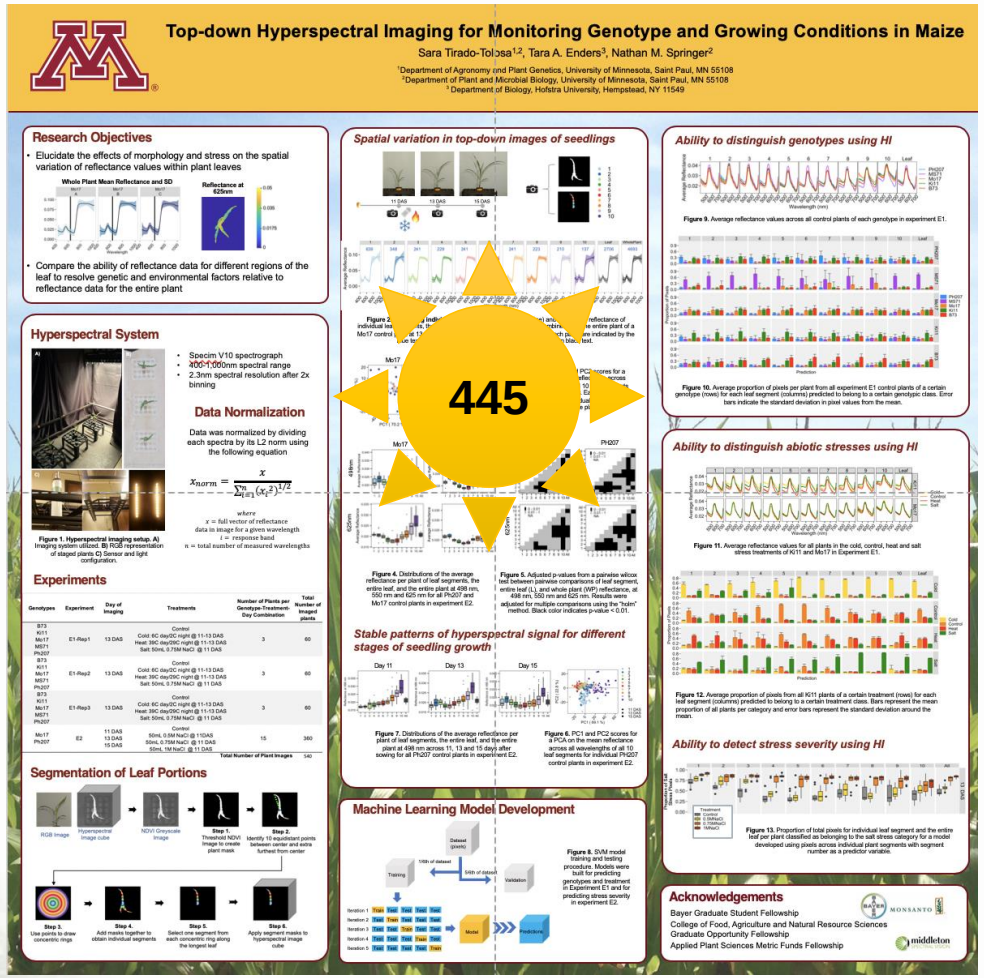
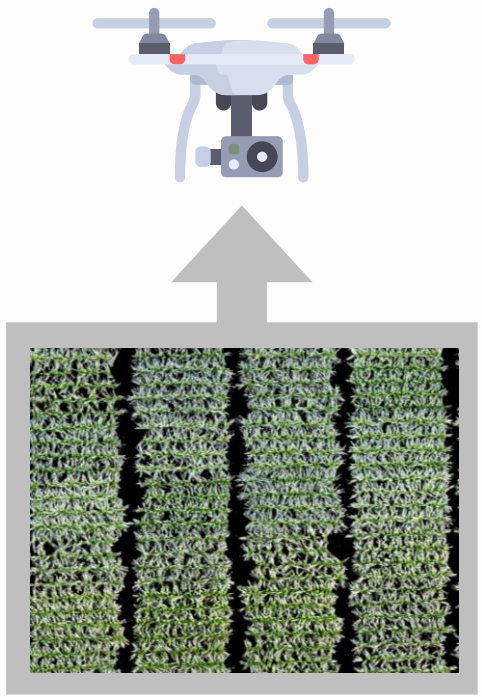
CHARACTERIZING GENETIC AND ENVIRONMENTAL IMPACTS ON MAIZE USING PHENOMIC APPROACHES

SARA TIRADO

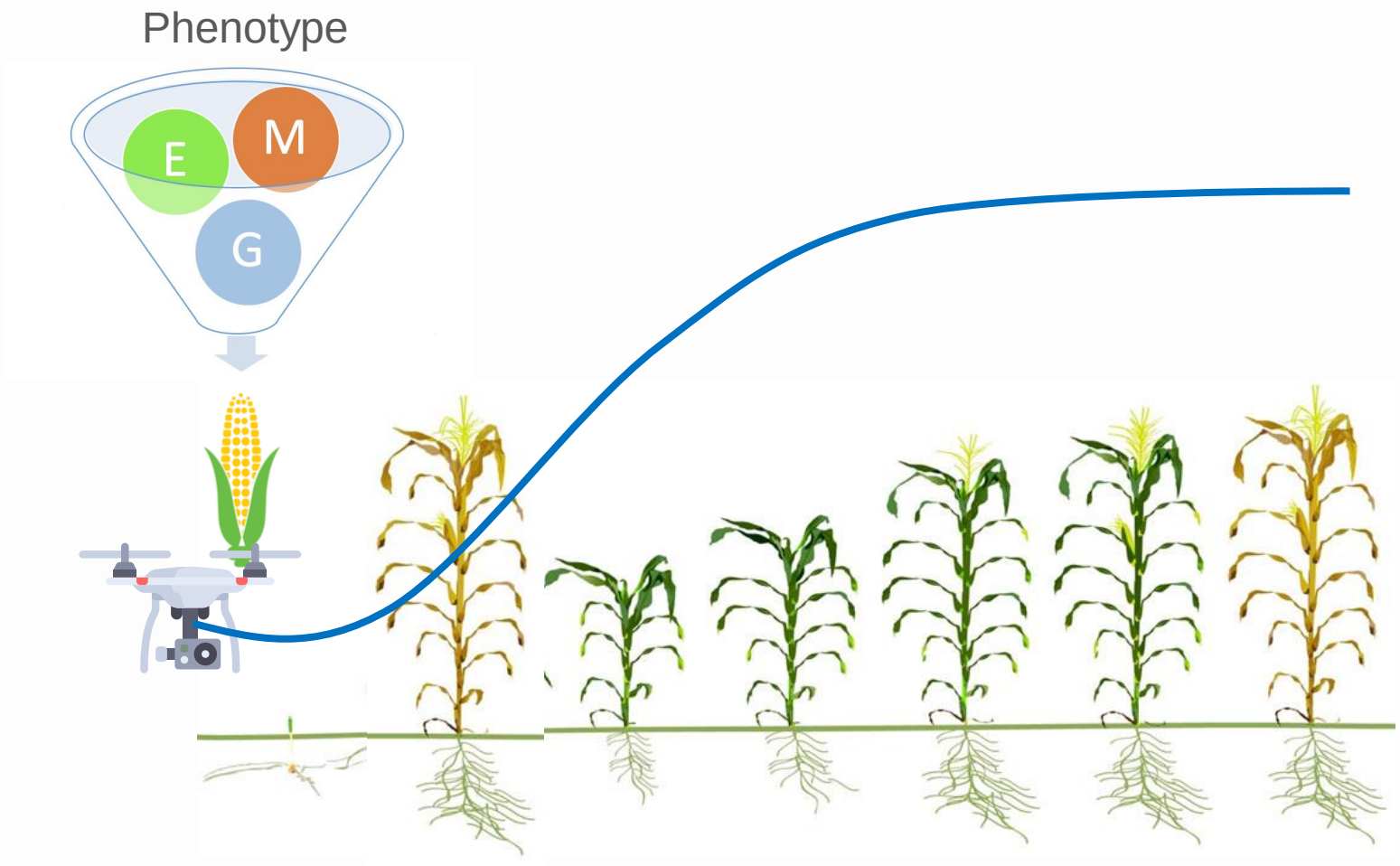
Using phenomic approaches for monitoring genotype and growing conditions in maize



RGB UAV imaging



Temporal phenotypic data can advance our understanding of end-season productivity

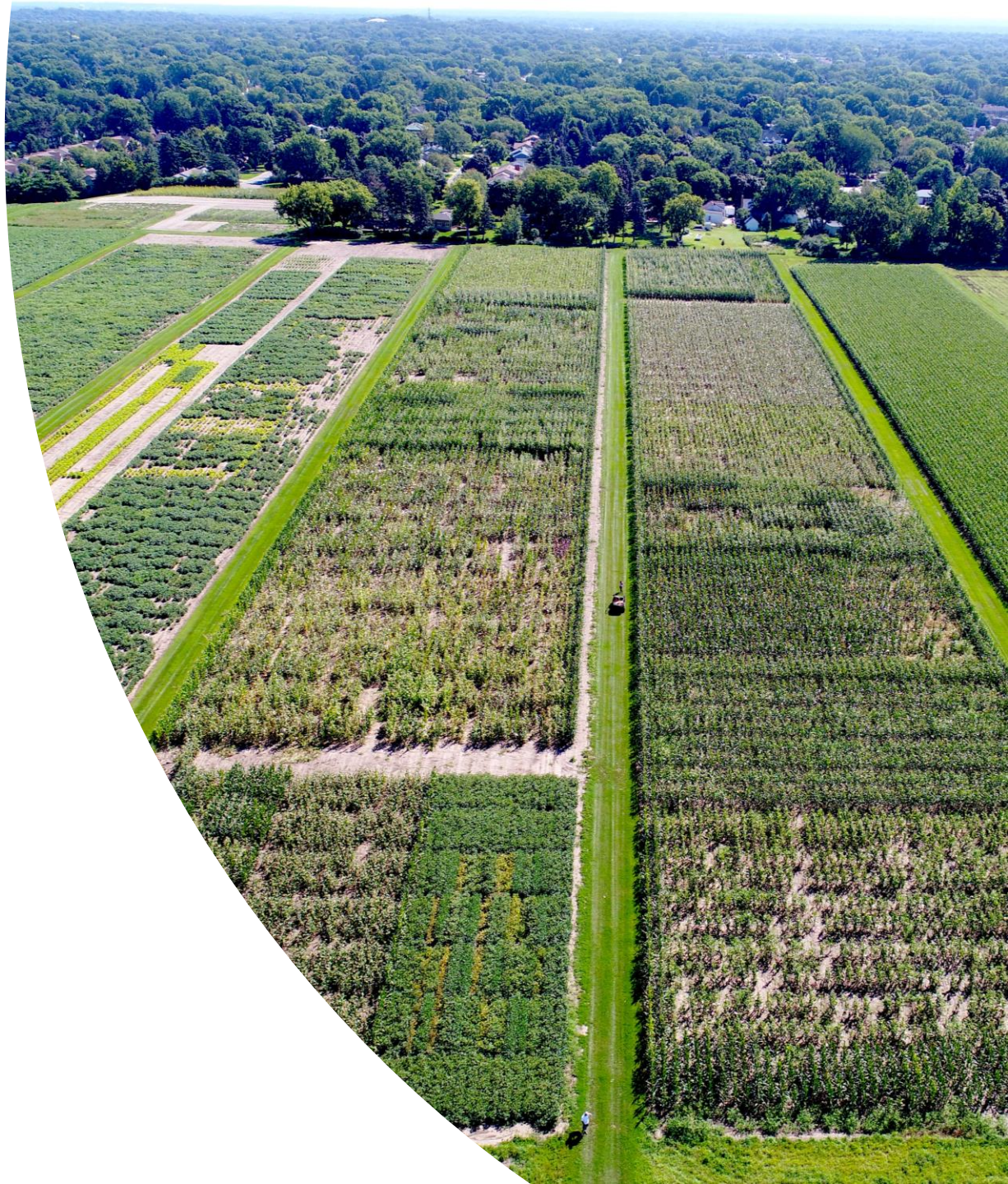


Project Aims:

1. Develop procedure for extracting traits using drone imagery

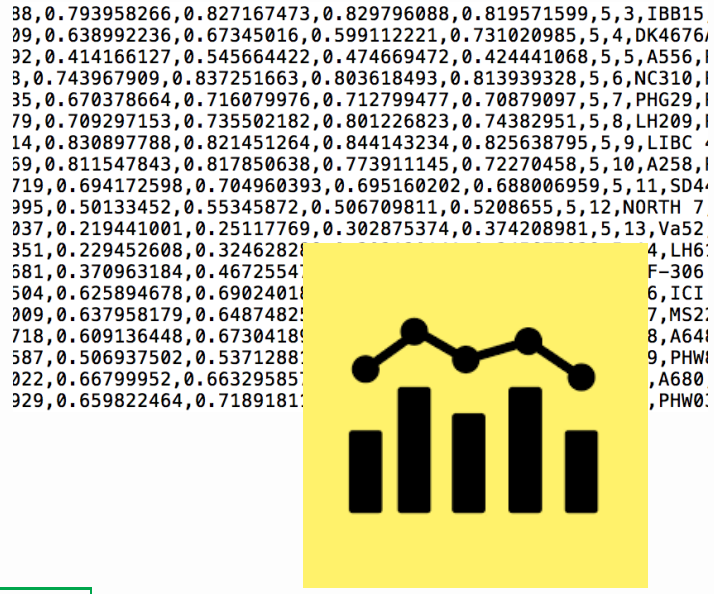
2. Use HTP for understanding a plant's reaction to E+M in terms of in-season growth and end-season productivity

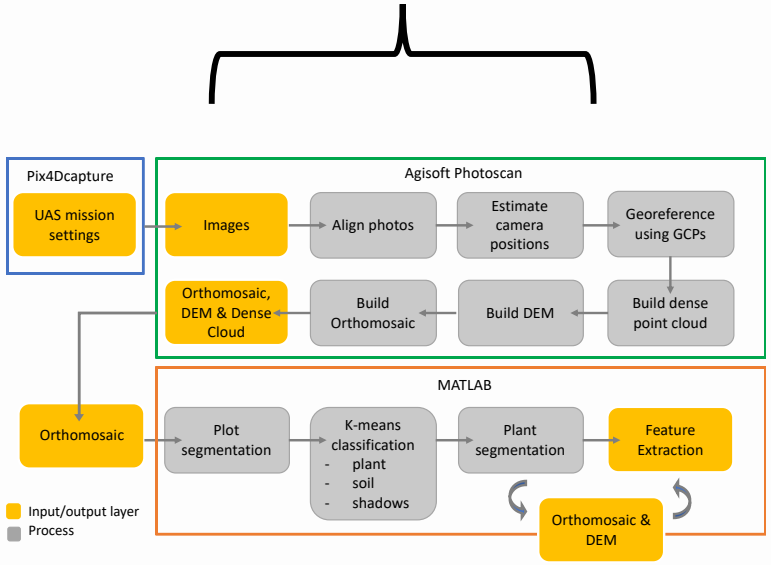
3. Use HTP to get a better understanding of different factors that affect lodging severity and recovery in maize nurseries

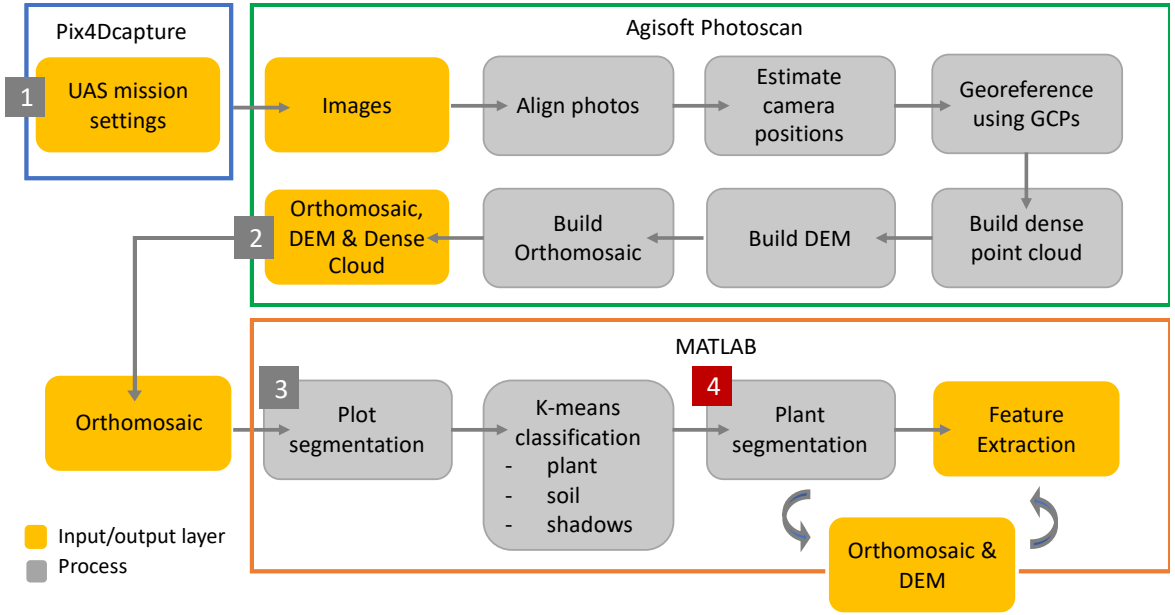


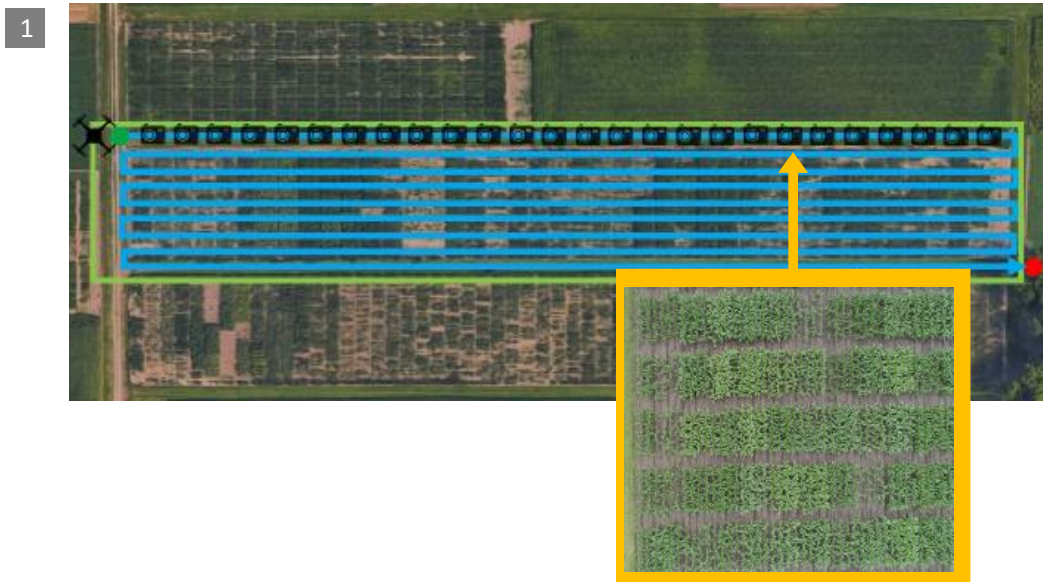
How do we go from drone imagery to meaningful data?

???






Pix4Dcapture
1
UAS mission settings
Agisoft Photoscan
Images
Align photos
Estimate camera positions
Georeference using GCPs
2
Orthomosaic, DEM & Dense Cloud
Build Orthomosaic
Build DEM
Build dense point cloud
MATLAB
Orthomosaic
3
Plot segmentation
K-means classification
- plant
- soil
- shadows
4
Plant segmentation
Feature Extraction
Orthomosaic & DEM
Input/output layer
Process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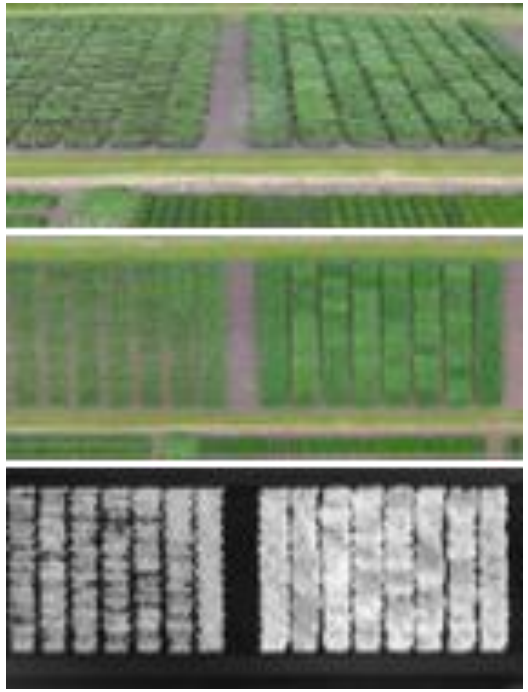
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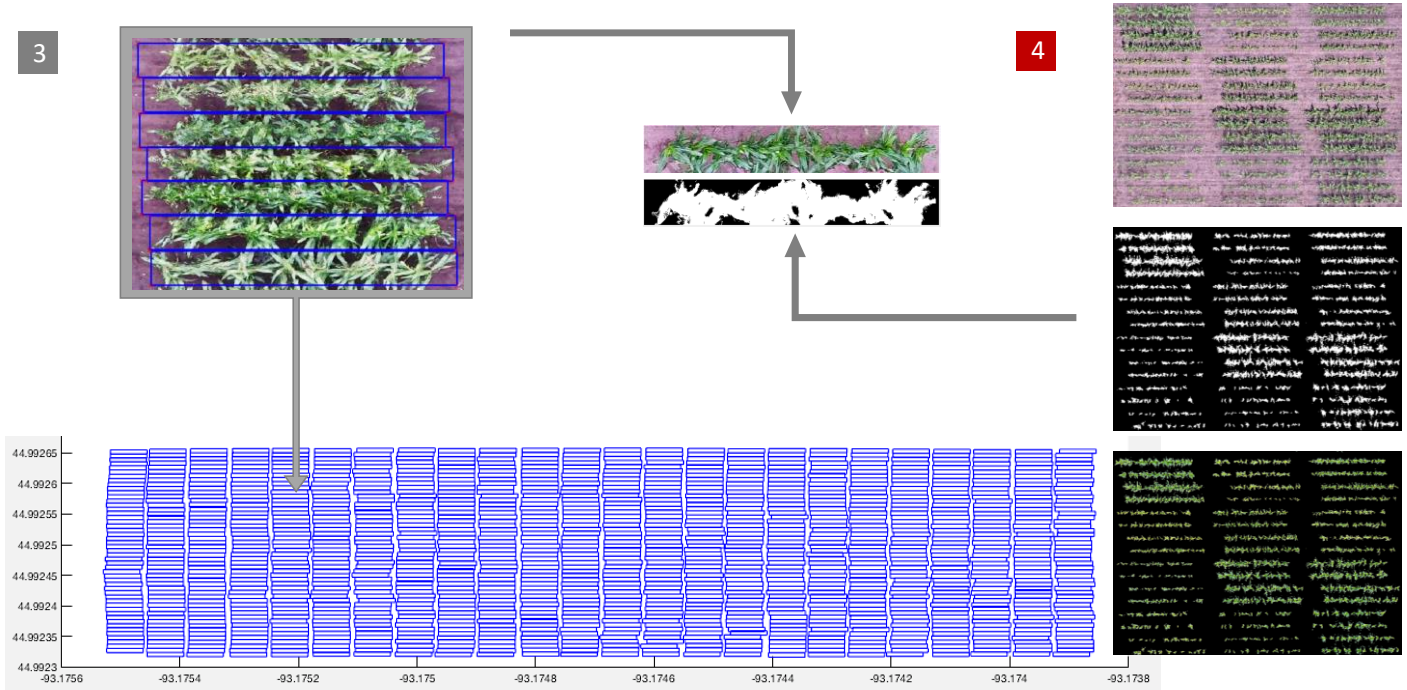
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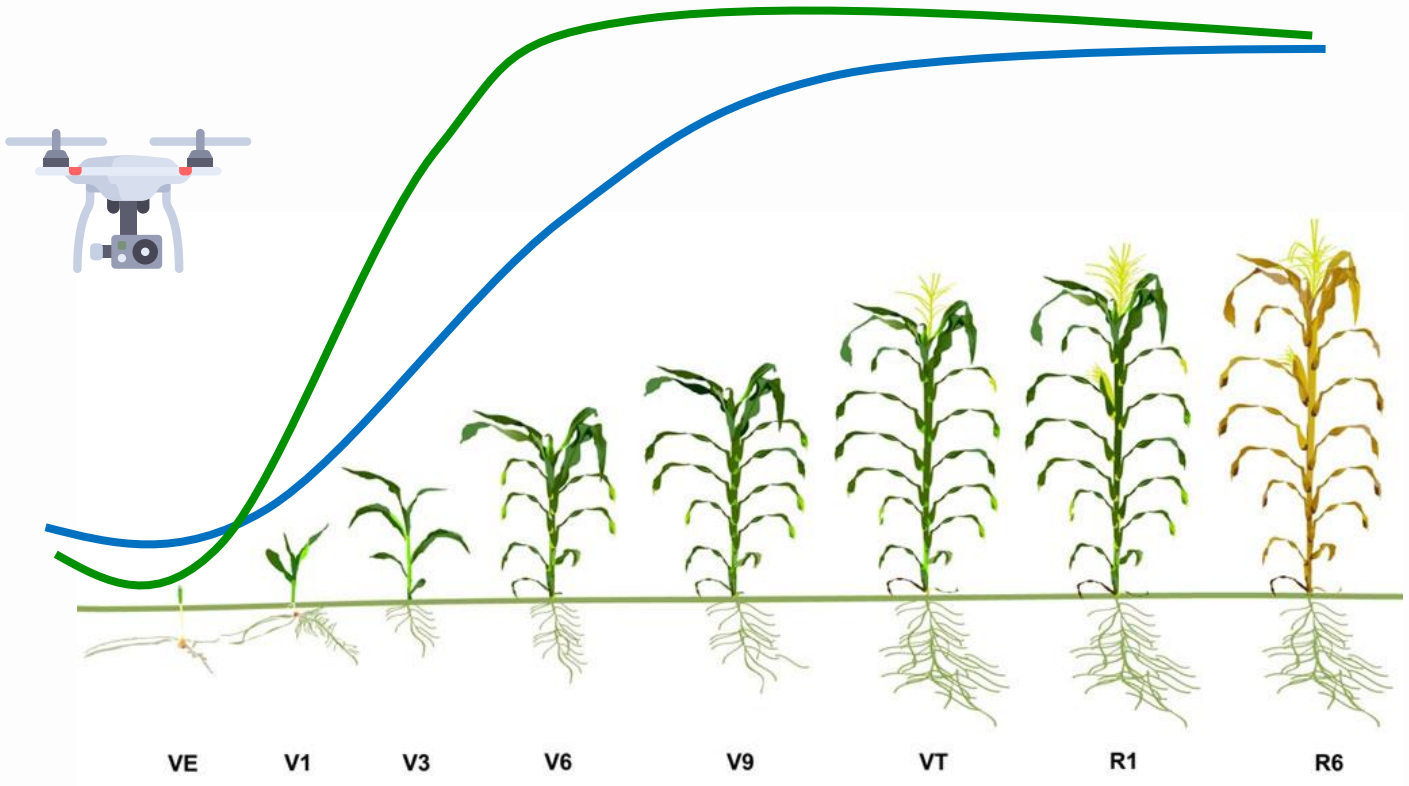
-93.1754
-93.1752
-93.175
-93.1748
-93.1746
-93.1744
-93.1742
-93.174
-93.1738

What phenotypic traits can we get?

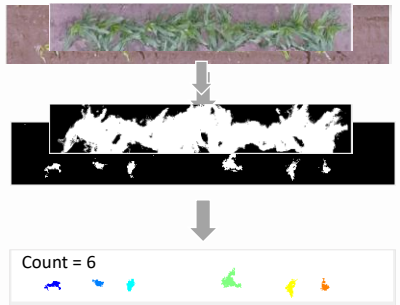


Stand Counts
Plant Rotation

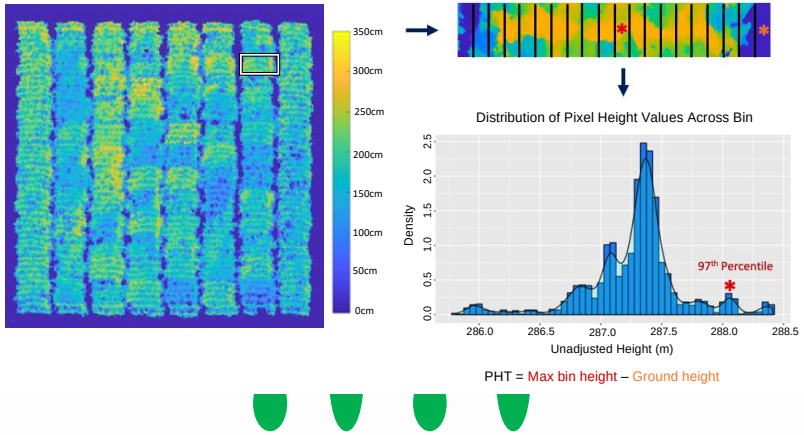
Flowering

- Canopy Closure
- Plant Height
  Plant Color

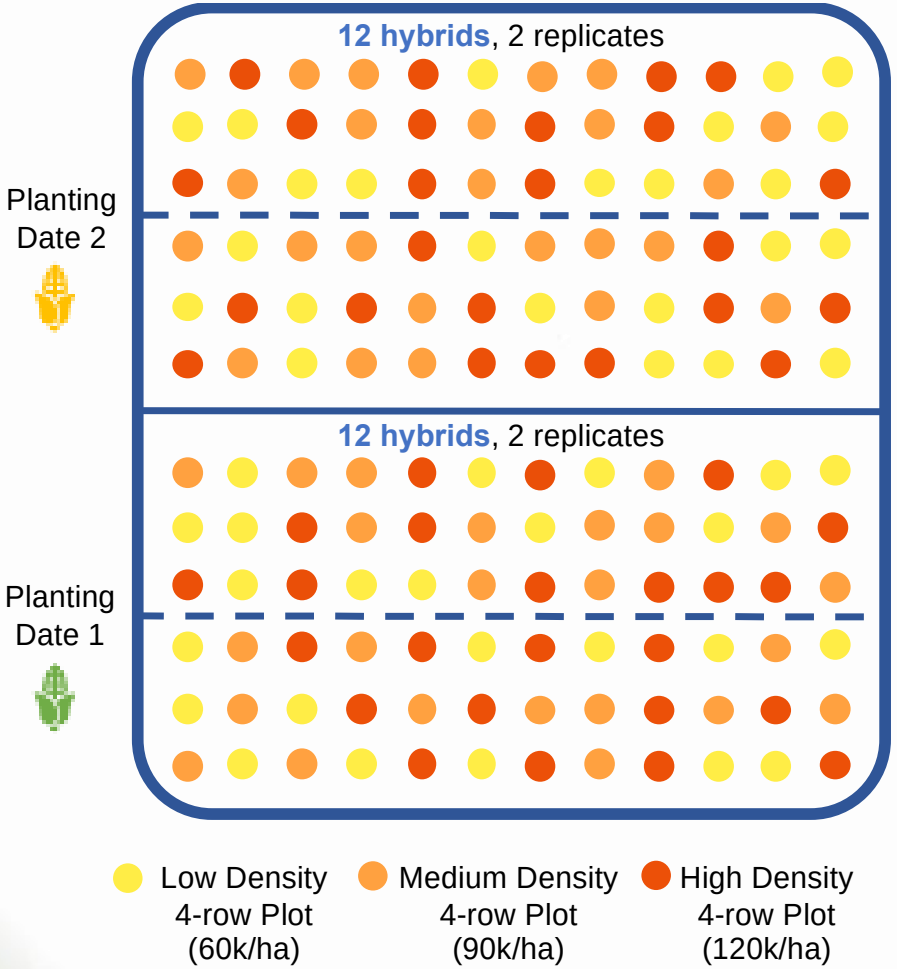
Canopy Closure



Plant Height
Plant Rotation

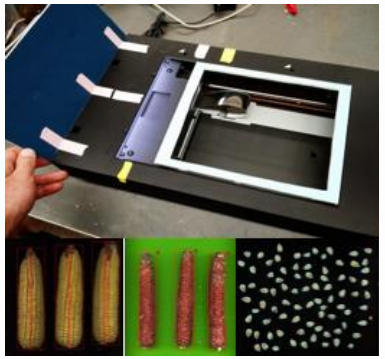


Experimental Design for 2018 and 2019

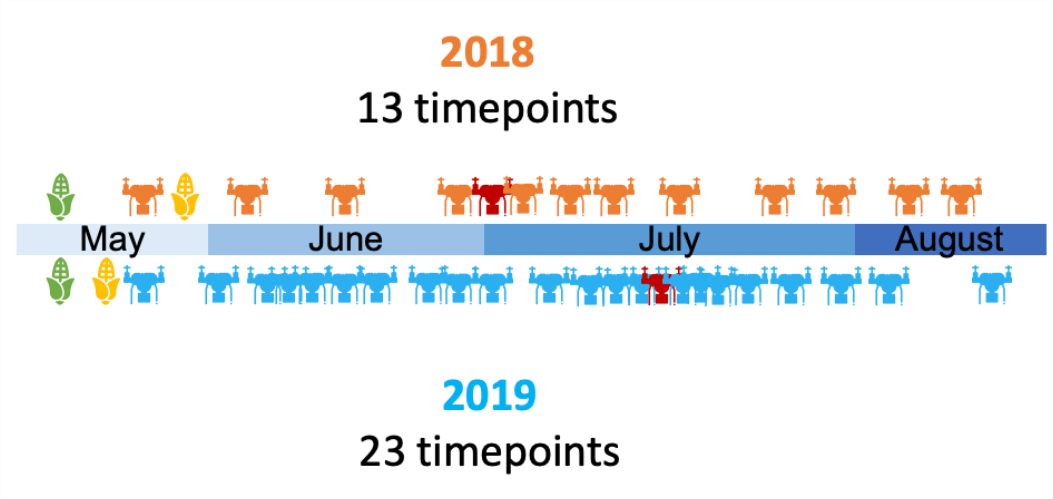


Data collection:

- Weekly trait data
  - Drone platform
  - Hand measurements
- Environmental Data
  - Weather station
  - Soil tests
- Yield
- Ear-cob-kernel traits

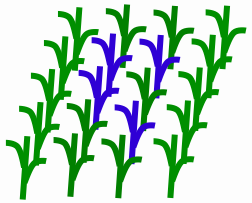


Miller et al., 2016

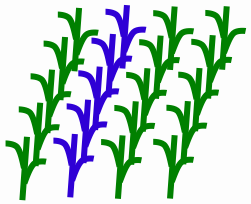


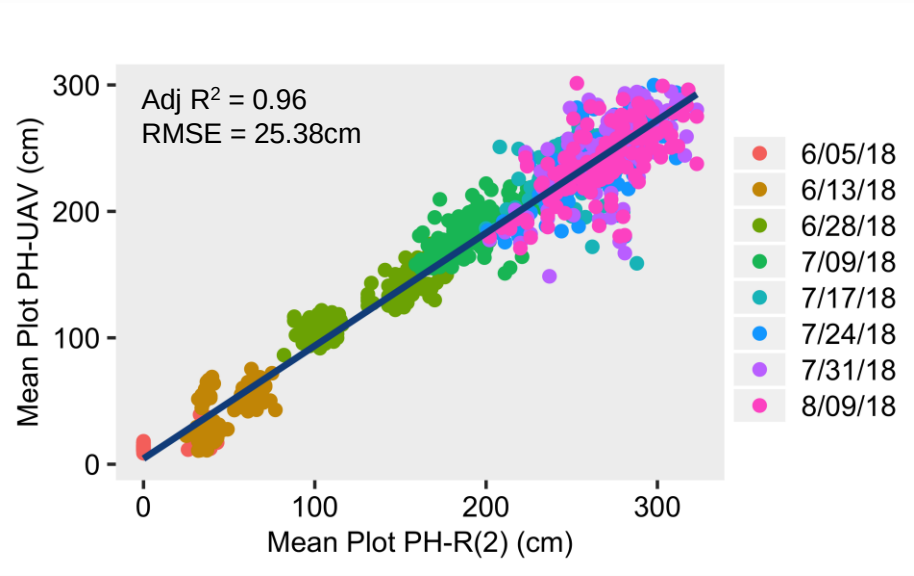
Accuracy of UAV-derived height is variable throughout development

PH-R(2) Hand-measurements



PH-R(All) Hand-measurements



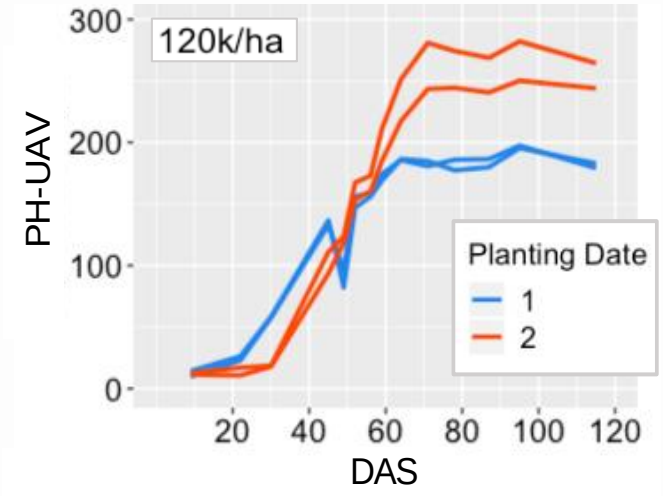


	PH-UAV to PH-R(2)		PH-UAV to PH-R(All)	PH-R Subsample Replicates
	Planting Date 1	**Planting Date 2**	**Planting Date 1**	**Planting Date 1**
	Adj R2	**Adj R2**	**Adj R2**	**Adj R2**
6/5/18	0.06	NA	0.21	0.32
6/13/18	-0.01	0.11	0.40	0.20
6/28/18	0.32	0.09	0.47	0.48
7/9/18	0.24	0.26	0.35	0.18
7/17/18	0.09	0.31	0.20	0.42
7/24/18	0.33	0.17	0.49	0.51
7/31/18	0.20	0.14	0.69	0.32
8/9/18	0.27	0.66	0.62	0.54
All Dates	0.95	0.98	0.96	0.97
	RMSE	**RMSE**	**RMSE**	**RMSE**
6/5/18	14.39	NA	14.65	4.65
6/13/18	14.53	15.78	20.82	11.19
6/28/18	15.89	10.24	11.57	11.95
7/9/18	21.51	12.14	13.64	23.73
7/17/18	36.47	17.38	30.18	17.23
7/24/18	37.97	26.39	29.72	17.01
7/31/18	38.74	28.81	16.55	28.04
8/9/18	38.80	33.59	27.27	12.90
All Dates	29.31	21.31	21.74	17.29

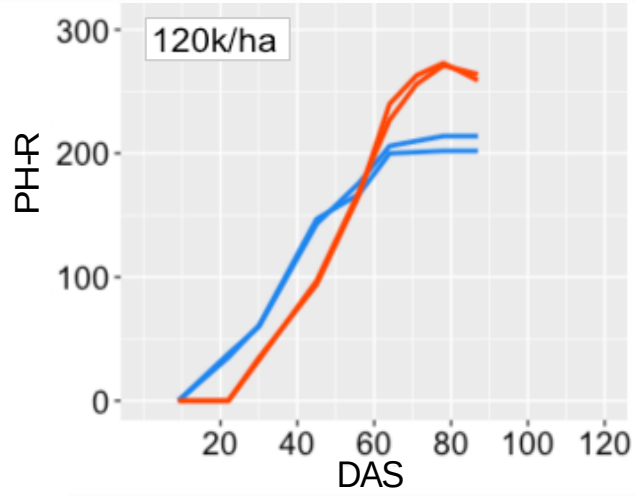
Tirado, SB , CN Hirsch, NM Springer. 2019. UAV Based Imaging Platform for Monitoring Maize Growth Throughout Development. bioRxiv.doi.org/10.1101/794057

UAV-derived height can be useful for assessing growth patterns

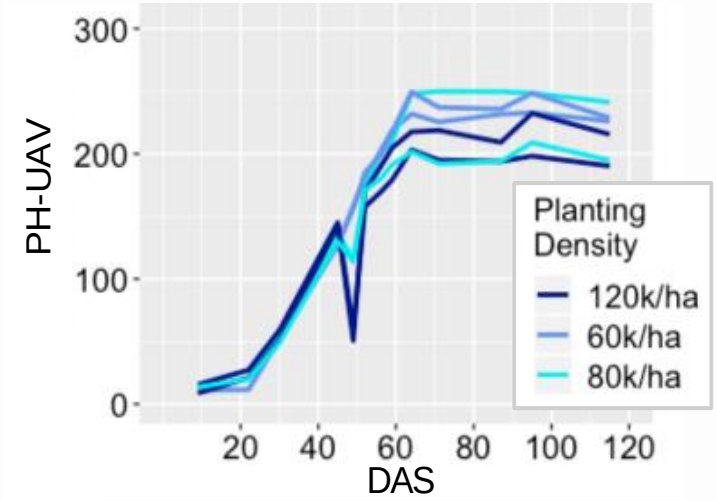
LH82 x DK3IIH6- 120k/ha

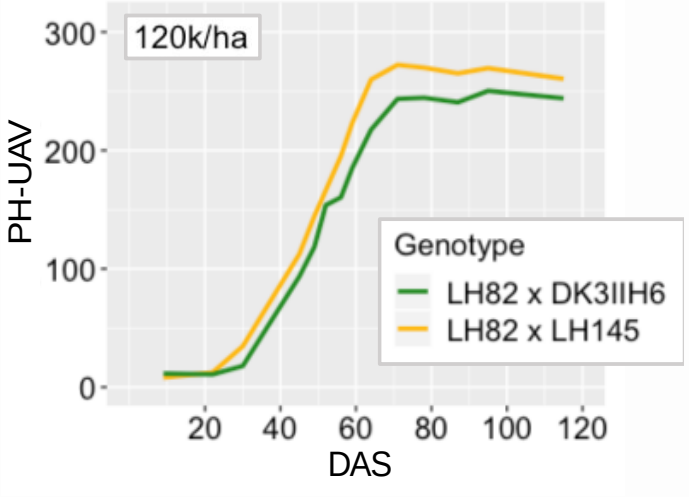


LH82 x DK3IIH6- 120k/ha



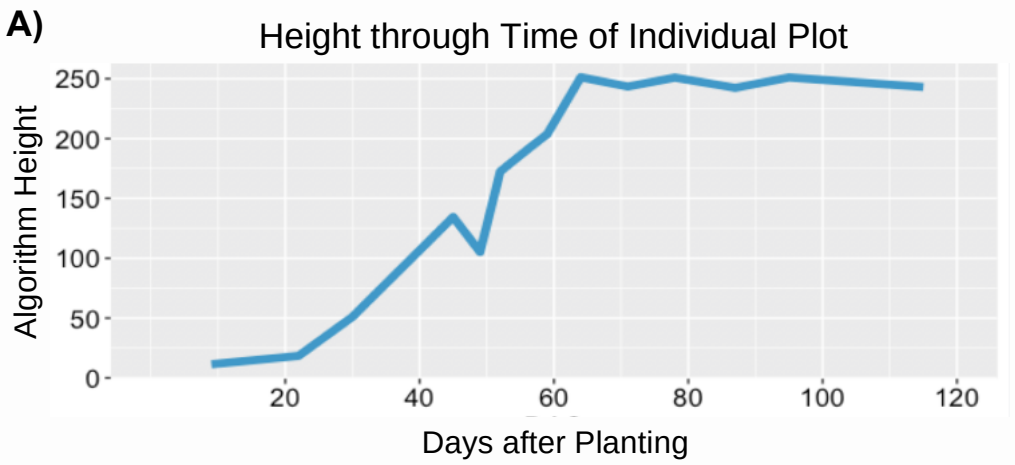
LH82 x DK3IIH6

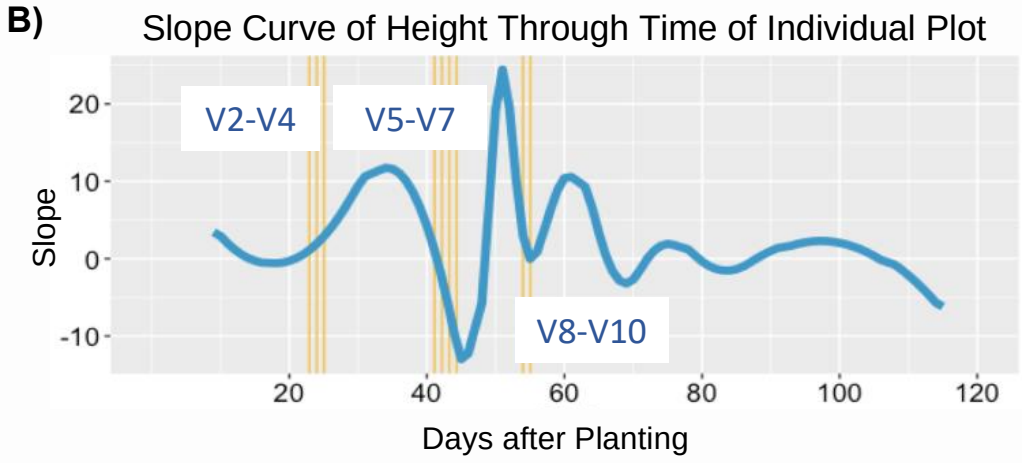


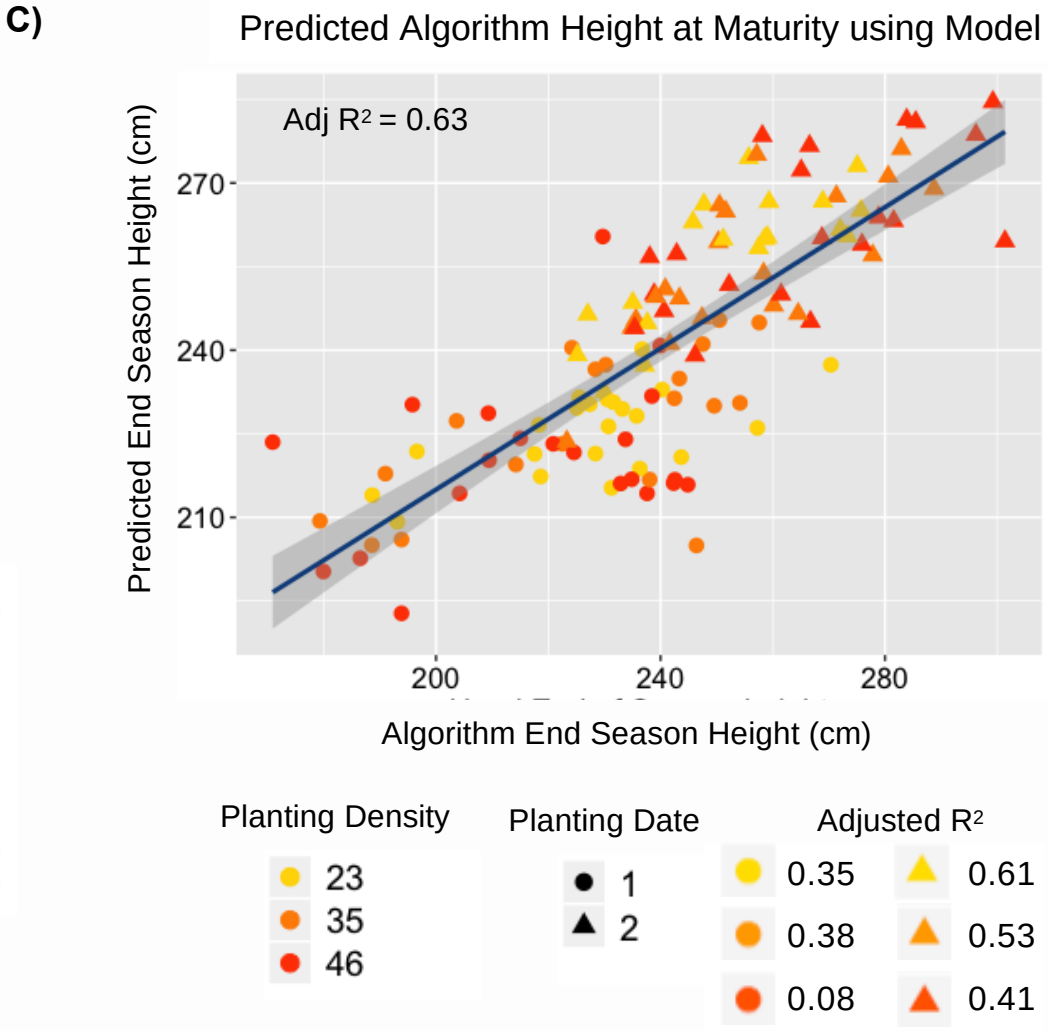


Tirado, SB , CN Hirsch, NM Springer. 2019. UAV Based Imaging Platform for Monitoring Maize Growth Throughout Development. bioRxiv.doi.org/10.1101/794057

Predicting end-season traits using early-season UAV measurements







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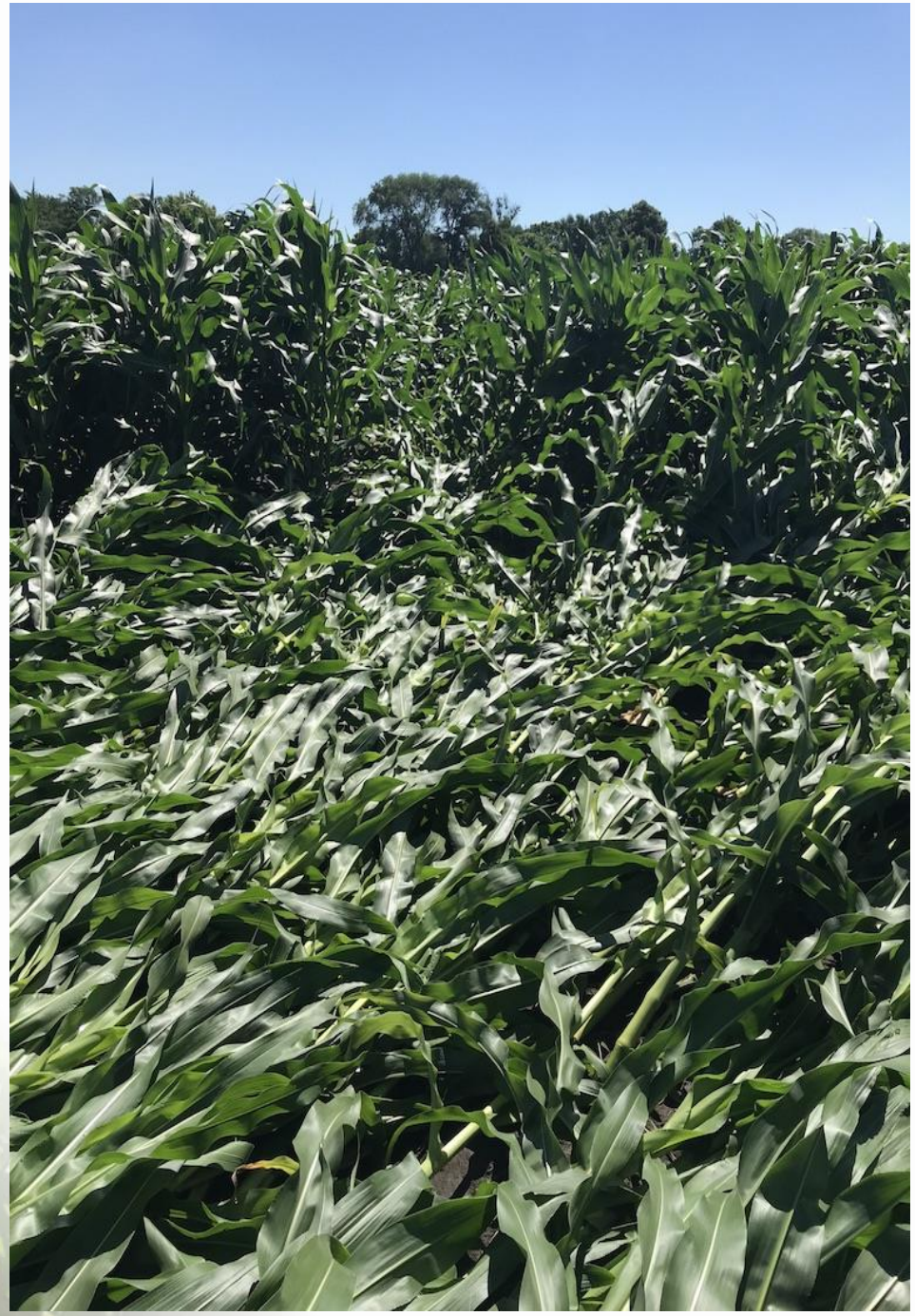
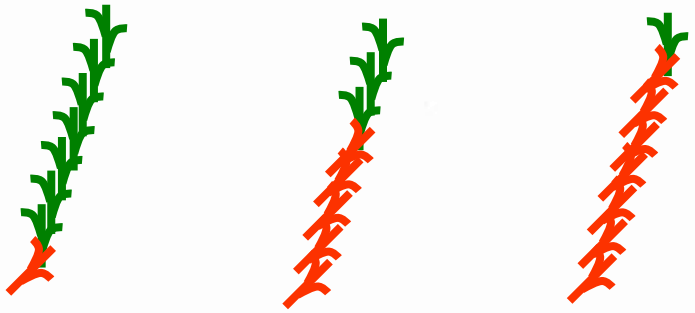


Root lodging has become a large issue across the US

No Lodging	Partial Lodging	Extreme Lodging
< 25%	25% - 75%	> 75%



152 bu/acre

- 8 bu/acre

144 bu/acre

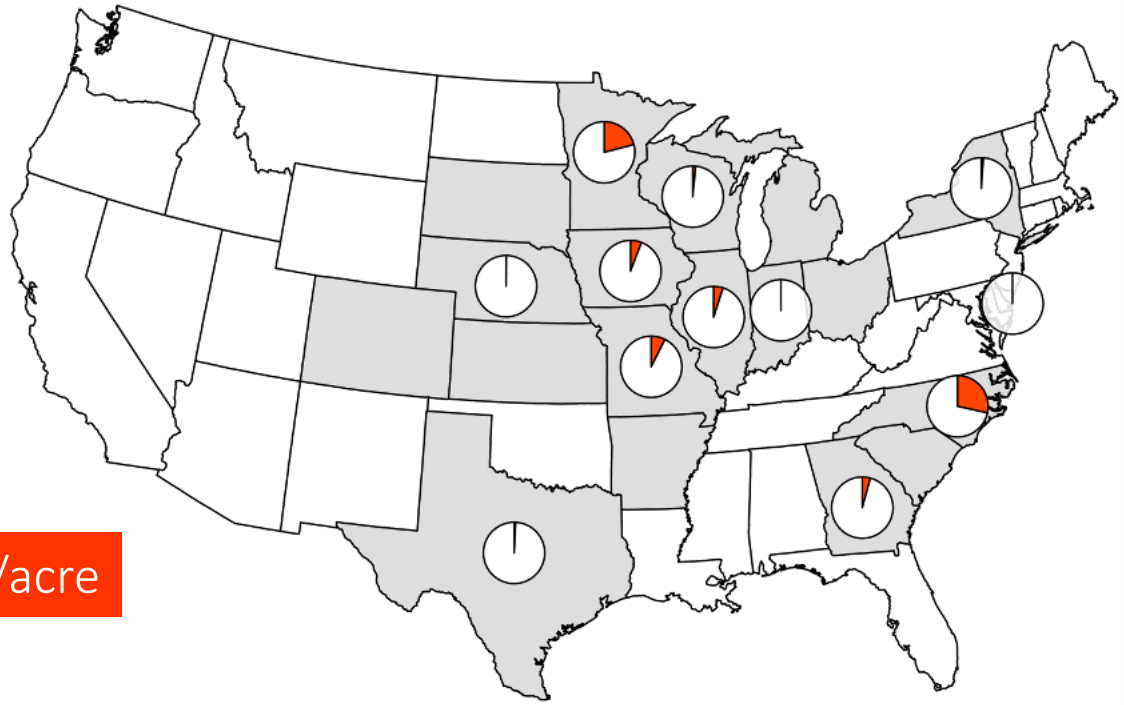
- 4 bu/acre

140 bu/acre

- 12 bu/acre

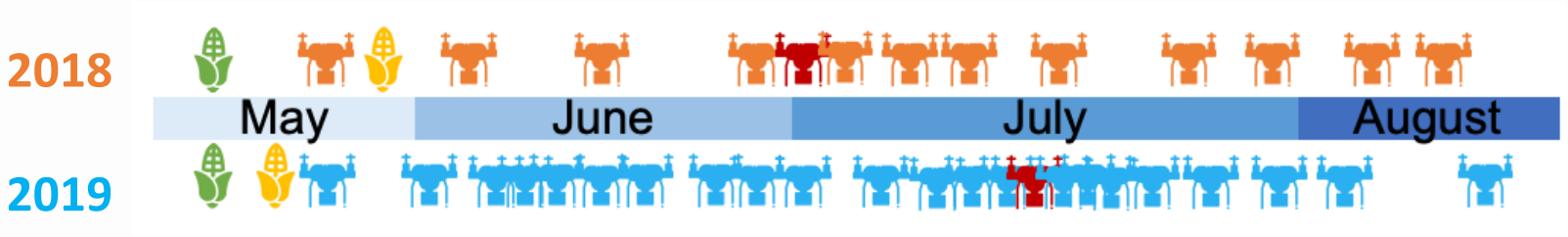
Percent of lodged plots

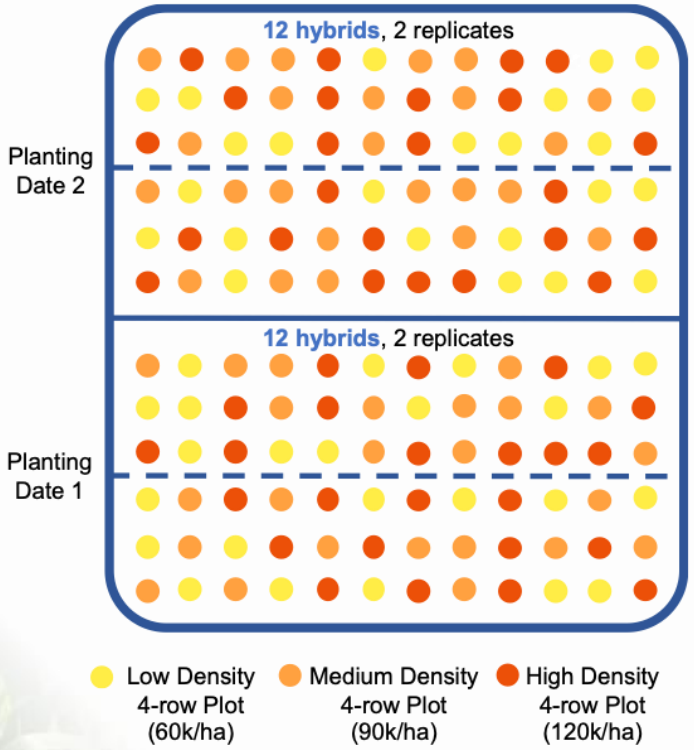
2014

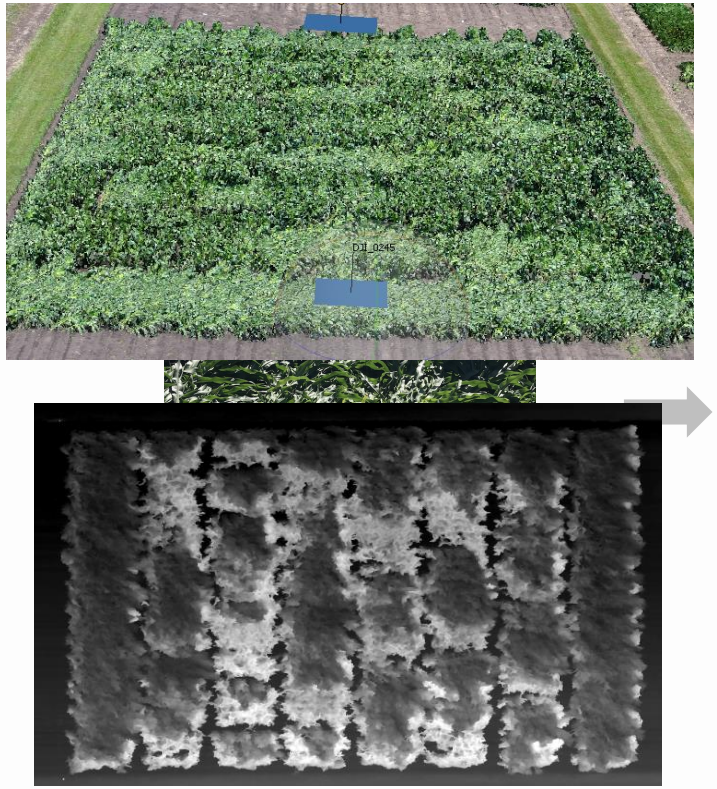


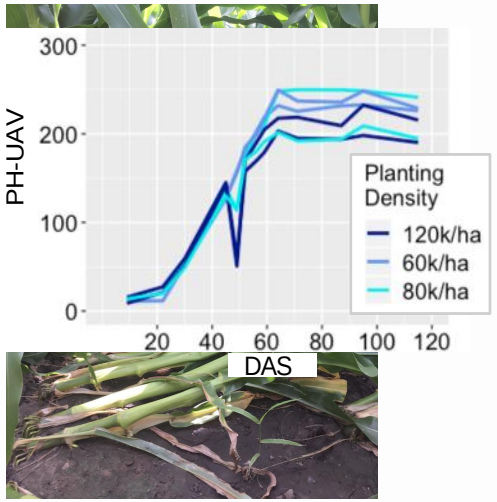
the Genomes to Fields initiative

Can we study lodging responses using UAV data?





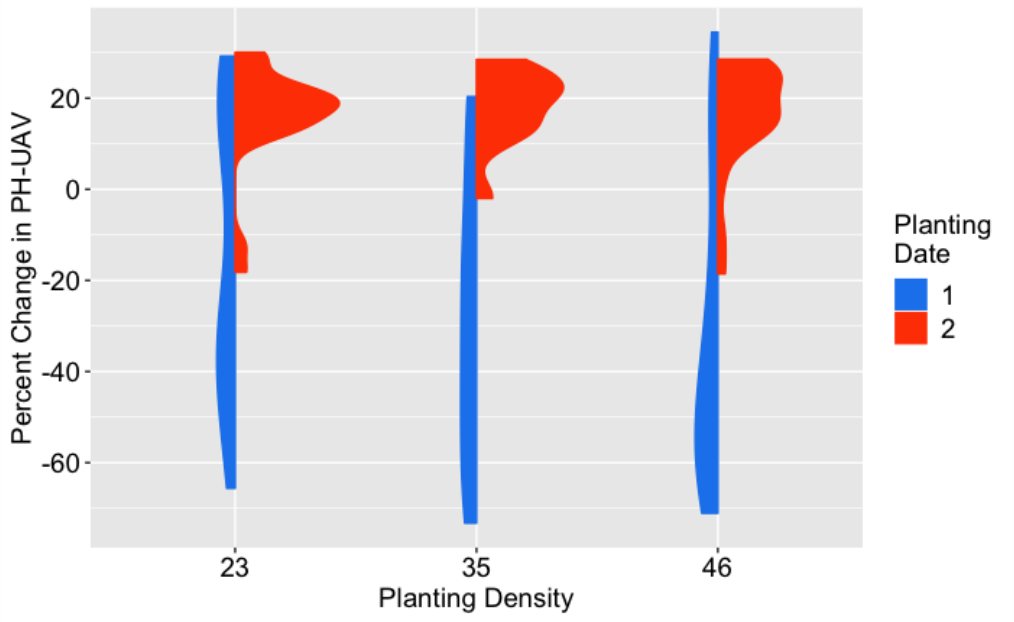




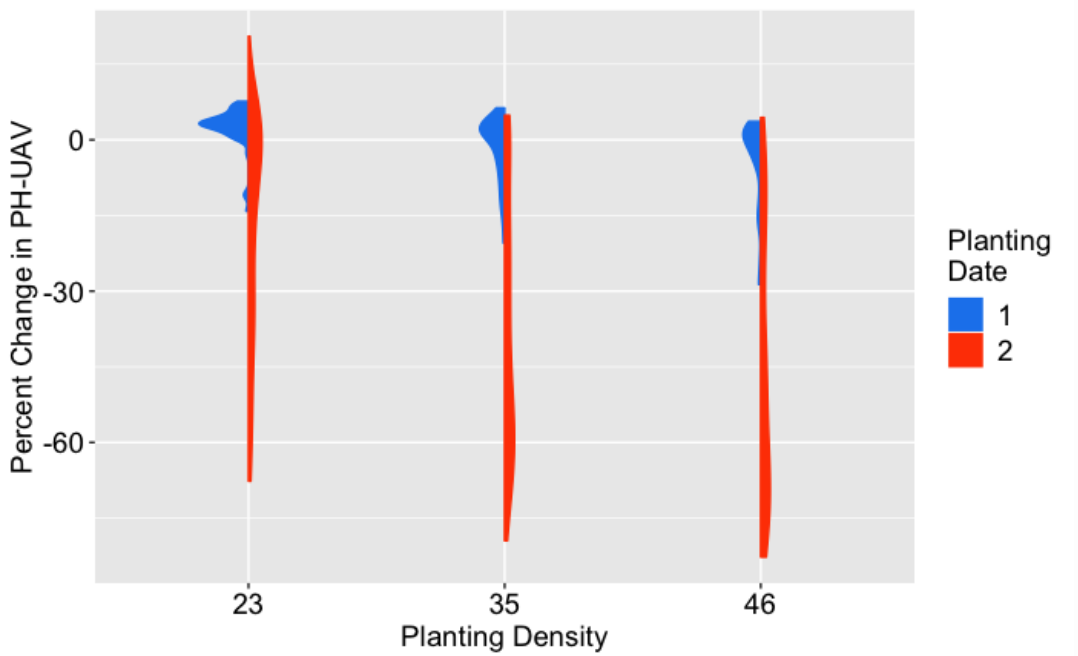
What metric can we use to assess lodging from UAV imagery?

Percent change in height from the height the day before lodging

2018



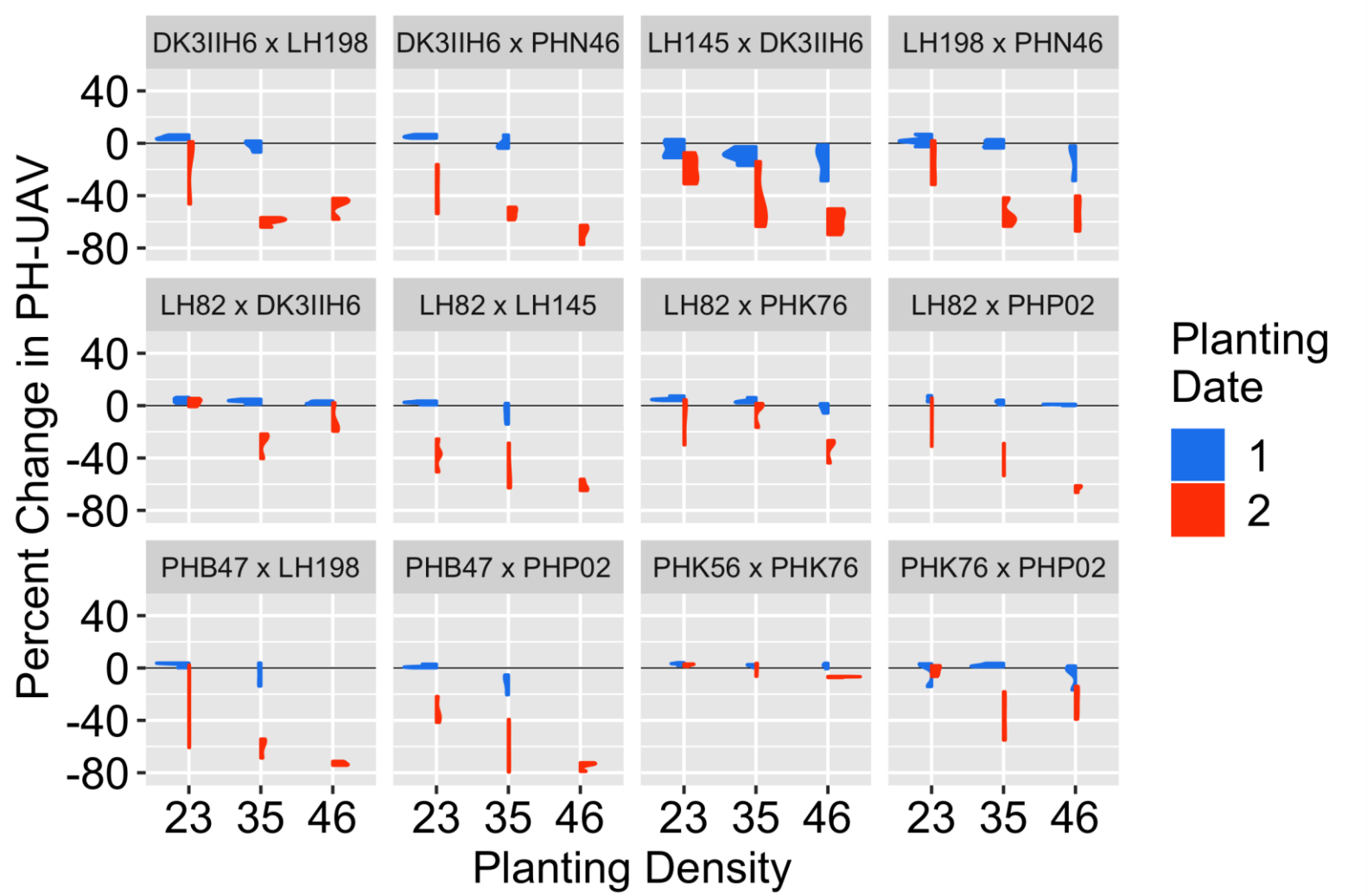
2019

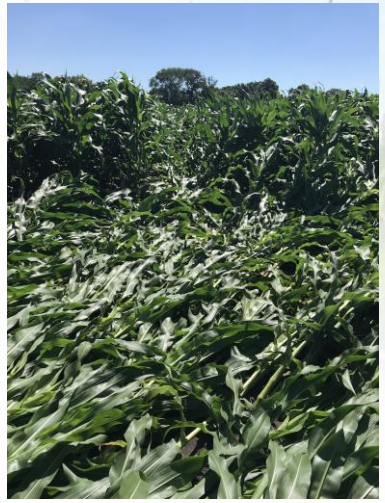


What variables impact lodging responses in maize?

Percent change in height from the height the day before lodging

2019





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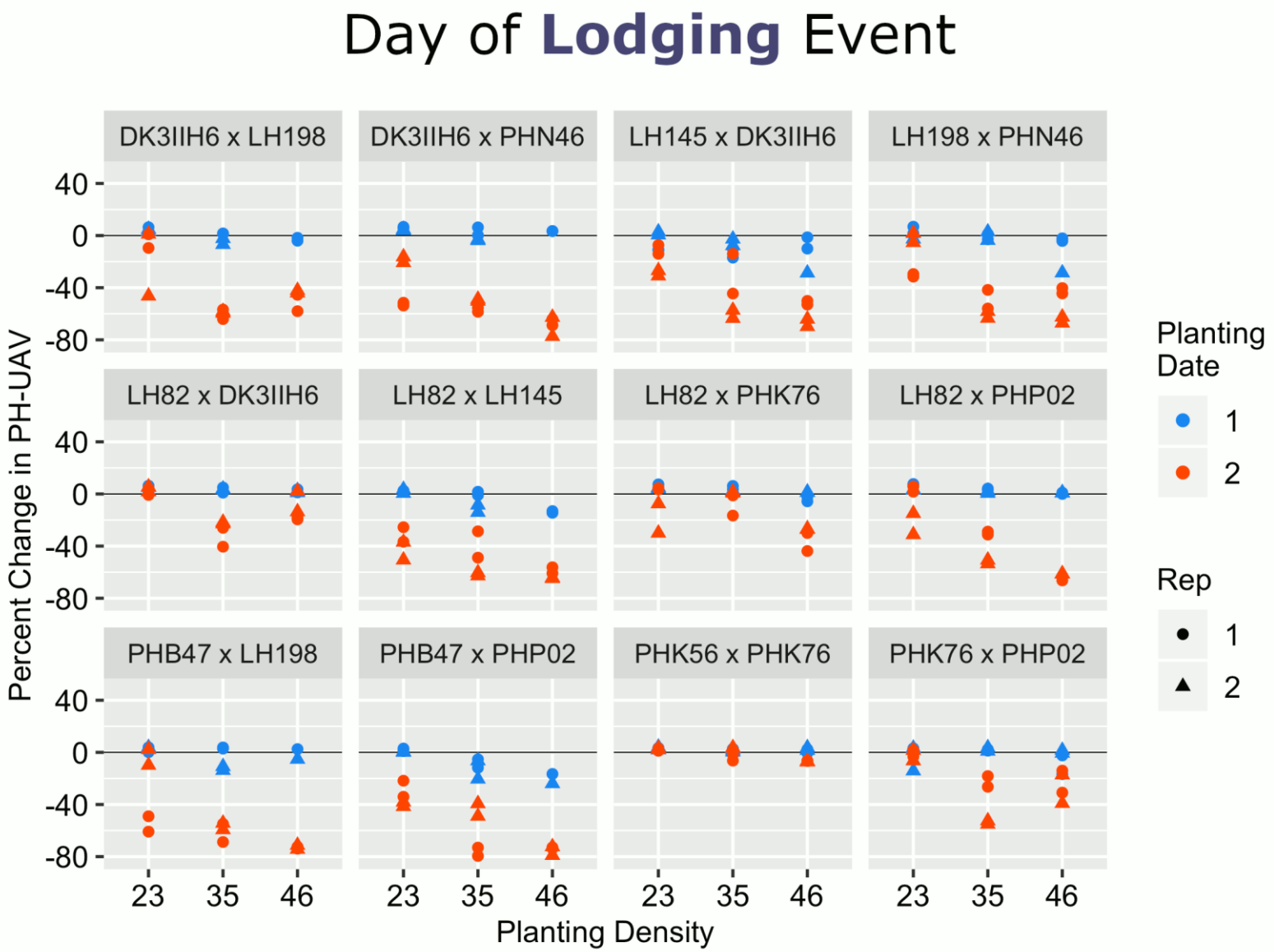
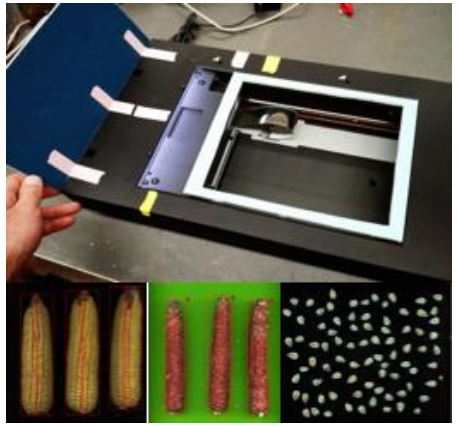


Future directions

1. Get a better understanding of different environmental factors that cause lodging in maize nurseries

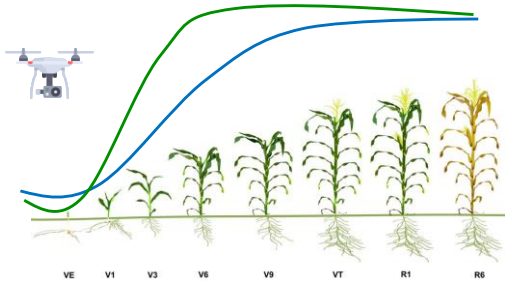
2. Identify different avenues of lodging resistance

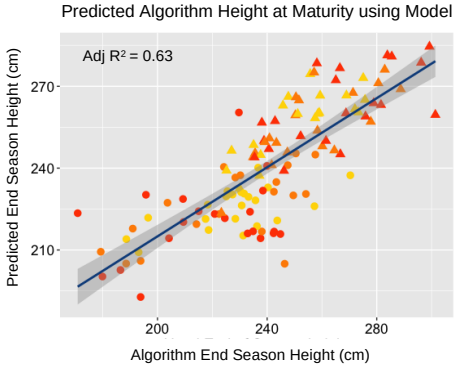
3. Get a better understanding of how early season growth rates as well as lodging impact yield and yield component traits

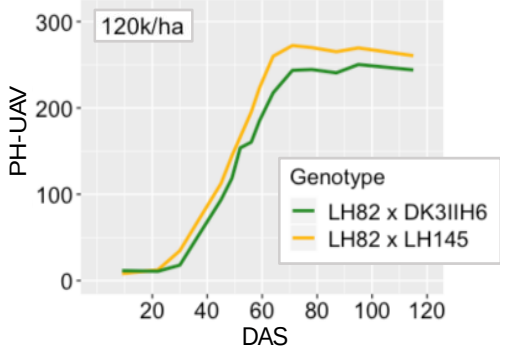


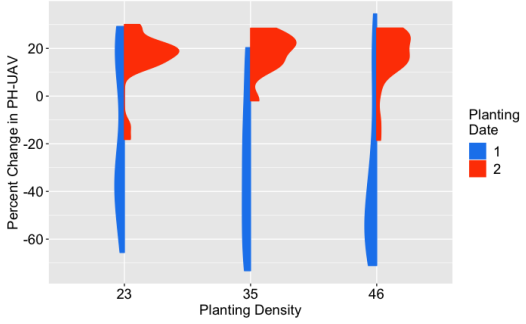
Take-away Points

- Temporal phenotype estimates are needed to better understand of how genetic and phenotypic elements interact with the environment
- We can use PH UAV measurements to document differences in growth rates throughout the growing season
- PH measurements collected at multiple timepoints early in development can be useful in improving predictions of PH at the end of the season
- We can use UAV PH estimates to assess variation for lodging responses









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