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# Developing Tools to Support Agricultural Research

Advances in Agricultural Research Series
January 16, 2024

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The University of Saskatchewan is located on Treaty 6 Territory, homeland of the Metis and other indigenous peoples.

The Land Acknowledgement is a reminder of our community and who our neighbours are

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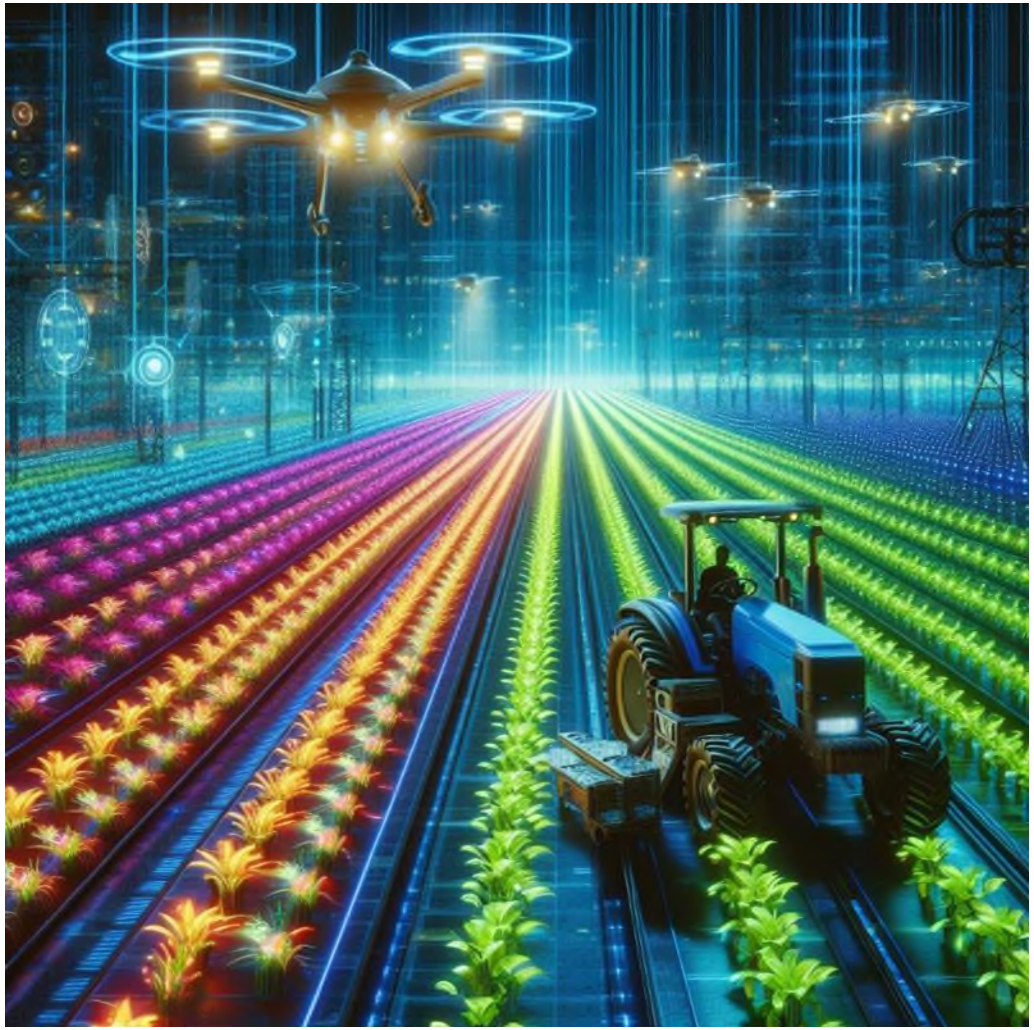
# What is “Digital Agriculture”?



“Digital Agriculture”, images generated by Microsoft Bing Chat Enterprise

# Overview

- What is “digital agriculture”?
  - What does digital agriculture promise research?
  - What does it require?
- Case Studies of USask Enabling Technologies
- Neighbours : The USask Advantage

# Digital Agriculture:

Using computers to compensate for a limited number of fingers.

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# The Promise of Digital Ag

Managing more data at higher resolution will lead to more value

(i.e. yield, efficiency, greater premiums etc.)

Research

Production

Marketing

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# Demands of Digital Ag on Research

## More Data

More complex models with more variables need more data

## Greater Precision

Managing variance to gain improved separability

## Re-Thinking Metrics

How golden are gold standards?

# SpecLab - What we do

## Systems to Assist Data Collection

Automate

Develop/adapt instruments

Improve quality

Increase quantity

Increase frequency

Develop methods and assess new technologies

## Methods for Data Interpretation

Calibration

Model development

Multi-modal data models (“sensor fusion”)

Understanding limitations

# Case Studies

## Tools we build

- Stem Testing (with Aaron Beattie)
- Seed Imaging (with Kirstin Bett and Randy Kutcher)
- UFPS – USask Field Phenotyping System (Many Collaborators)

## Connecting Measurements to Traits

- Leaf Optical Properties
- Optical Coherence Tomography of Seeds
- Lidar and Plant Maturity
- Lidar Biomass Distribution in a Canopy

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# Tools

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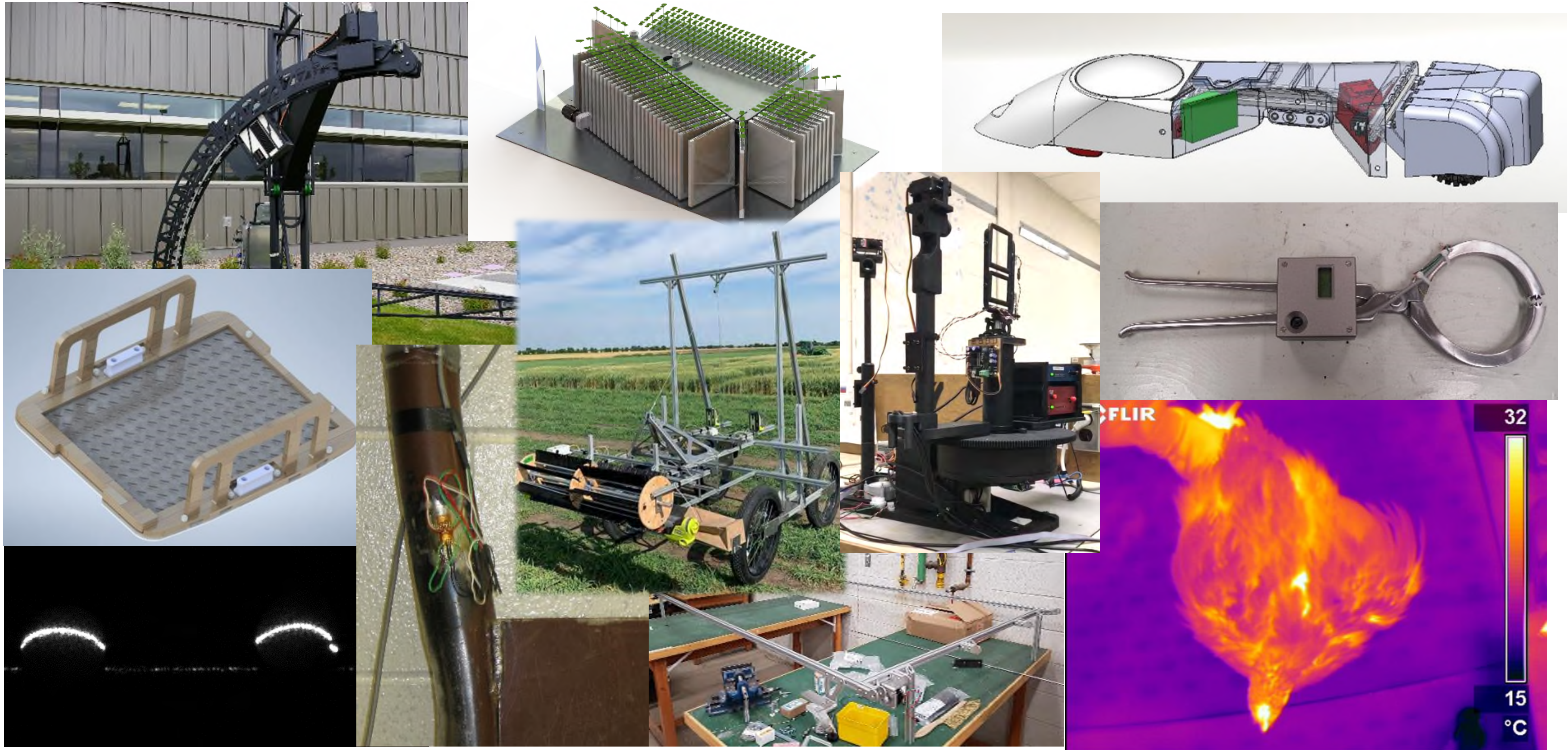
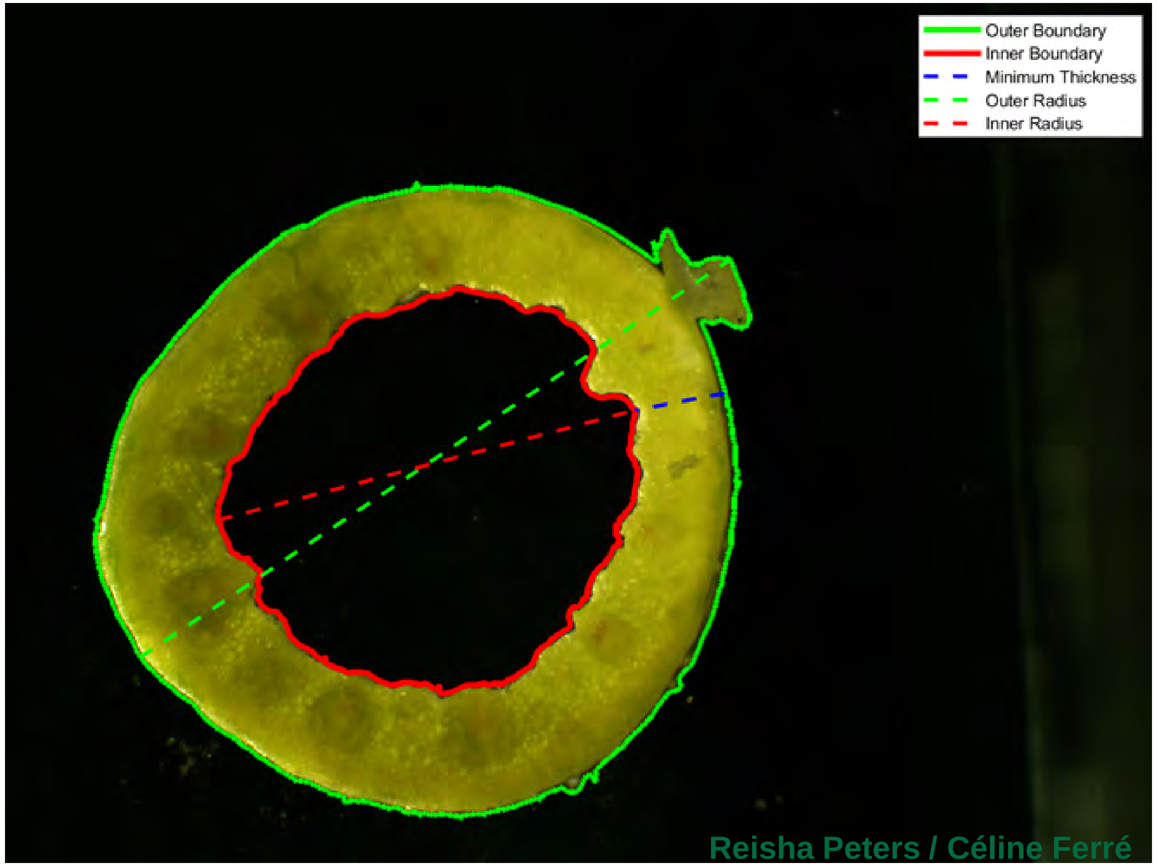


# Stem Imaging

- Polarizers used to reduce glare on glass
- X-Y adjustment stage for positioning
- Uses an inexpensive microscope camera and acquisition software
- Structure laser-cut and 3D-Printed

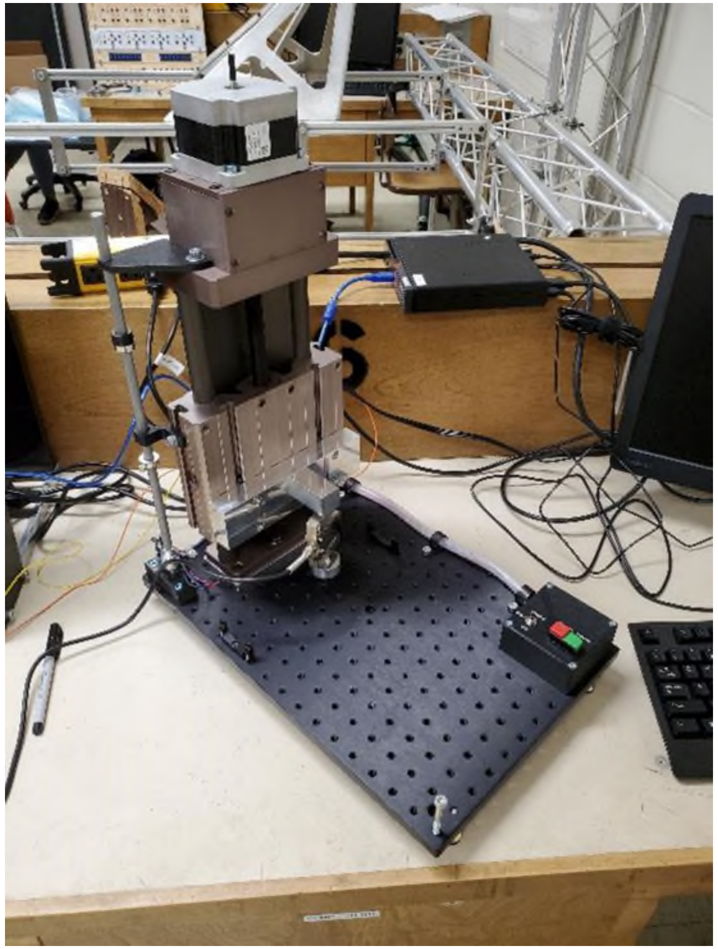
- In-house code for analysis (courtesy of Reisha Peters)
- Final design is relatively inexpensive – can sit in crop lab or go to the field.

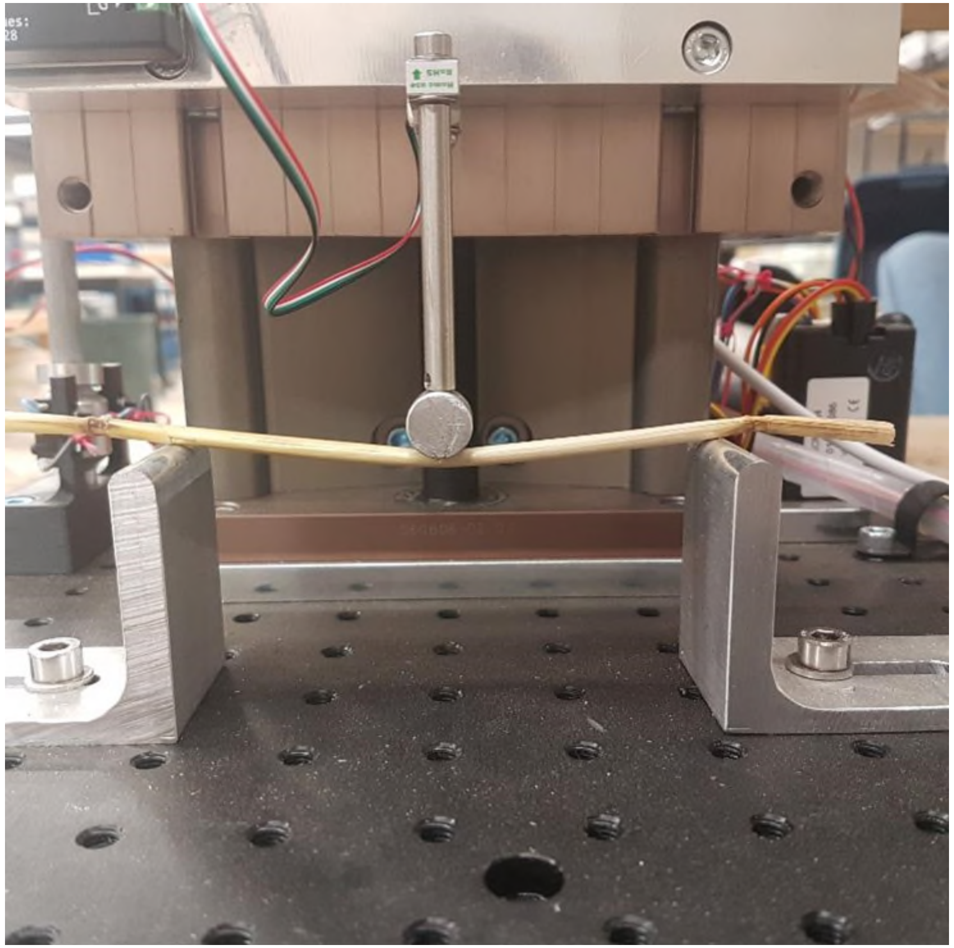


# Stem Bending

- Refit UTM with inexpensive, 750g load cell
- Added rotary encoder to drive motor for position information
- USB-connected data acquisition

- Stem bending project has led to improvements in equipment for the undergraduate lab.
- Has supported two M.Sc. projects to date (M. Taylor and C. Ferré)





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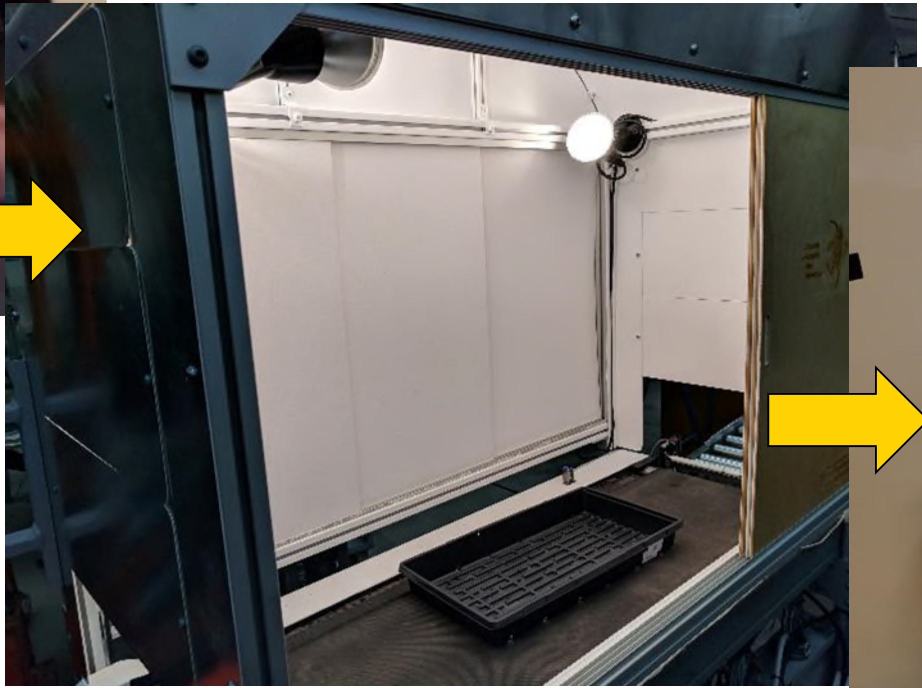
# The BELT Seed Imager

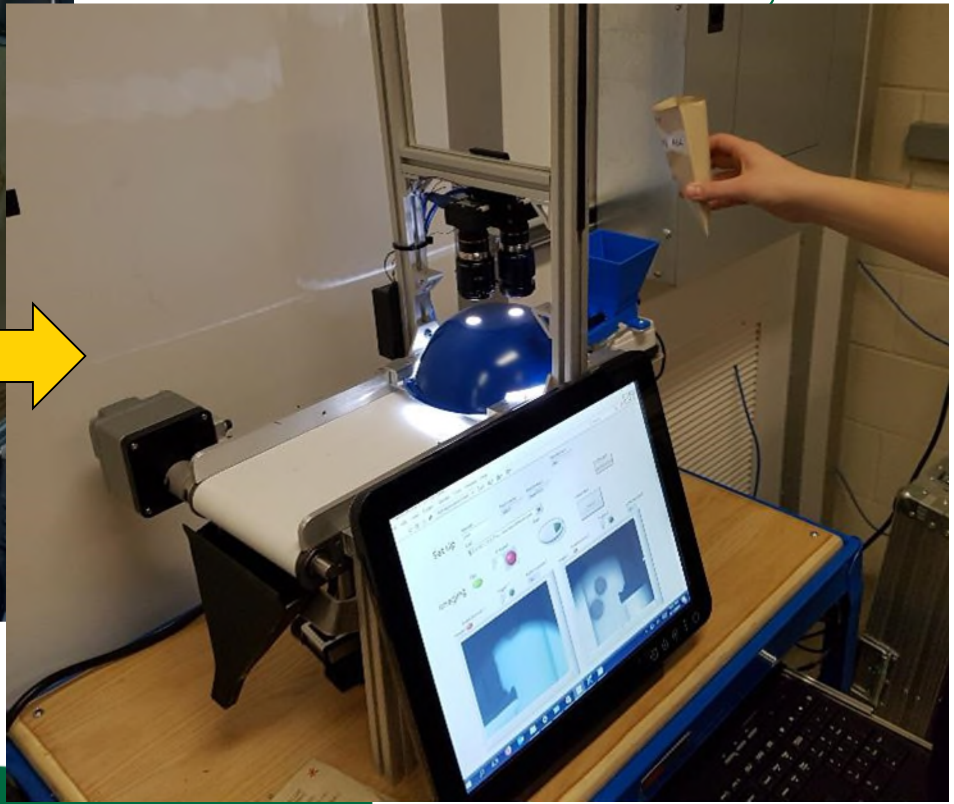
## A story about the importance of serendipity and latitude

**LEGO downer-lifter prototype
(Joe Stookey, WCVM)**



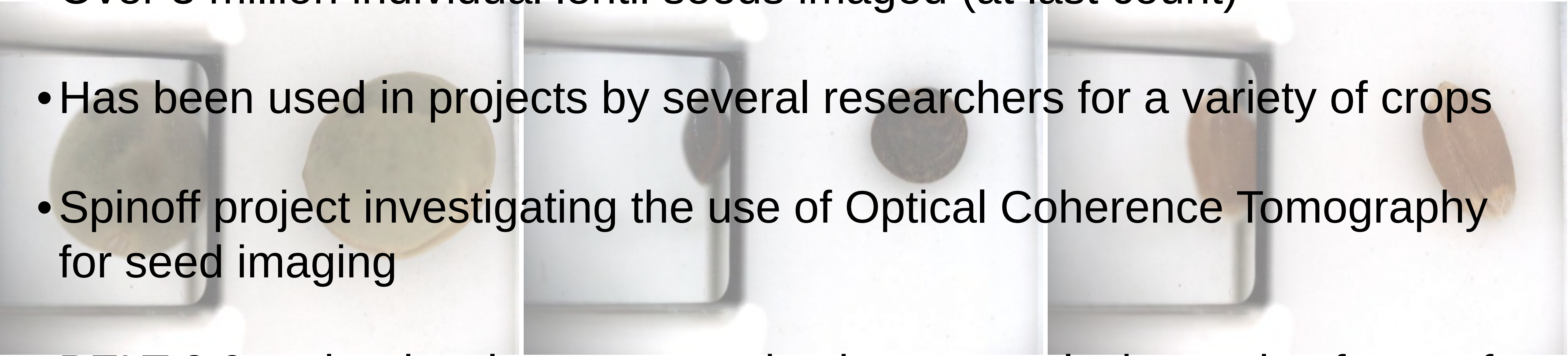
**Treadmill plant imager (TAPP) *$P^2$IRC/CFREF***

**Single-Seed Imaging System (BELT) with
Kirstin Bett -*$P^2$IRC/CFREF, EVOLVES***



# BELT Impact

- Over 3 million individual lentil seeds imaged (at last count)



- Has been used in projects by several researchers for a variety of crops
- Spinoff project investigating the use of Optical Coherence Tomography for seed imaging
- BELT 2.0 under development, emphasis on cereals, improving focus of side view and sample feeding (NSERC Alliance/SaskWheat, PI Randy Kutcher).

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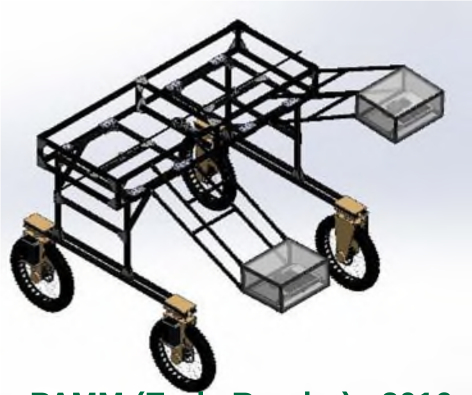
# Field Phenotyping System Evolution

ULGS2 - 2008

Platform Concept – P$^2$IRC Proposal - 2015



PAMM (Early Render) - 2016

PAMM – 2018-2019

SPAMM - 2017

miniPAMM v1 - 2018

~~miniPAMM~~ UFPS v2- 2019-20

UFPS v2.5- 2021

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# UFPS – University of Saskatchewan Field Phenotyping System

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# This is also the UFPS…

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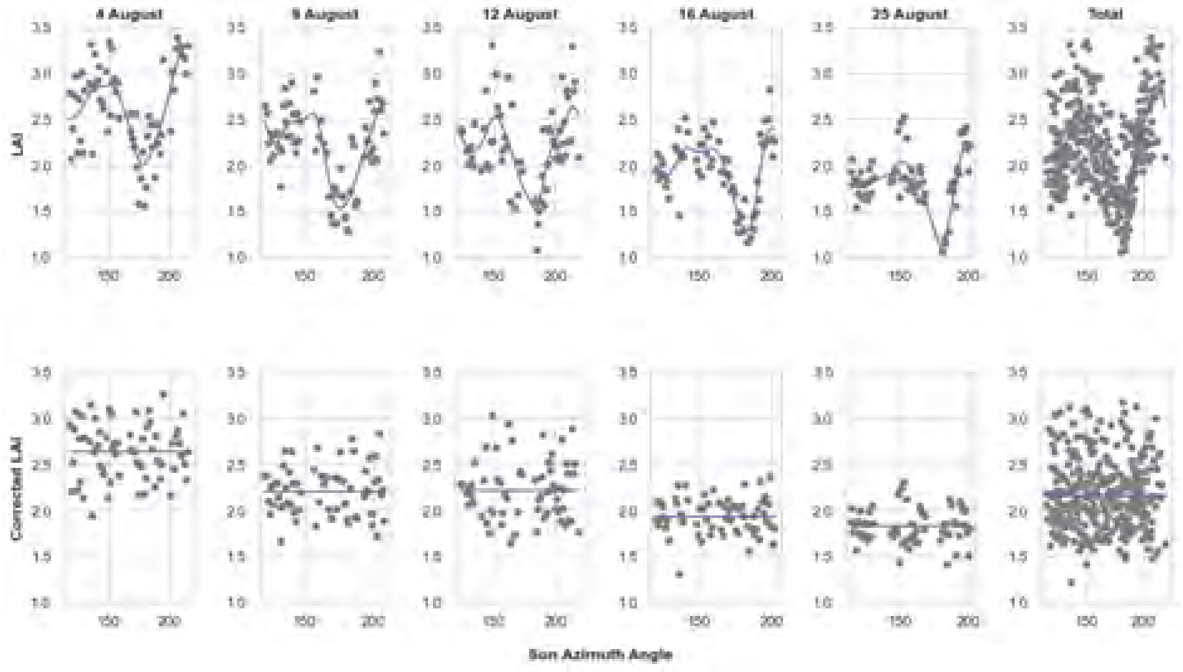
# Connecting Measurements to Traits

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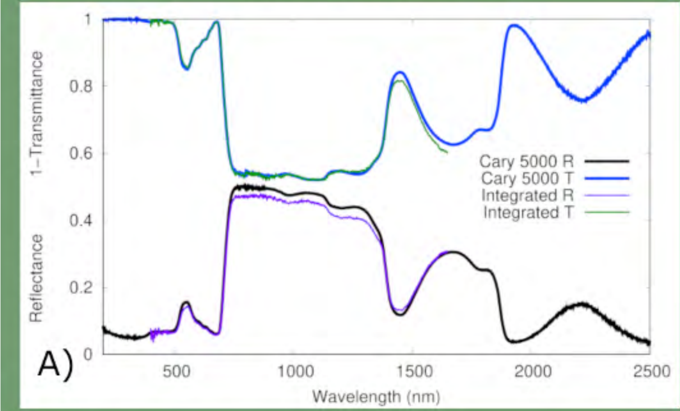
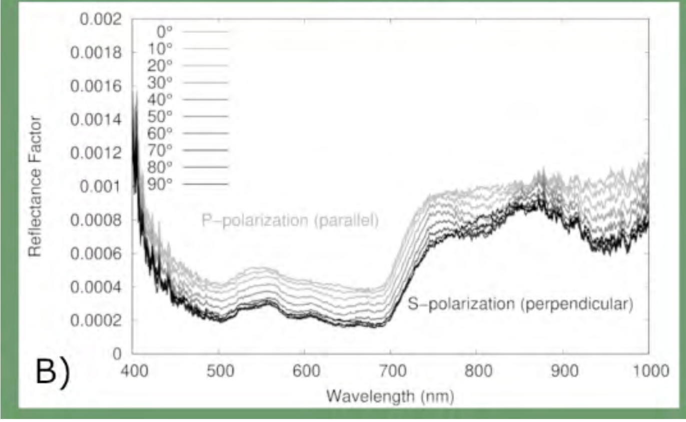
# Leaf Optical Traits USask (LOTUS)

Spectral Data:

A) Hemispherical Reflectance and Transmittance
B) Polarized Reflectance Factors
C) Partial Bidirectional Distributions

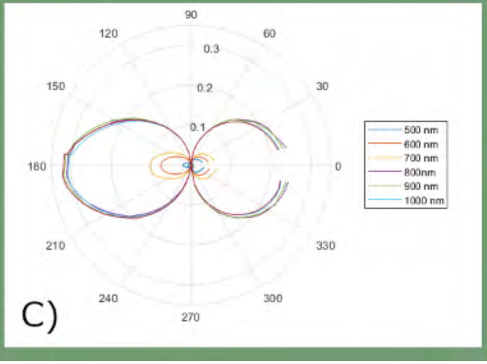


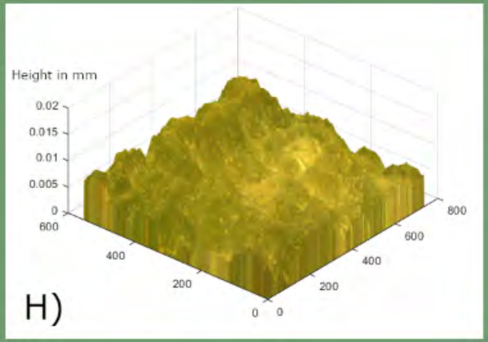




## LOTUS Dataset (Leaf Optical Properties collected at the Univeristy of Saskatchewan)

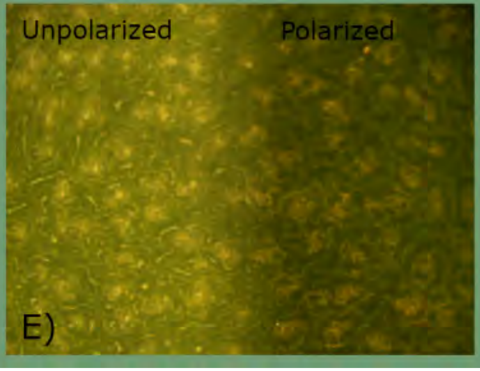
The LOTUS dataset aims to represent a wide variety of species, pigment expression, and leaf age. All data shown here is collected for 290 leaf samples

Leaf spectra and biochemical analysis of samples is augemented with biophysical assessment, partial bidirectional reflectance distributions, and microscope analysis. These data will help advance leaf optical modelling with applications in precision agriculture.



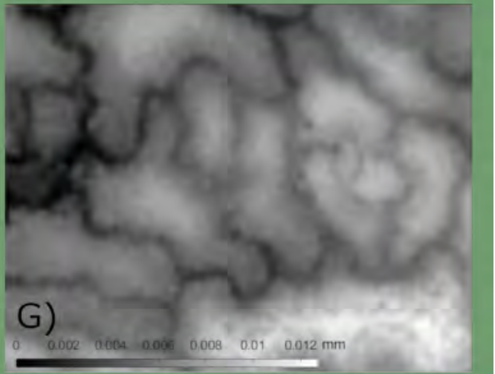








Biochemical and Physical Data:

Chlorophyll (a and b)
Carotenoids
Anthocyanin
Dry Matter
Water
Leaf Thickness
Epidermal Cell Size
Surface Roughness
Trichome Identification
Wax Identification



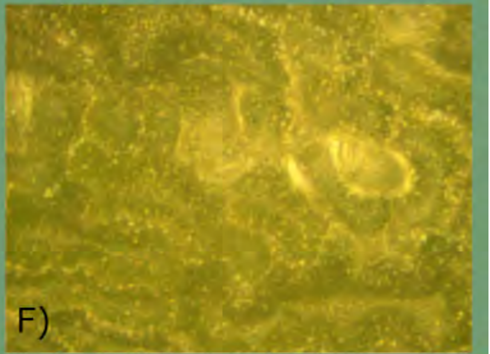
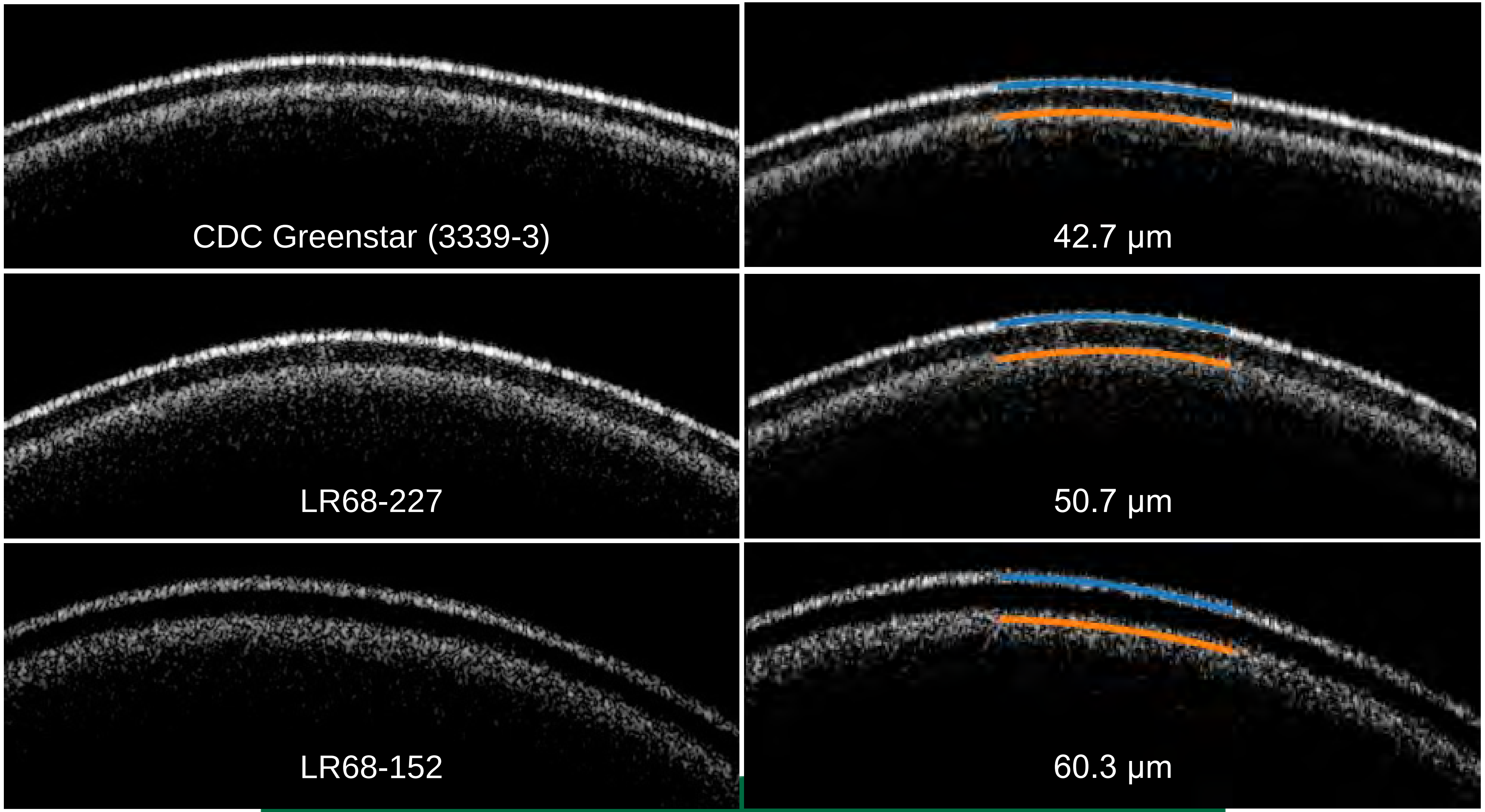




Image Data:

D) Image of Leaf
E) 100x Microscope with Polarization
F) 500x Microscope
G) 500x Height Map
H) 3D Leaf Surface

Reisha Peters

# OCT – Non-Destructive Seed Coat Thickness



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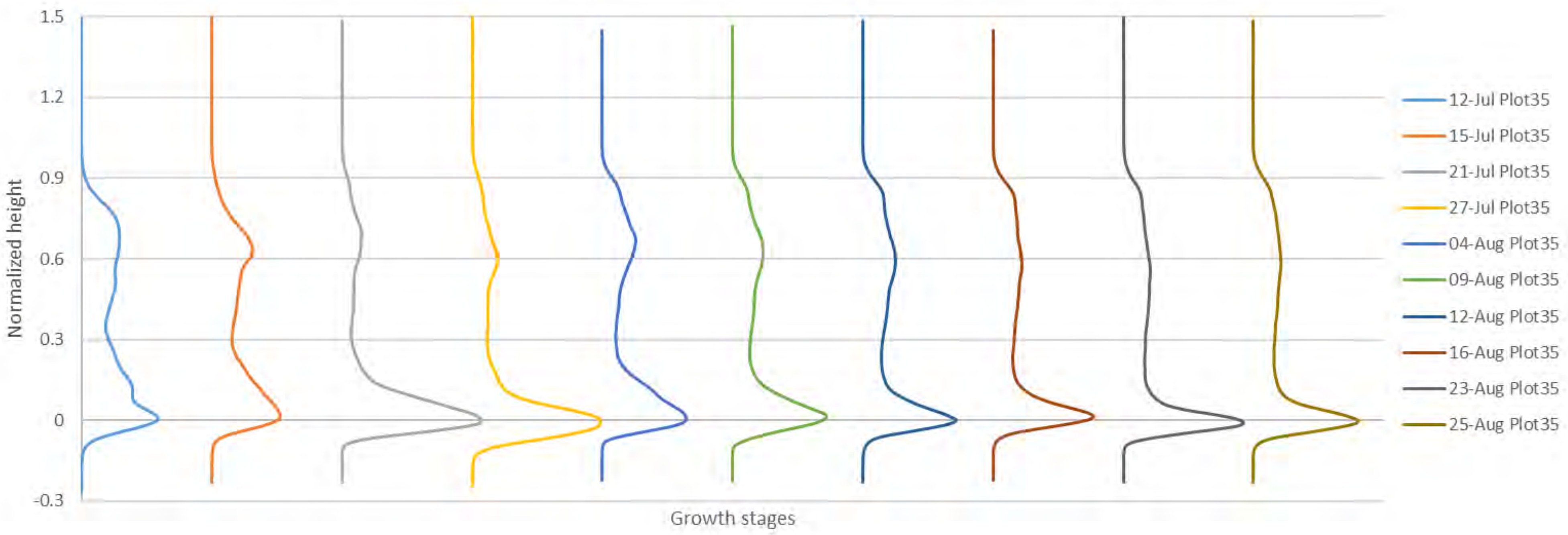
# Estimation of Growth Stage using normalized Lidar histograms (Azar Khorsandi)




53- Heading | 63- Flowering | 68- Flowering | 77-Milk stage | 83-Dough stage | 85-Dough stage | 87-Dough stage | 89-Dough stage | 92- Ripening | 95- Ripening

| Classes | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|

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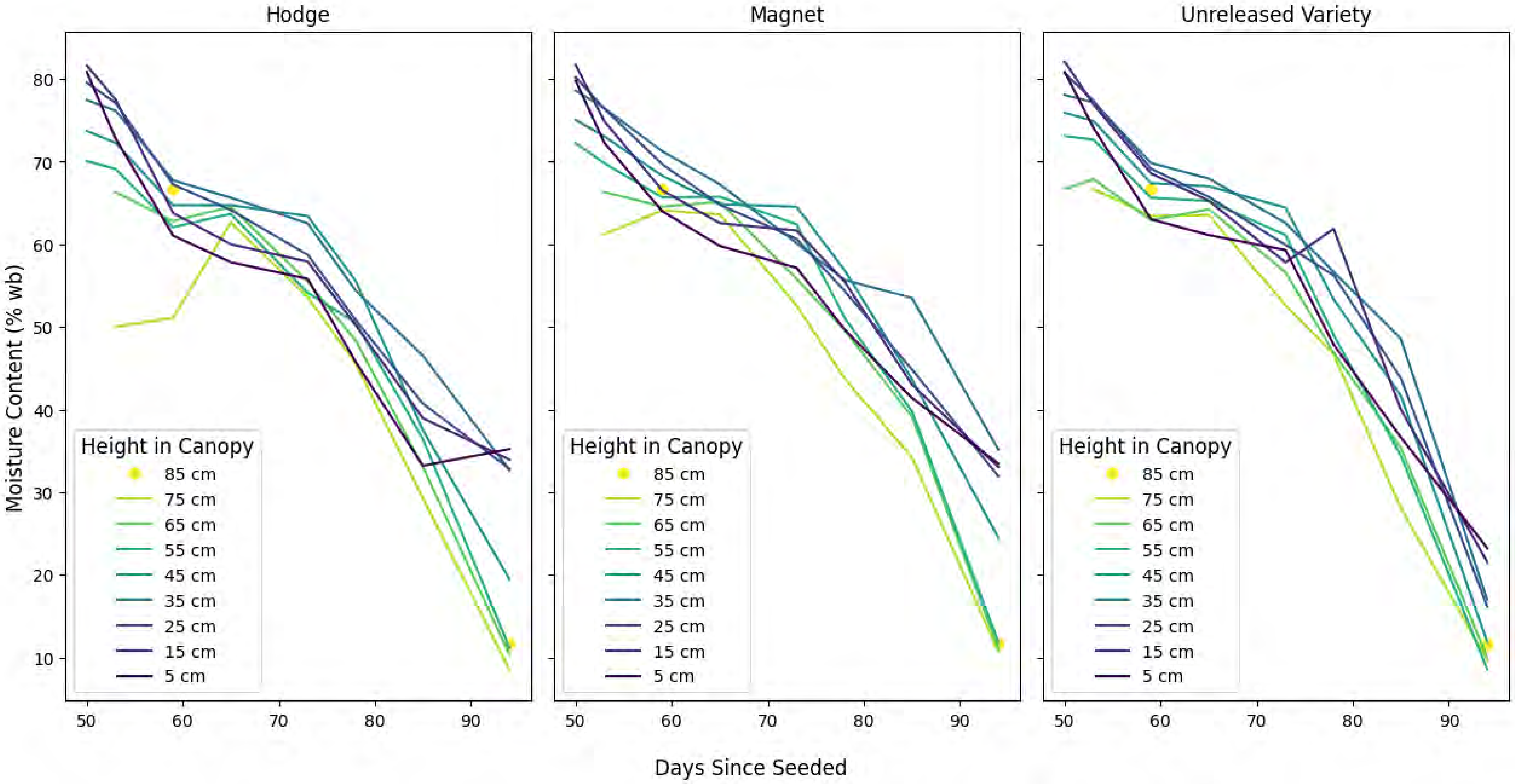
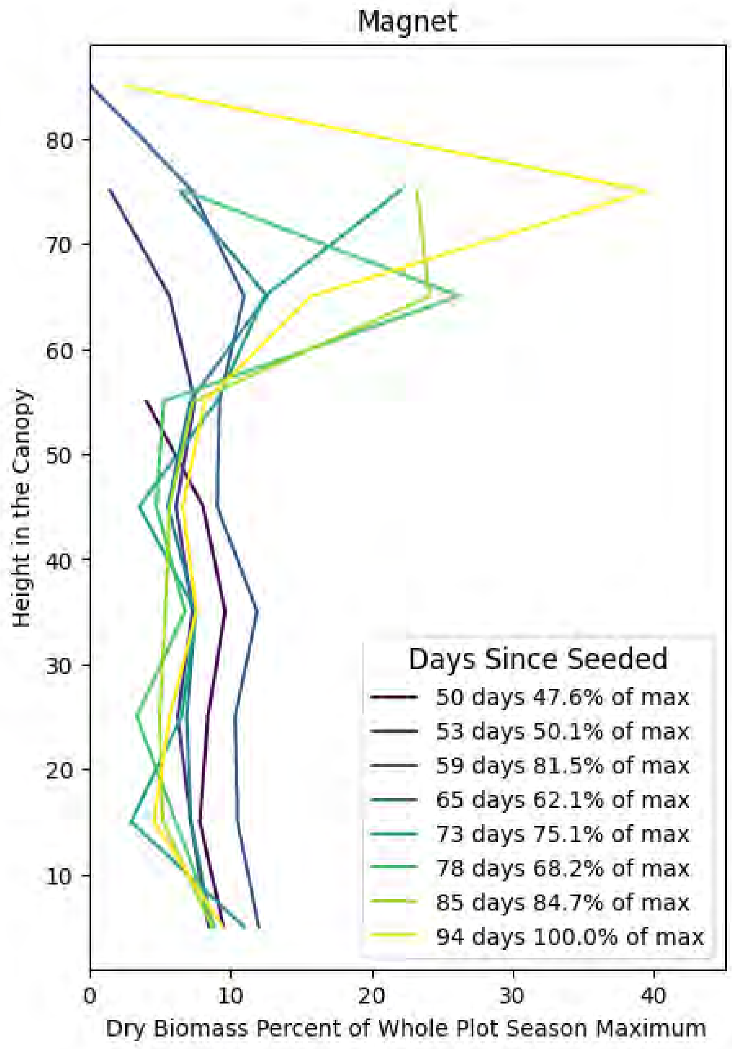
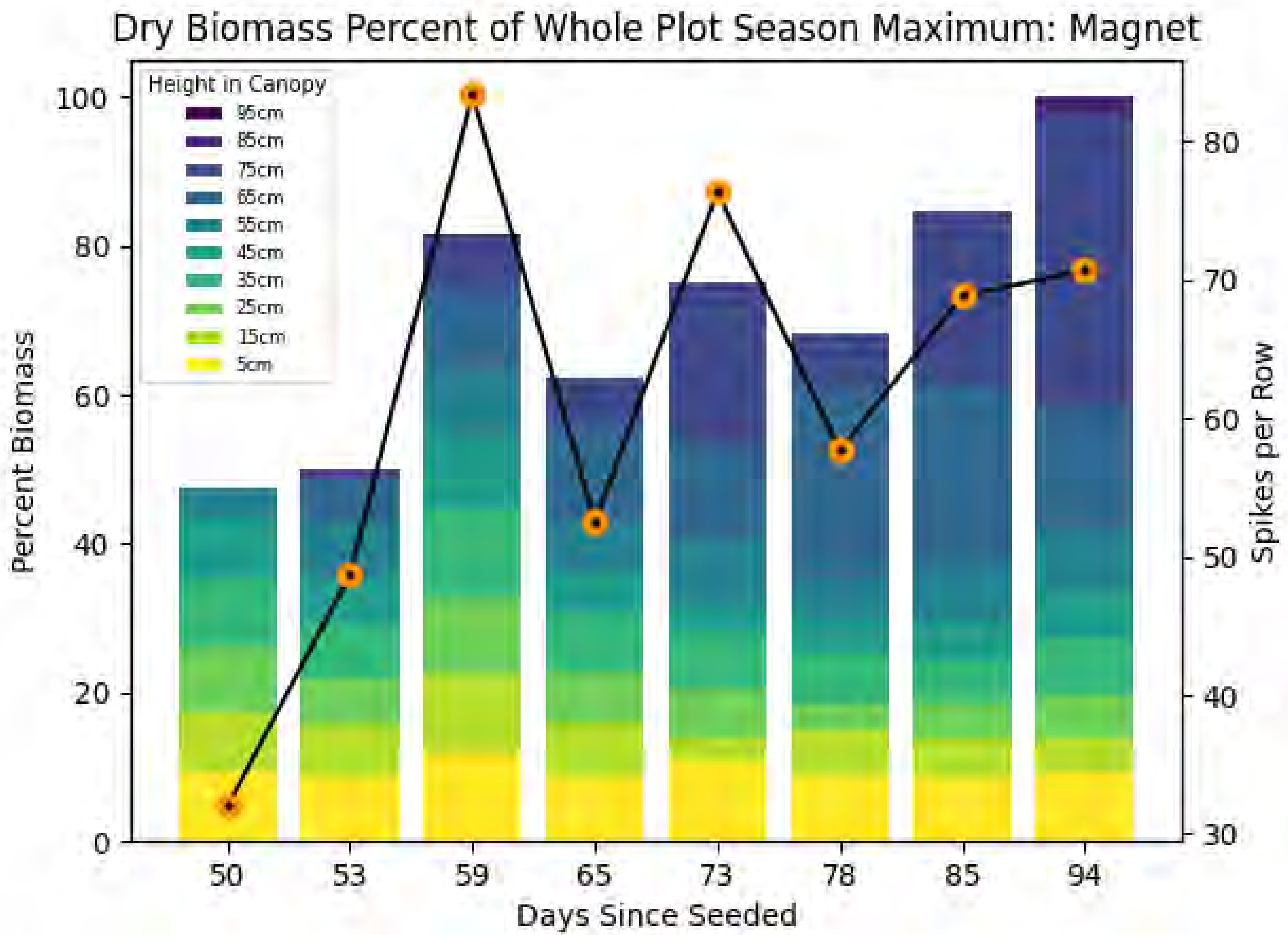
# Biomass - Vertical Moisture Content Partitioning




Kara Walz

# Nuances of Interpreting Biomass Data

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# Neighbours – The USask Advantage

Image Credit: Google/Airbus 2024

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# Acknowledgements


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