ISMB 2022 Panel: Digital Agriculture at Scale

Addie Thompson
Michigan State University
July 2022

Background

- Iowa State University
  - *B.S. Genetics*
- University of Minnesota
  - *Ph.D. Plant Breeding and Molecular Genetics*
- Purdue University
  - *Postdoc in maize/sorghum quantitative genetics and phenomics*

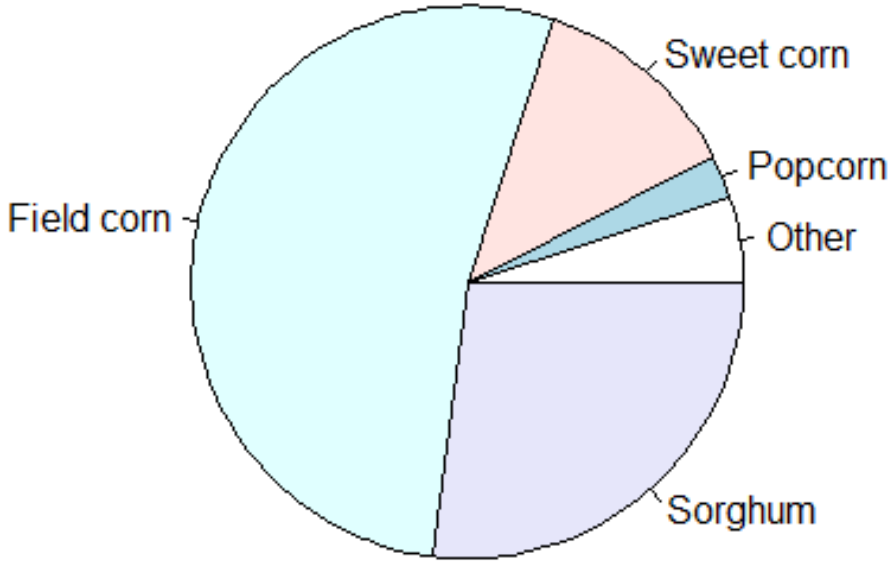
Current Appointment – Michigan State

Research

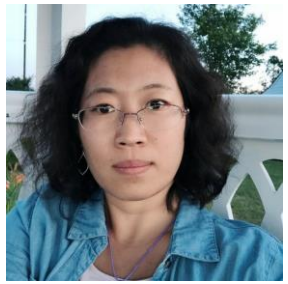
- **Genetic mapping and genomic prediction** for both basic (genetic mechanisms) and applied (plant breeding) outcomes;
- **High-throughput phenotyping** to increase efficiency and throughput of trait data collection; and
- **Innovation in modeling and prediction** approaches to maximize the impact of data and information.

Teaching

- Transdisciplinary skillsets and communication
- Hands-on, project-based, experiential learning
- Real-world job prep for graduate students



Current projects in maize and sorghum



Ruijuan Tan

Anuradha Singh

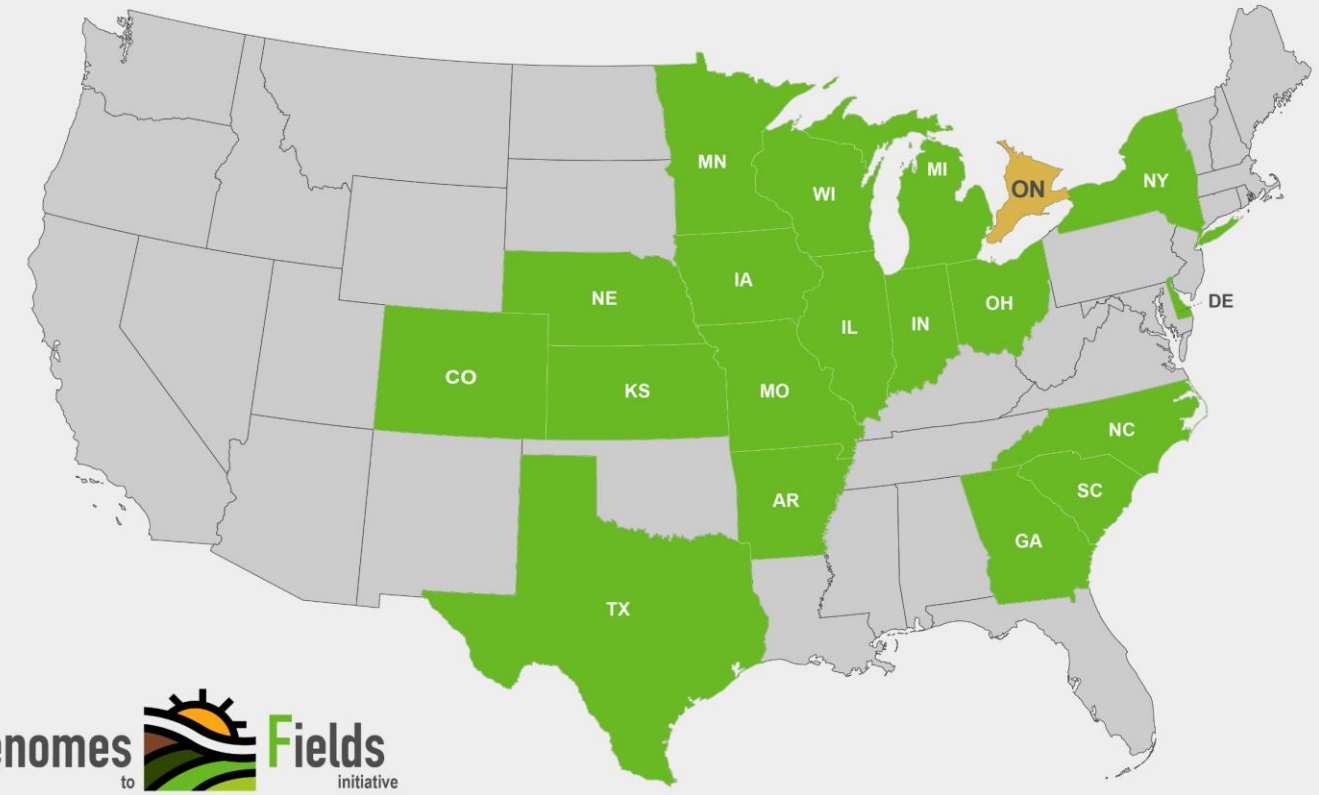
Zhongjie Ji

…painstakingly measuring thousands of plants

We get great datasets…but it is SO SLOW

2019 Academic & Federal Institutions

Arkansas State University
Clemson University
Colorado State University
Cornell University
Iowa State University
Kansas State University
Michigan State University
North Carolina State University
Ohio State University
Purdue University
Texas A&M University
University of Delaware
University of Georgia
University of Guelph
University of Illinois
University of Minnesota
University of Missouri
University of Nebraska
University of Wisconsin
USDA-ARS
Georg-August-Universität Göttingen
(Not shown on map)



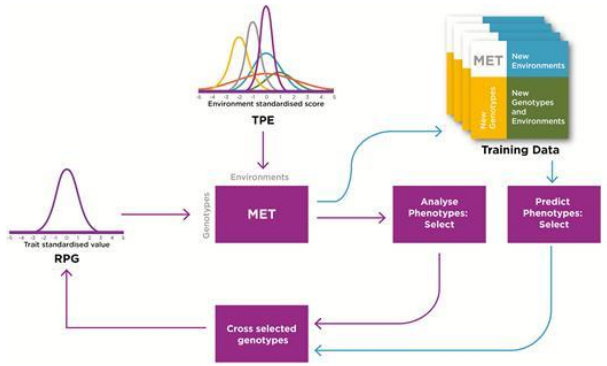
the Genomes to Fields initiative

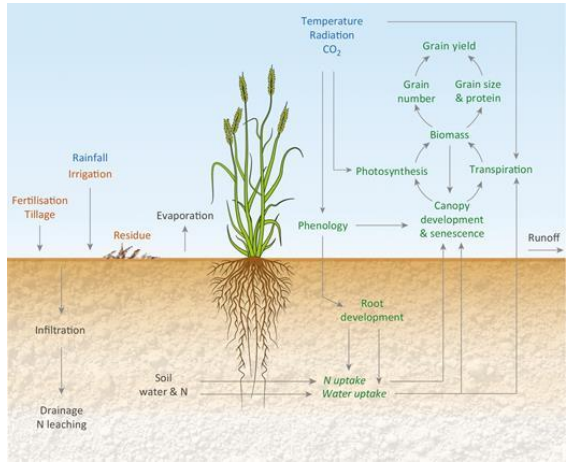
2019 GxE Principal Investigators and Academic & Federal Institutions in the United States and Canada

Our Big Question

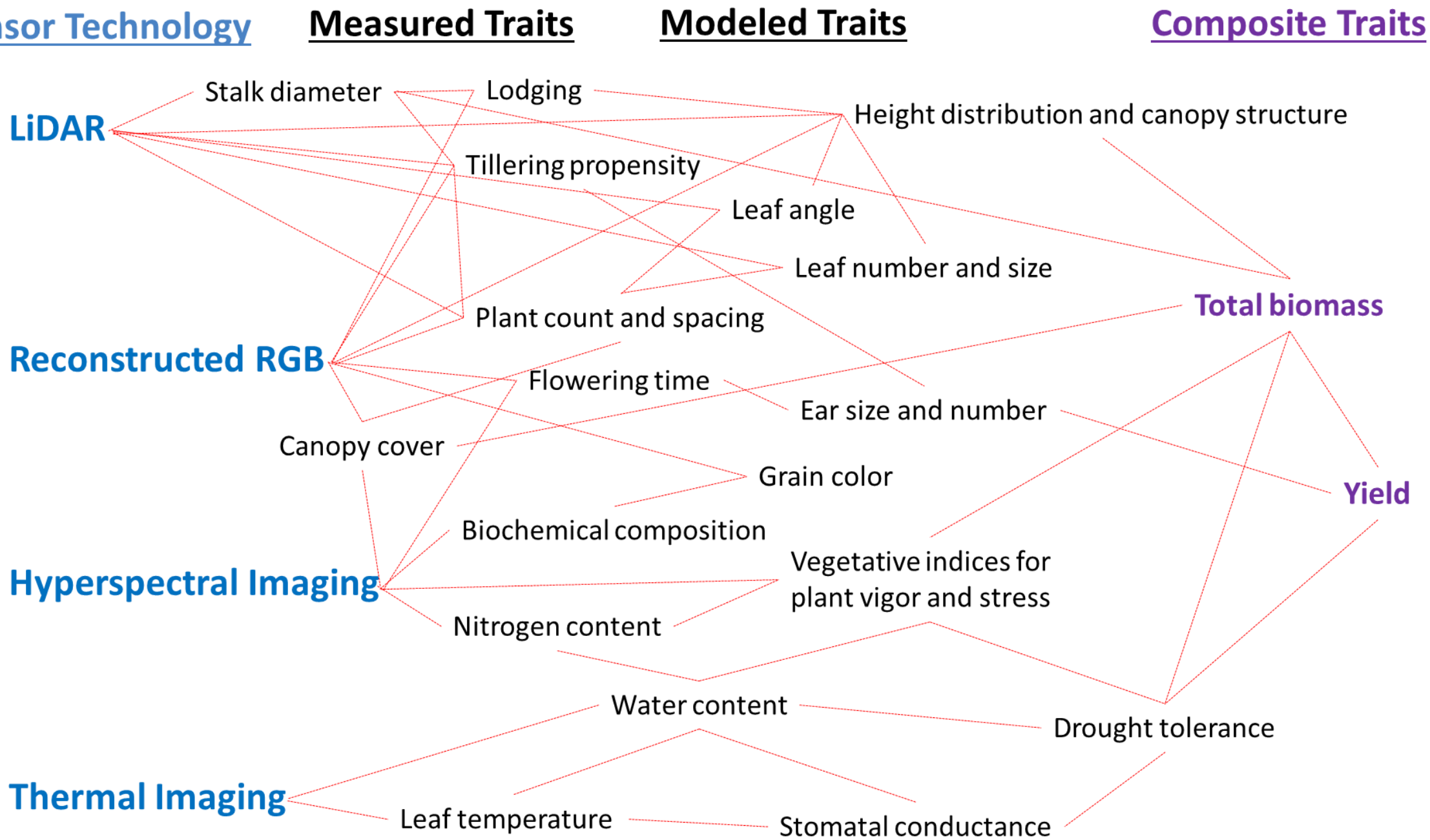
- From a plant breeding and genetics perspective, we want to predict how a variety will perform to assess its usefulness.
- We can use genetics to predict phenotype (Genomic Prediction), but this is does not perform well in new environments.
- We can use physiological modeling (Crop Growth Models) to simulate varieties in different environments, but this relies on many [tedious] hand-measured phenotypes to parameterize the models.

- ***Can we acquire those phenotypes some other way?***





Hammer, Messina, Wu, and Cooper, *in silico Plants*, Volume 1, Issue 1, 2019


Sensor Technology
Measured Traits
Modeled Traits
Composite Traits
LiDAR
Reconstructed RGB
Hyperspectral Imaging
Thermal Imaging
Stalk diameter
Lodging
Height distribution and canopy structure
Tillering propensity
Leaf angle
Leaf number and size
Plant count and spacing
Total biomass
Flowering time
Ear size and number
Canopy cover
Grain color
Yield
Biochemical composition
Vegetative indices for plant vigor and stress
Nitrogen content
Water content
Drought tolerance
Leaf temperature
Stomatal conductance

Our Team (2019)

Plant, Soil & Microbial Sciences


Thompson


Chilvers


Olson


Douches

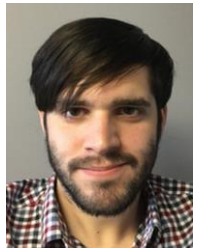
USDA-ARS

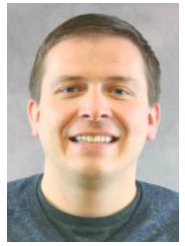

Weebade


Cichy

Horticulture


Brainard


VanBuren


Edger


Hollender


Hayden

Biochemistry and Mol. Bio.


Grotewold

Computational Math, Sci, and Eng


Xie


Shiu

MSU IT


Lim

Geography, Environ., & Spatial Sci.


Bunting

Statistics and Probability

de los Campos

Electrical and Computer Eng.


Biswas


Morris

Comp Sci & Eng


Liu


Ross


Tong

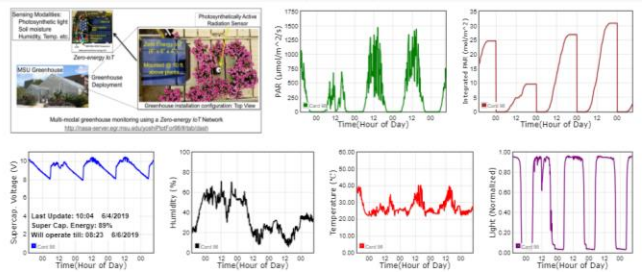

Tang

Our Vision (2019)

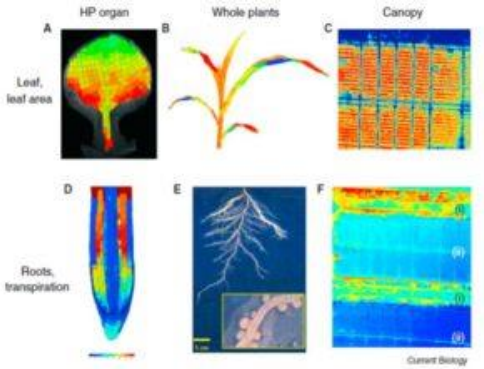
Multi-scale platforms

Commercial sensors

Network protocols for data collection



Big data, predictive analytics, machine learning and AI

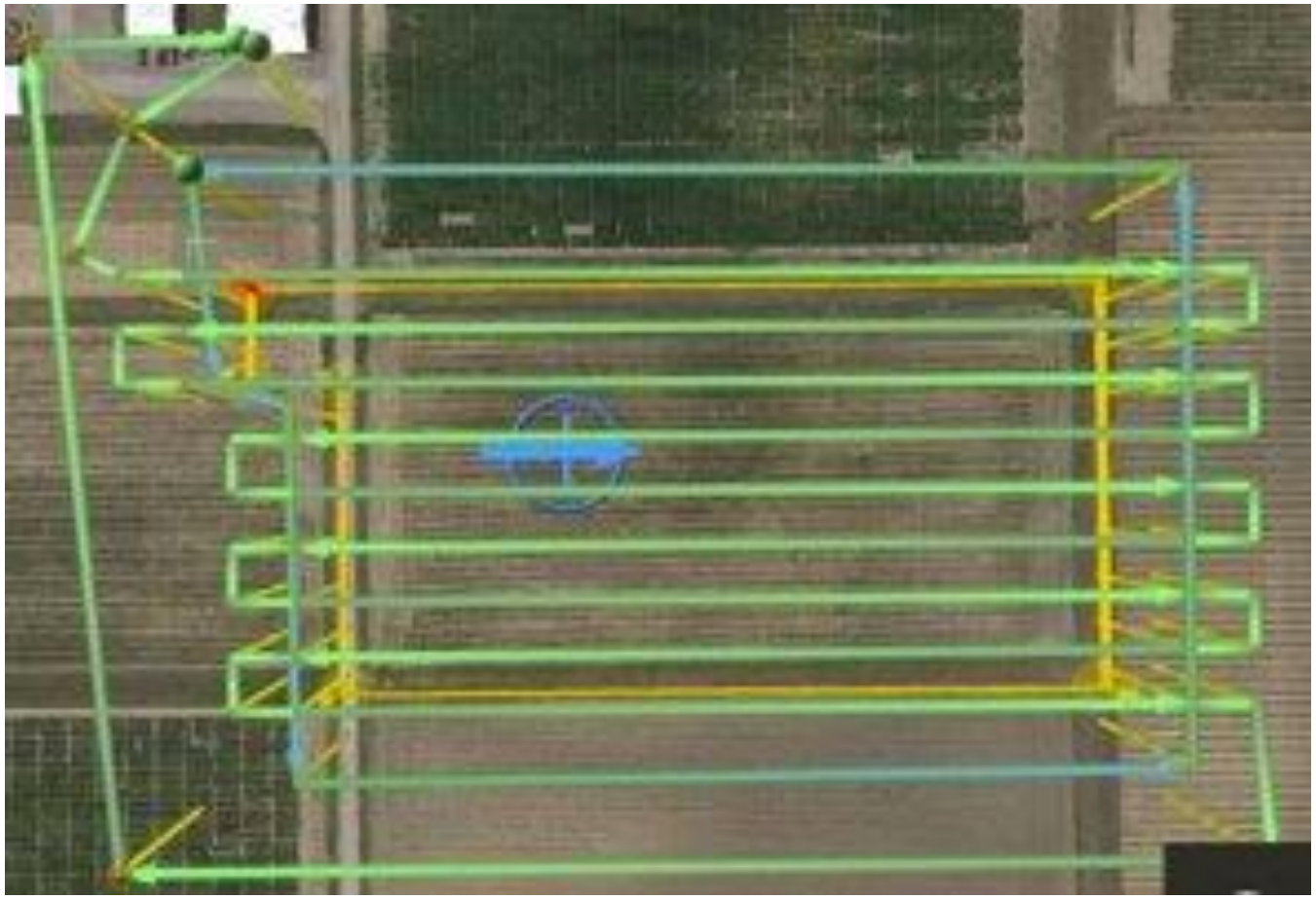


Enhanced outcomes for plant science and breeding

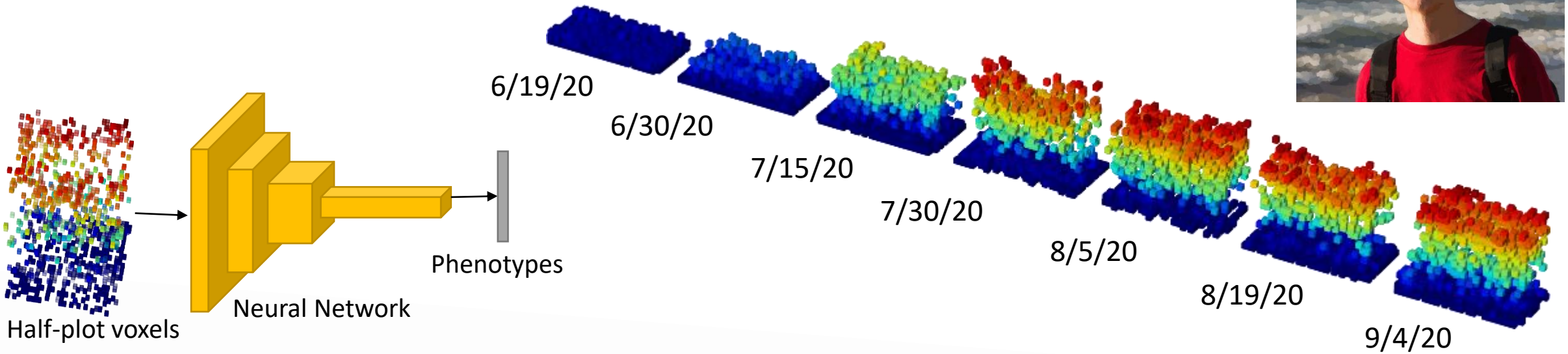
Image Credits: Fruit Grower News; Royal Brinkman; Tardieu 2017; Biswas; Olsen; PRI; Douches; Chilvers

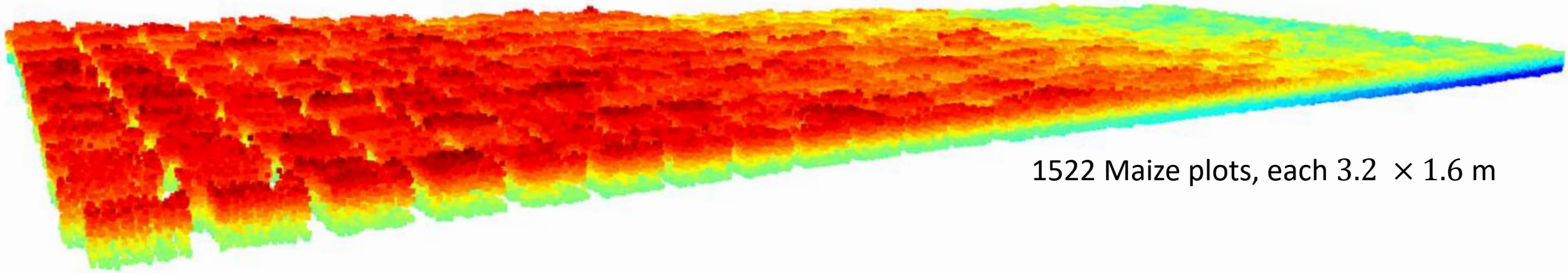
UAV-Measured Data

- LiDAR, VNIR-SWIR, RGB, MultiSpec



Using LiDAR data to predict plant traits

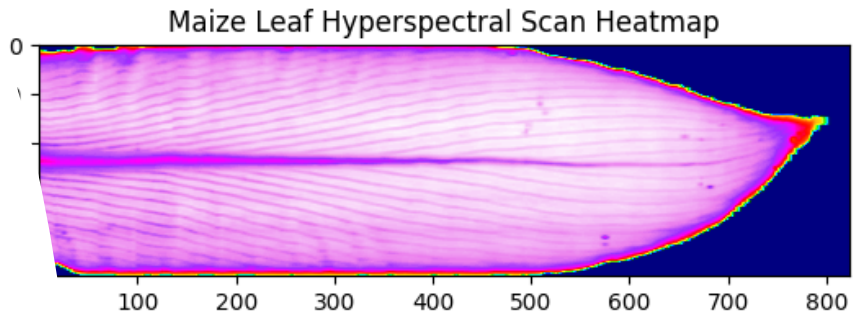


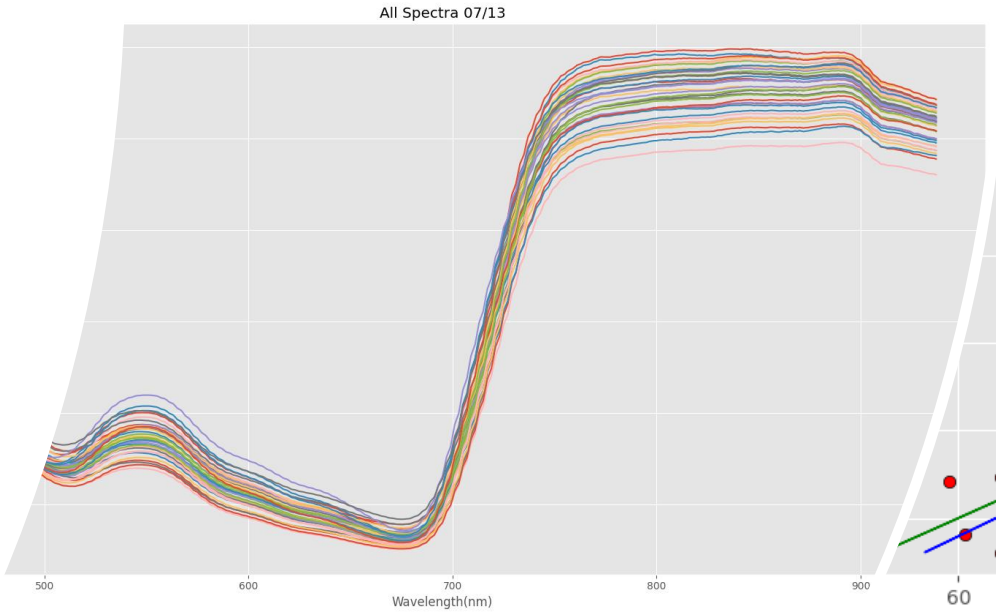


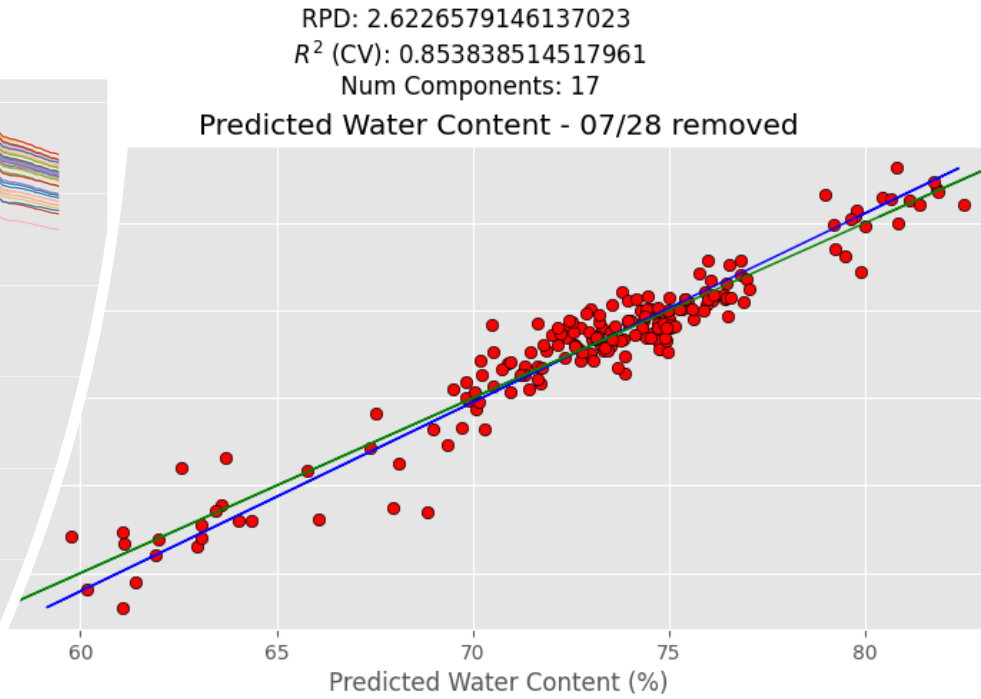
1522 Maize plots, each 3.2 × 1.6 m

Training computers to “see” plant physiology

- Reflected and transmitted light changes based on biochemical properties
- Machine learning techniques to train and predict important traits

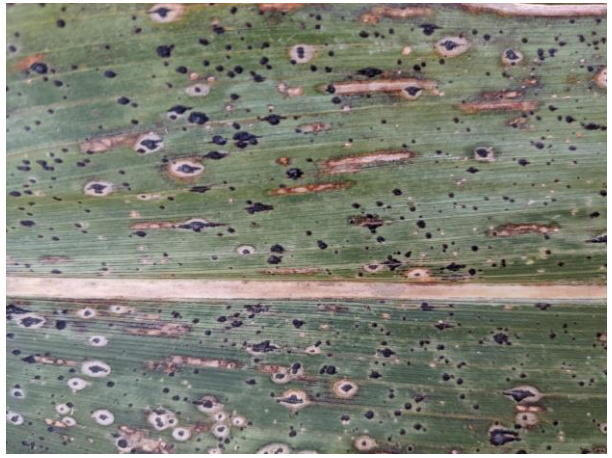






Improving detection of onset and severity of tar spot disease in maize

- Collect data throughout the season and relate back to disease onset and severity
- Can we identify disease before it is abundantly visible in the field?
  - Enables more management options



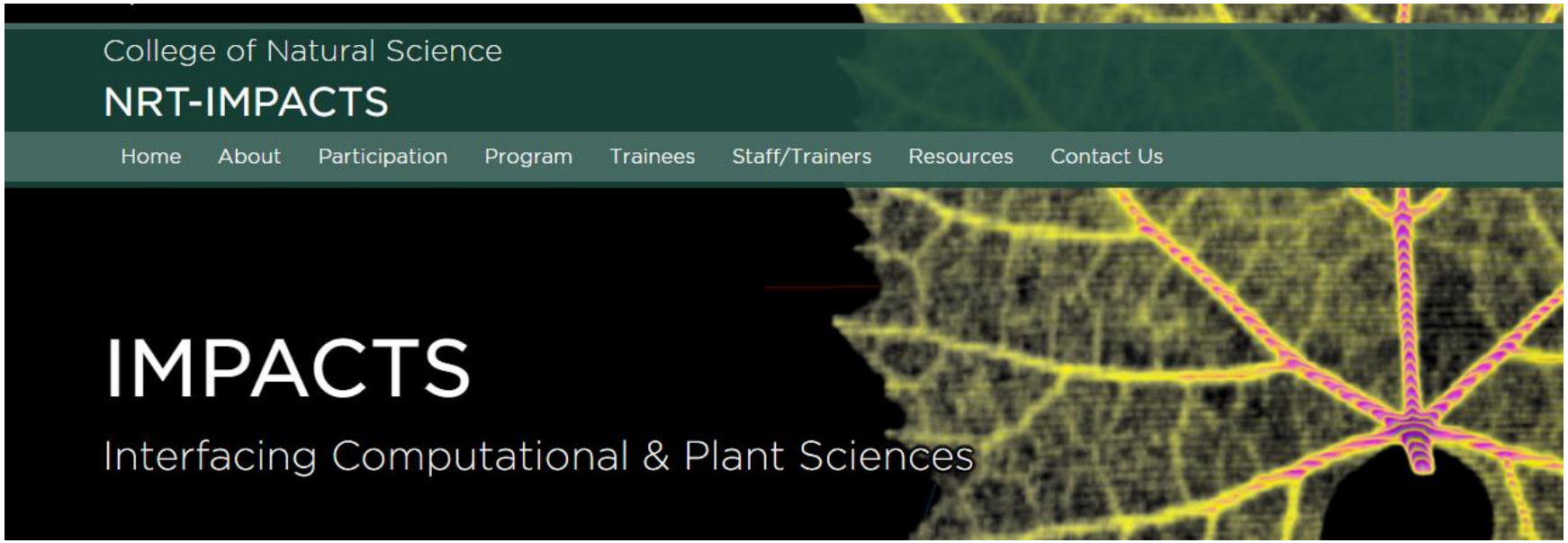
Other Research Projects

- Multi-objective genomic mating optimization for breeding programs
- Physiological impacts of N and biostimulant
- Functional genomics and modeling in sorghum
- Assessment and prediction of flavonoid content in maize kernels and leaves

Collaboration | Communication | Creativity

"The world needs different kinds of minds to work together. When different kinds of minds work together effectively, there can be great successes. They complement each other's skills." – Temple Grandin

- Find common language with collaborators – this can take time

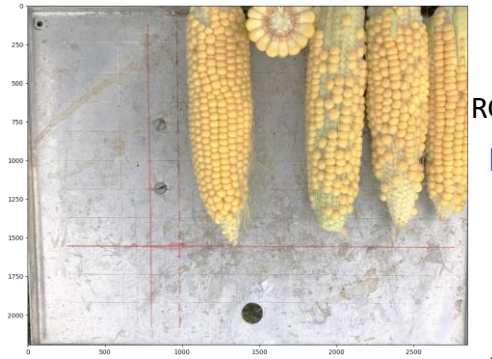


CSS 844:
Project-oriented
Team-based
Interdisciplinary
Communication skills

From xkcd

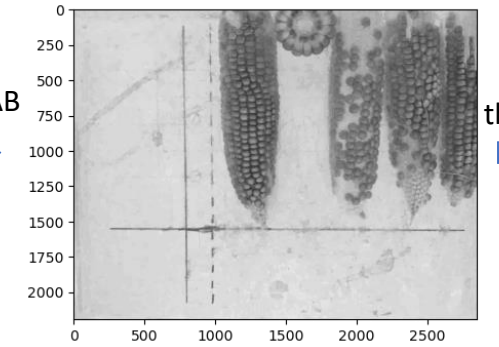
CSS 844: Frontiers in Computational and Plant Sciences – Spring 2021 Module 2

Cropped Image

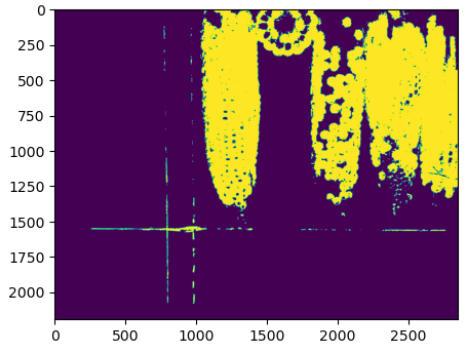


RGB to LAB

Blue Channel

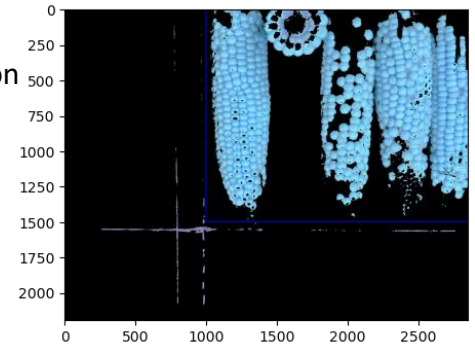


threshold

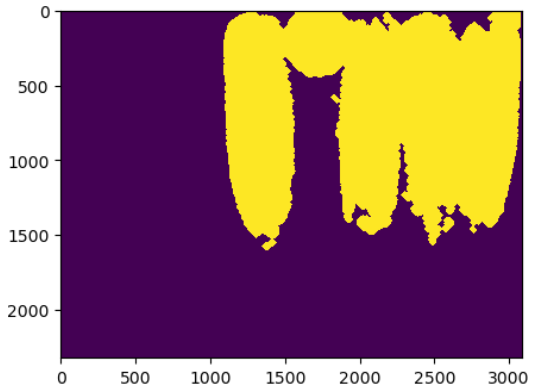


Apply mask
Define region of interest

Area of ears with kernels



Total area of ears



Total area of Ears –
Area of ears with Kernels =
Total Blank Fill

AG2PI
Agricultural Genome to Phenome Initiative

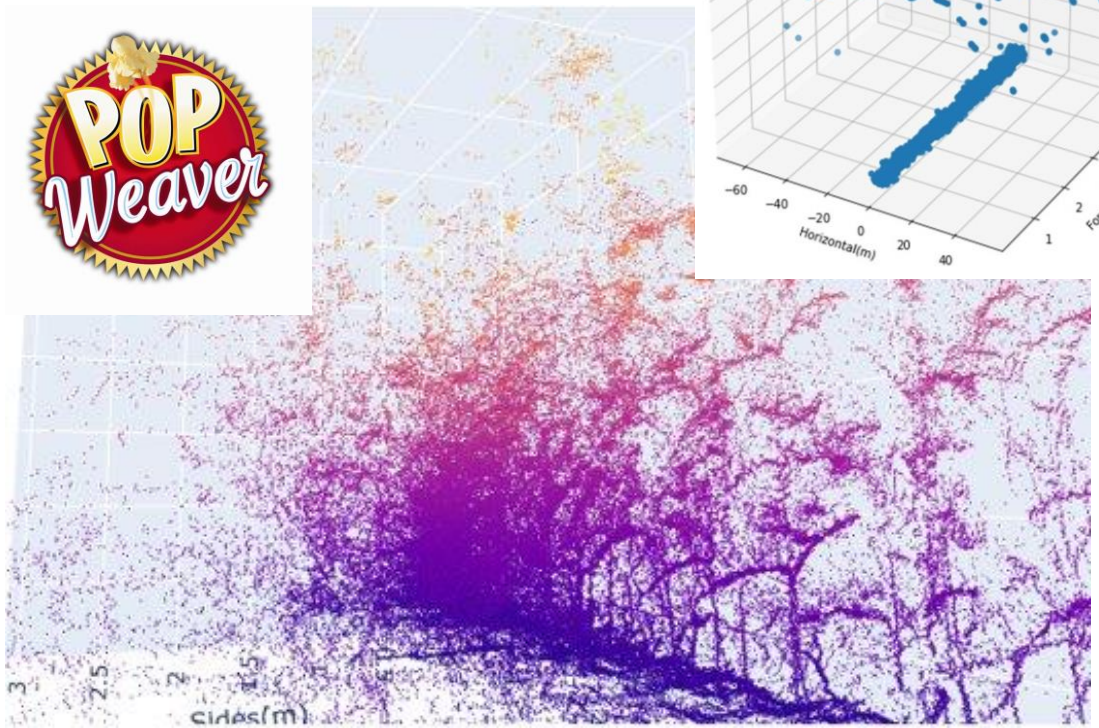
syngenta®



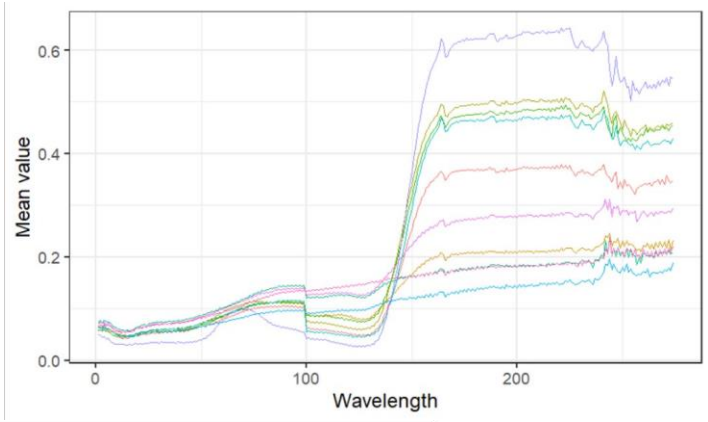


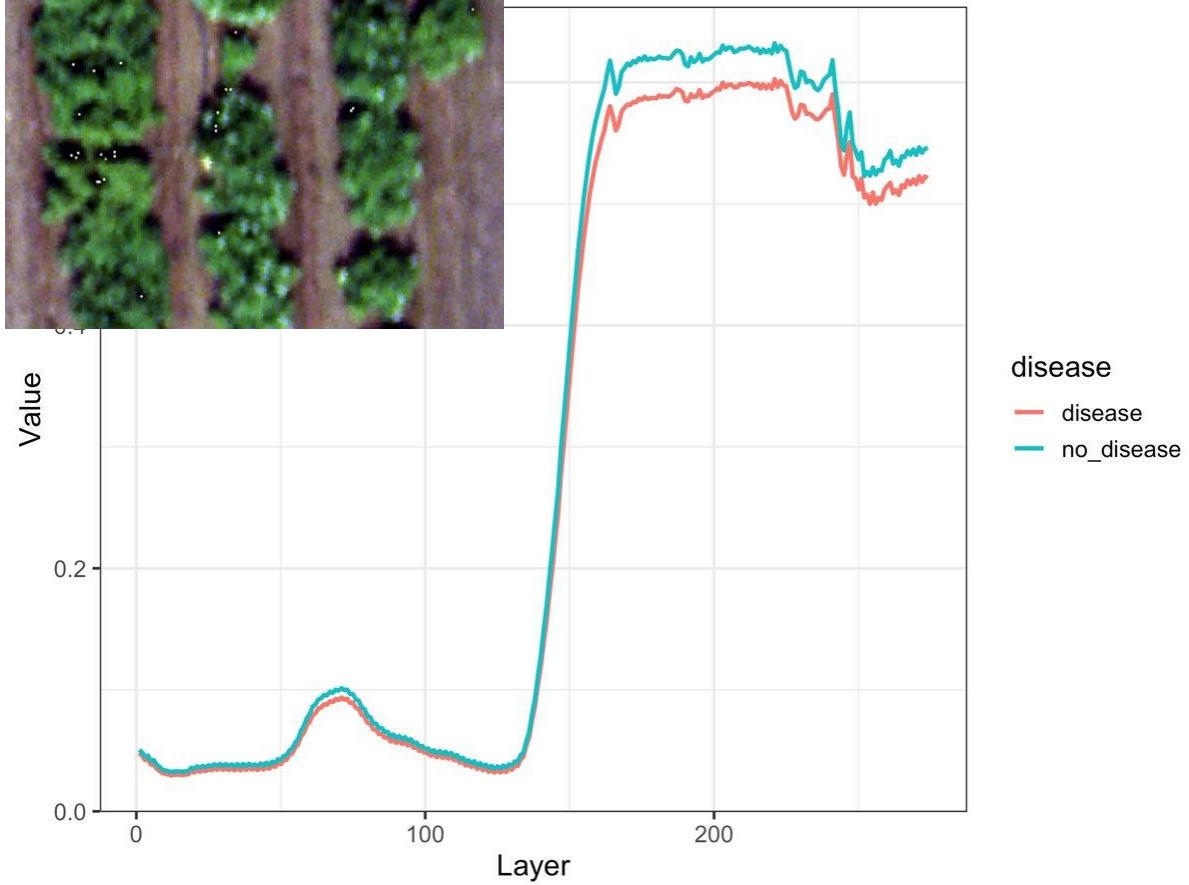
IMPACTS; CANR PSM: Thompson; CNS CMSE: Colbry; Syngenta

2022: Module 2



Asia Hightower, Brandon Webster, Joanne Thomson, & Nick Johnson





Kara Dobson, Sidney Sitar, MacKenzie Jacobs, Claudia Miranda

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2021 GRANTS4AG AWARDEES
Bayer Crop Science

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Strategic Partnership Grant
Research and Innovation
MICHIGAN STATE UNIVERSITY

MICHIGAN STATE UNIVERSITY | AgBioResearch

U.S. DEPARTMENT OF ENERGY | Office of Science

Thank You