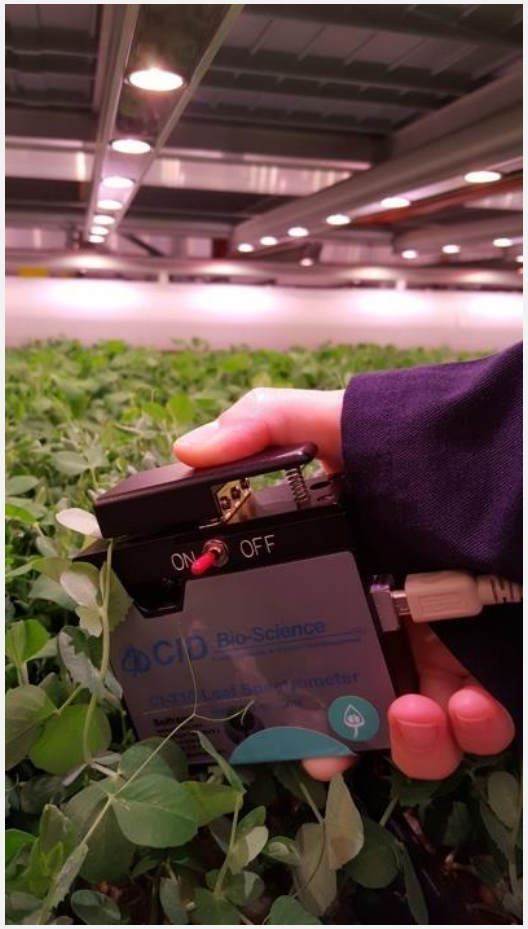
- Reflect excess VIS and IR light
- Regulates temperature
- Prevents excess evaporative cooling
- Save 31,000 L ha^{-1} daily

Two indices associated with EW

- Narrrow band: 694nm-625nm
- Broad band: $\frac{Red^2 - Blue}{Red - Blue^2}$

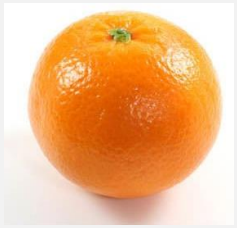
LEAF SPECTROMETER USE CASE

- Dr. Sabrina Carvalho, CoolFarm, Portugal
- "Smart" greenhouse control
- Focus on software and hardware implementation
- Goal of creating an ideal plant growth environment
- Use CI-710 on microgreens to validate how plants respond to greenhouse systems



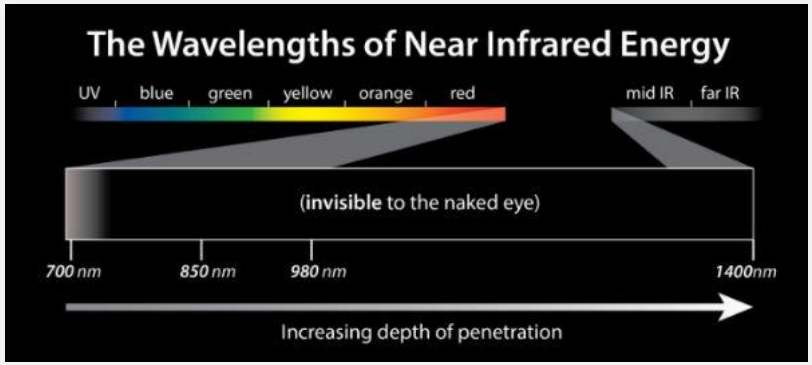
F-750 FRUIT QUALITY METER – WHY WE NEED IT

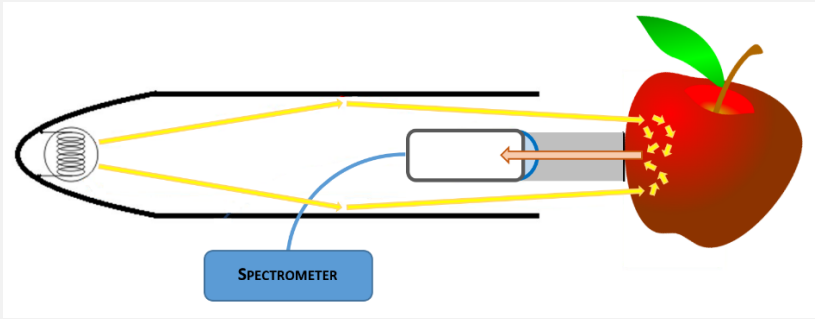
- Flavor is complex
  - Sugars
  - Acids
  - Dry Matter
- Fruit composition changes during ripening
- A non-destructive, standardized tool to measure quality has been lacking



F-750 PRODUCE QUALITY METER – HOW IT WORKS

- Bright light enters fruit
- Photons scatter internally via interaction with molecules
- NIR and visible spectrometer (310-1100 nm) detects returning light
- Measures time under 6 seconds
- Models tailored to specific commodities



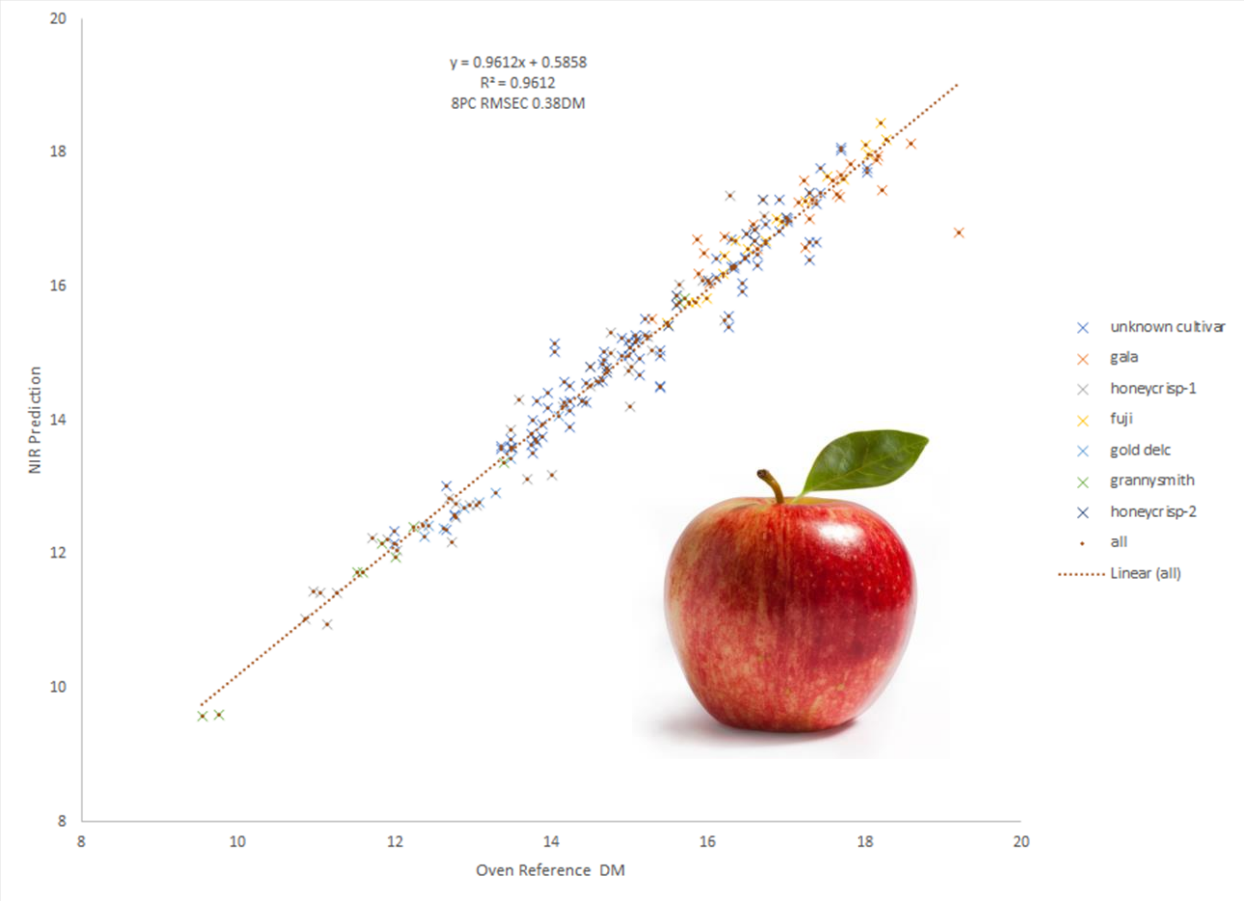


Lets you see tissue instead of skin

PRODUCE QUALITY METER - USES

- Preharvest and Postharvest research
- Screening tool for breeders, e.g. Kiwifruit at Plant & Food NZ
- Measure dry matter changes as fruit develops
- Measure quality changes after harvest

APPLE DRY MATTER



VISUALIZE READINGS WITH GPS

FRUITMAPS

Login / Sign Up

Introducing the World's First

Interactive Harvest Map

FRUITMAPS

Precision Farming Meets Plant Science

What is the size of this years crop? You need to know more than a month before harvest to plan... harvest labour, cartons. When do you call the harvest start – too early and the fruit will not be an optimum eating quality, too late and fruit will not travel well.

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FUTURE WORK

Computer vision for fruit size and count

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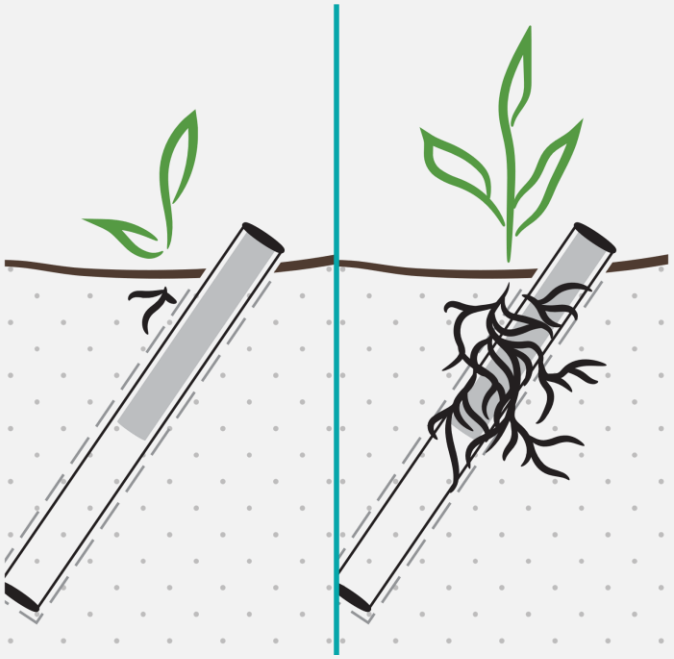
ROOT MEASUREMENT TECHNOLOGY



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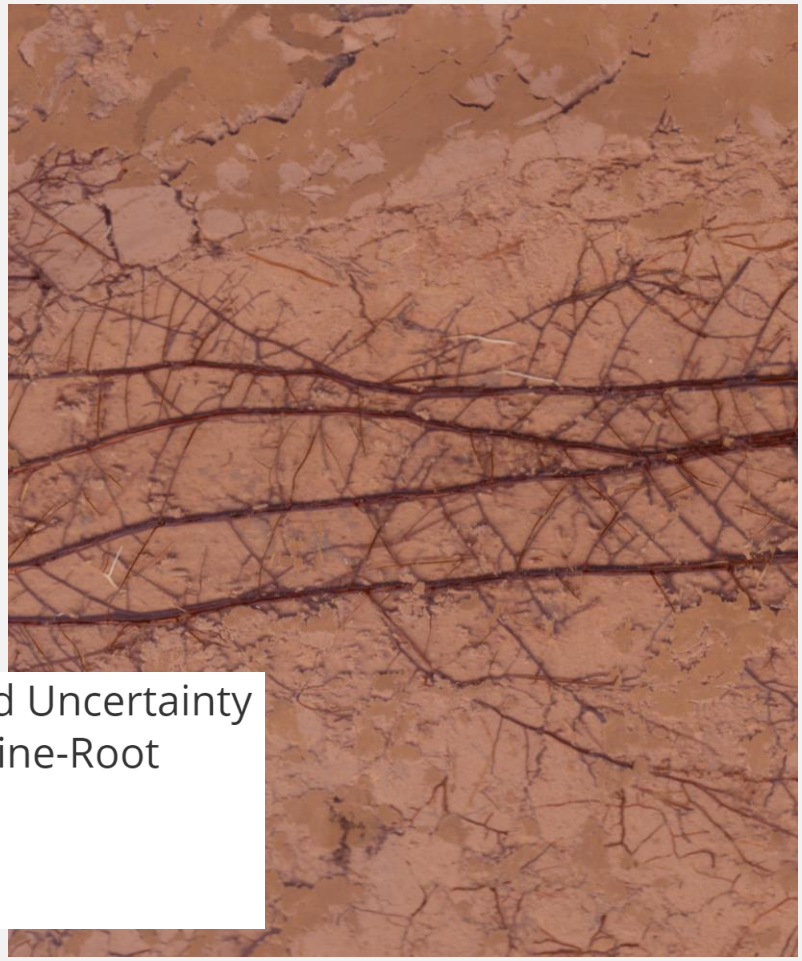
WHY USE MINIRHIZOTRONS IN PHENOTYPING?

- "Currently, minirhizotrons represent the best non-destructive method for measuring *in-situ* fine-root production, mortality, and turnover."



Traceable Calibration, Performance Metrics, and Uncertainty Estimates of Minirhizotron Digital Imagery for Fine-Root Measurements

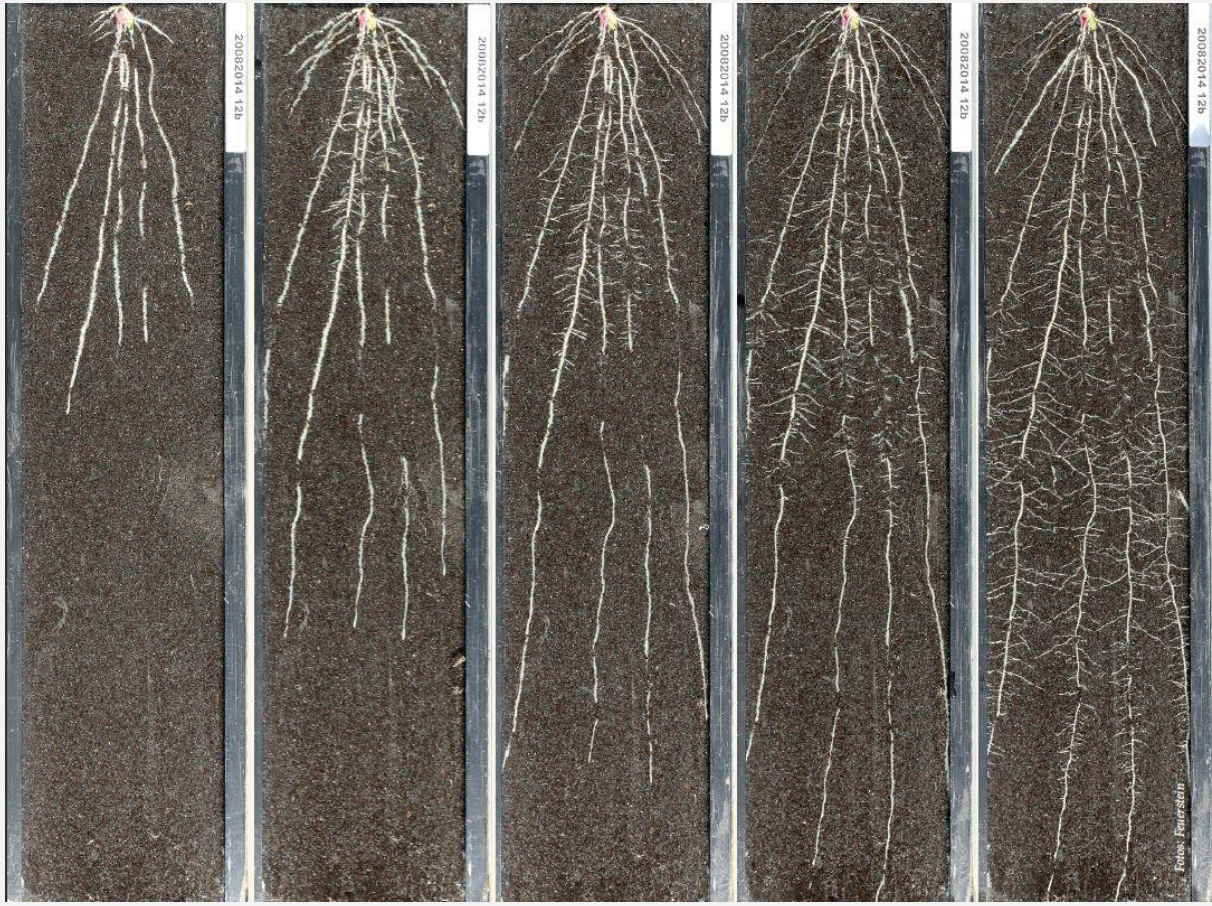
Joshua A. Roberti, Michael D. SanClements, Henry W. Loescher, Edward Ayres

Published: November 12, 2014 • https://doi.org/10.1371/journal.pone.0112362

HISTORY OF ROOT RESEARCH

Non-destructive Methods

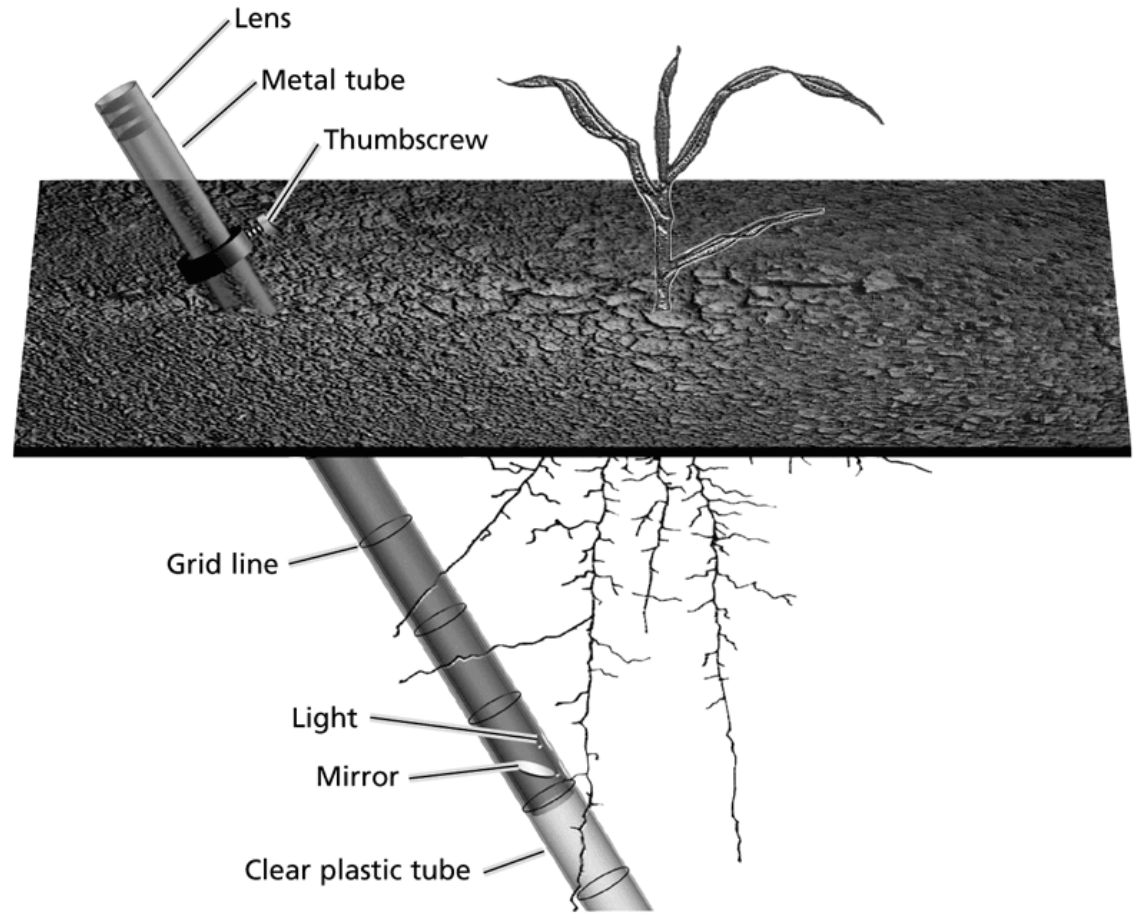
- Glass plates and root windows
  - McDougall, 1916



HISTORY OF ROOT RESEARCH

Non-destructive Methods

- Minirhizotron System
  - G.H. Bates 1937
  - Waddington, 1970



MEASUREMENT STRATEGIES

Historical setbacks

- Restricted accuracy
- Low image quality
- Limited size

Modern systems

- High image quality
- Large image size
- Magnification
- Software quantification
- Used in any soil type
- Field and Controlled Environment
- Annual crops
- Existing plantings
- Long-lived perennial plants

HOW IT WORKS:

CI-600 / CI-602
Minirhizotron Systems

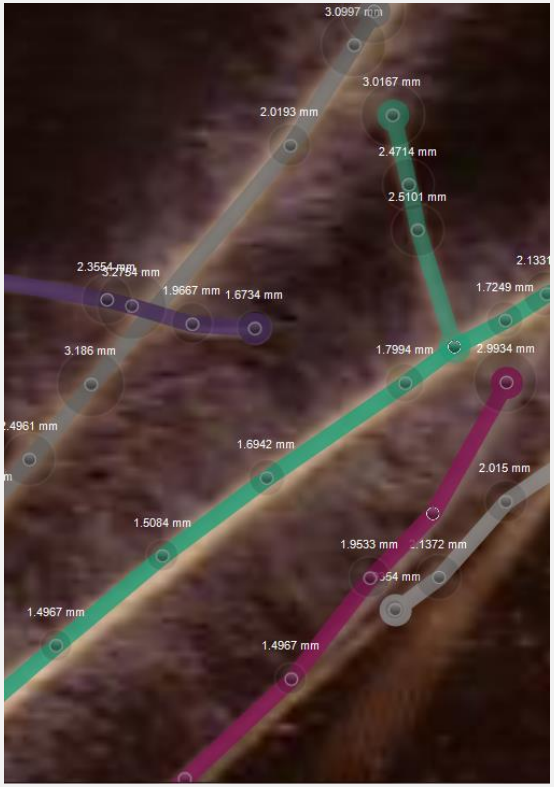
THE CI-600 IN-SITU ROOT IMAGER

- On the market for over 10 years
- Portable
- Scanner-based
- Powered by a tablet computer
- Scans at 100, 300, 600 DPI
- Indexed handle lowers tube in measured increments
- Acrylic tubes, 6.35 cm ID
  - Water tight
  - Insulated

THE CI-602 NARROW GAUGE ROOT IMAGER

- Acrylic tubes, 2” ID
  - Water tight
  - Insulated
- 5 cm ID (fits into existing tube installations)
- 5 cm tubes can be used with other sensors
- Scanner-based
- Powered by a tablet computer
- Scans at 1200 DPI

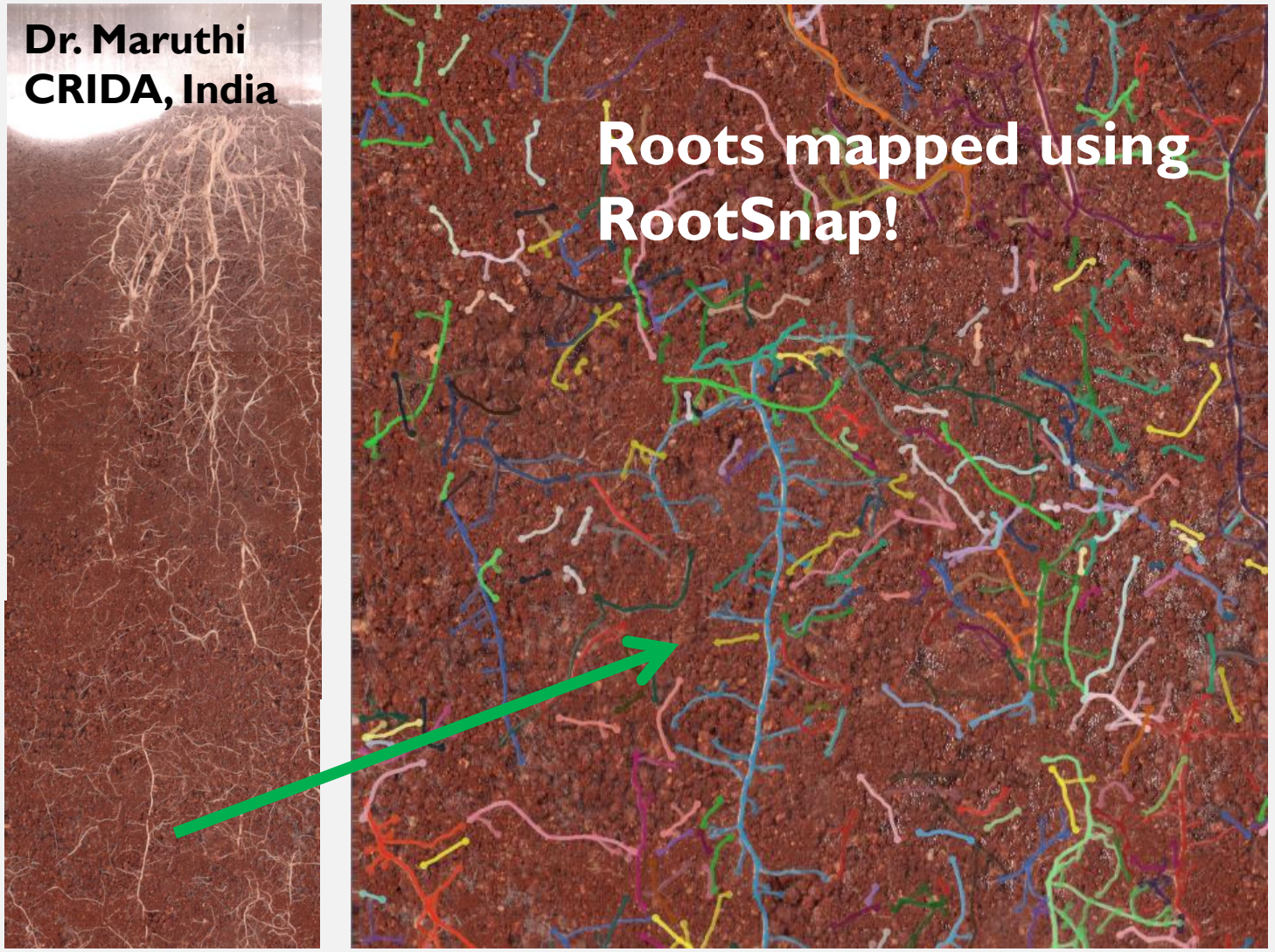
ROOTSNAP!
IMAGE ANALYSIS SOFTWARE



- Free!
- Included with each CI-600 and CI-602
- Easy and fast tool for analysis
- Prevents the backlog of root images
- Touch-screen compatible
- Trace individual roots with finger or mouse

Root Count
Total Root Length
Total Root Volume
Total Root Area
Average Root Diameter
Average Root Length
Average Root Area
Average Root Volume
Window Depth
Date and Time of Image
Physical Size of Image
Individual Root Length
Individual Root Area
Individual Root Volume
Individual Root Average Diameter
Root Angle
Branching Angle
Branch Count
Diameter of Individual Root Point


Dr. Maruthi & Dr. Srinivas
CRIDA: Central Research Institute for Dryland Agriculture, Hyderabad, India
To study **root growth and development** of two maize cultivars under two moisture regimes.


Dr. Maruthi
CRIDA, India
Roots mapped using
RootSnap!

Research question?

- **Is early root overproduction stimulated by nutrient availability or competion?**

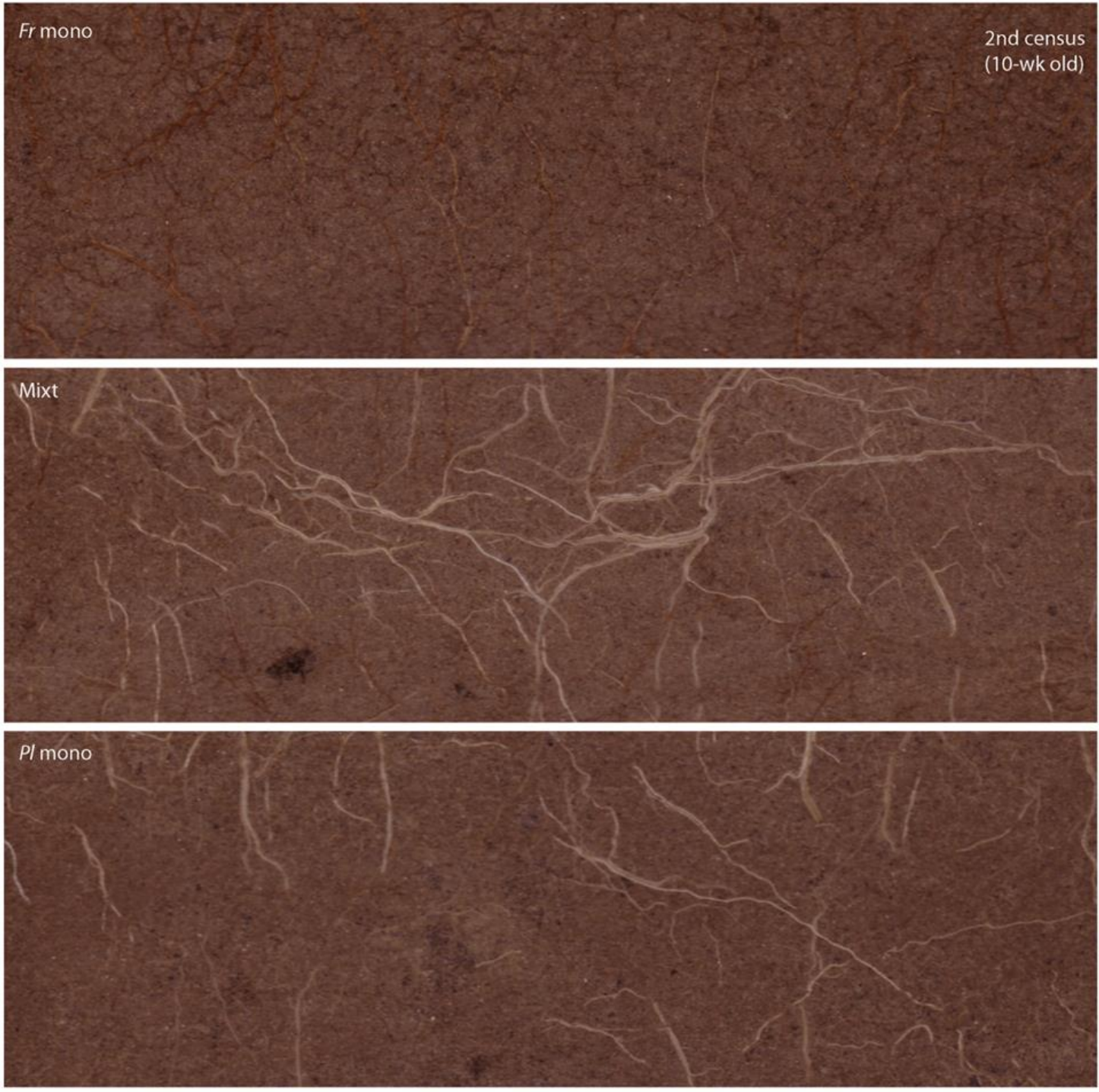
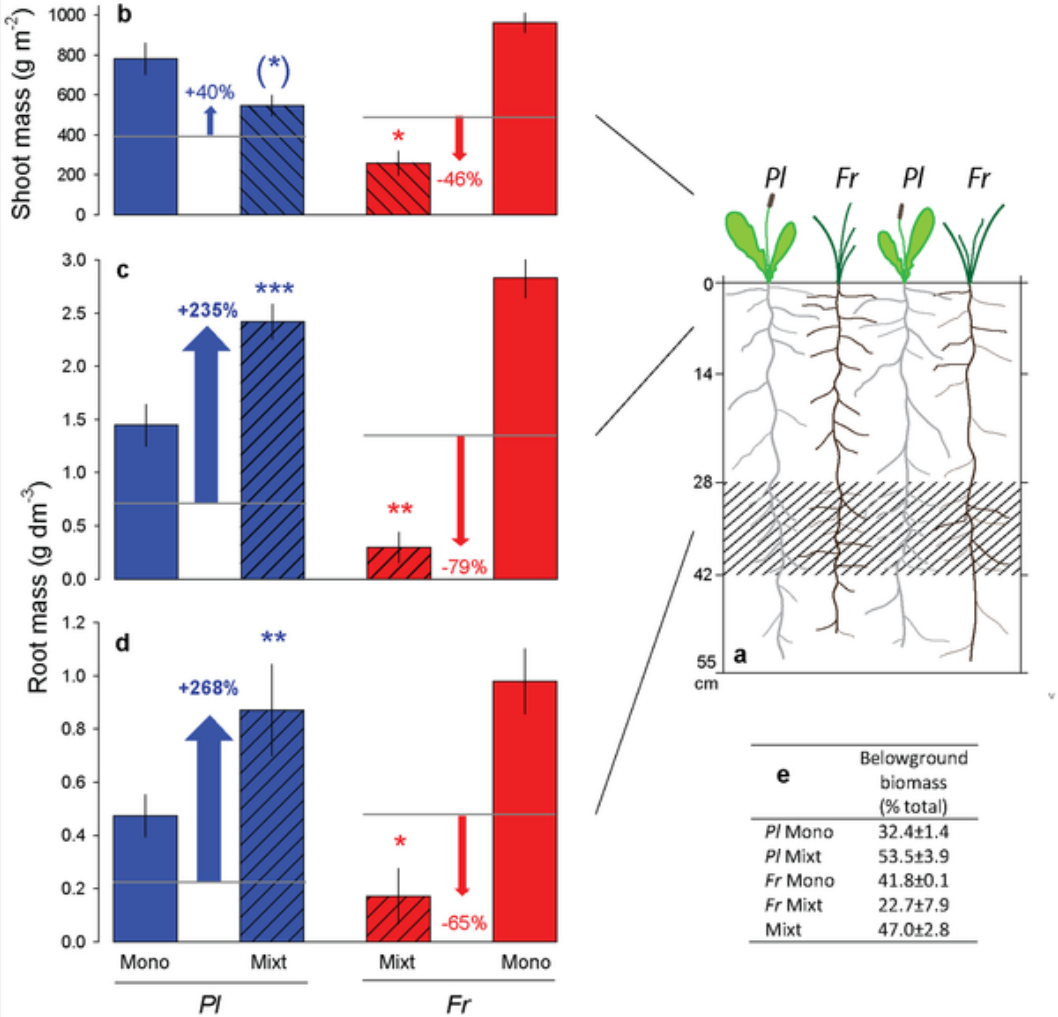


Figure 1. Experimental setup and biomass data.

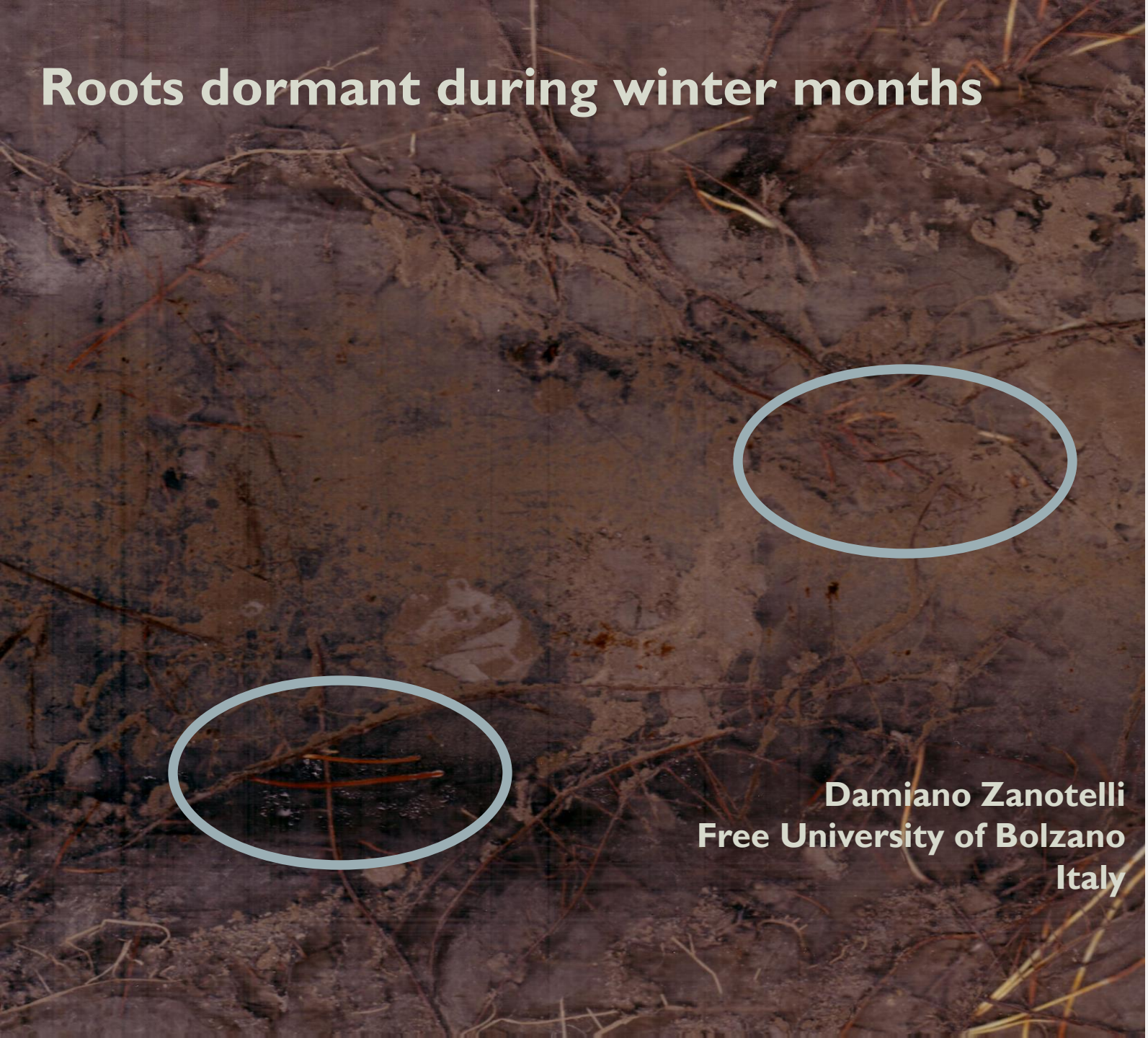


e	Belowground biomass (% total)
Pl Mono	32.4±1.4
Pl Mixt	53.5±3.9
Fr Mono	41.8±0.1
Fr Mixt	22.7±7.9
Mixt	47.0±2.8

Padilla FM, Mommer L, de Caluwe H, Smit-Tiekstra AE, Wagemaker CAM, et al. (2013) Early Root Overproduction Not Triggered by Nutrients Decisive for Competitive Success Belowground. PLOS ONE 8(1): e55805. https://doi.org/10.1371/journal.pone.0055805
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0055805

Damiano Zanotelli
Free University of Bolzano
Italy

Roots dormant during winter months



Damiano Zanotelli
Free University of Bolzano
Italy

TO19, L003,
May 17, 2010

Activity and growth in Spring/Summer

Damiano Zanotelli
Free University of Bolzano
Italy

TO19, L003,
June 10, 2010


Dr. Zoltan Toth: University of Pannonia, Hungary

WHY USE MINIRHIZOTRONS?

- Color classification
- Root turnover/mortality
- Non-destructive
- Repeated measurements
- Treatment effects
- Link belowground characteristics to aboveground phenotype

Zoltan Toth
University of Pannonia
Hungary

QUESTIONS?

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