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Swedish University of Agricultural Sciences

Integrating multiple sensors for phenotyping

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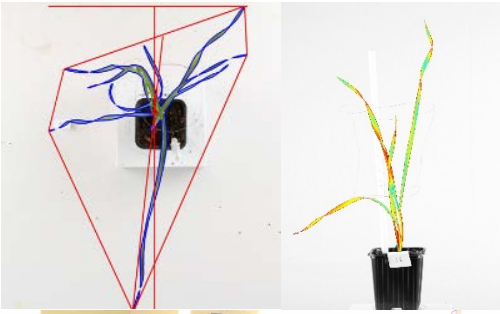
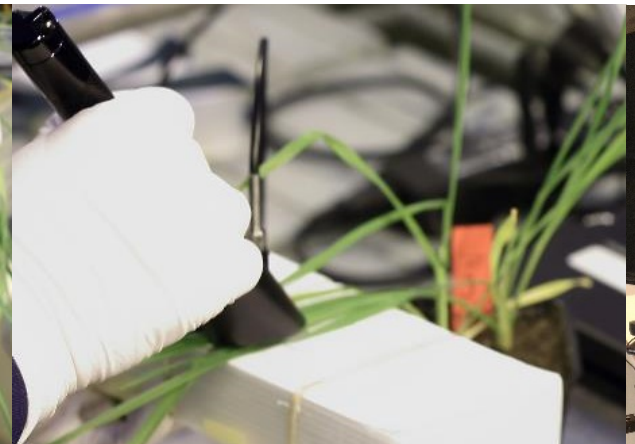


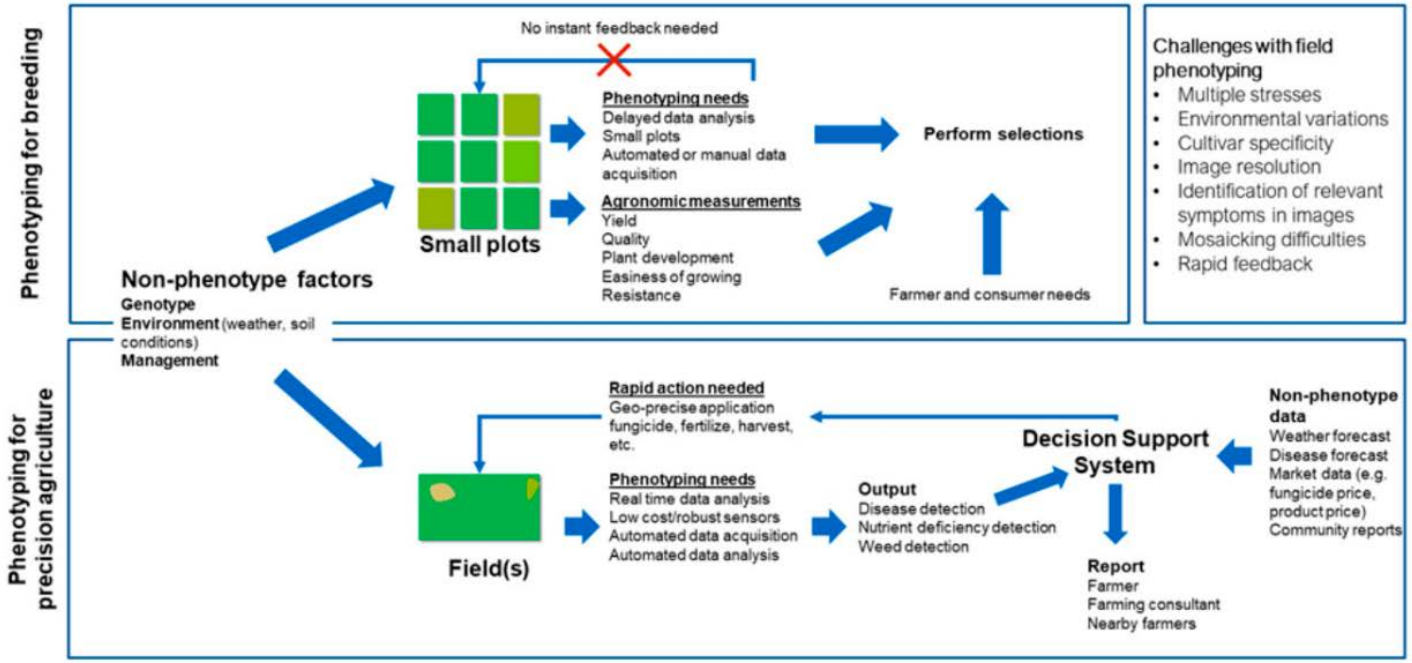





WP2 in 6P2 : Detection of diseases

- Which sensor is most optimal for a given disease?
- What resolution is required in space and time to detect symptoms?
- Can multiple sensors improve disease detection?

Chawade, A., et al. (2019). High-Throughput Field-Phenotyping Tools for Plant Breeding and Precision Agriculture. *Agronomy*, *9*(5), 258.



frontiers in Plant Science

ORIGINAL RESEARCH
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Proximal Phenotyping and Machine Learning Methods to Identify Septoria Tritici Blotch Disease Symptoms in Wheat

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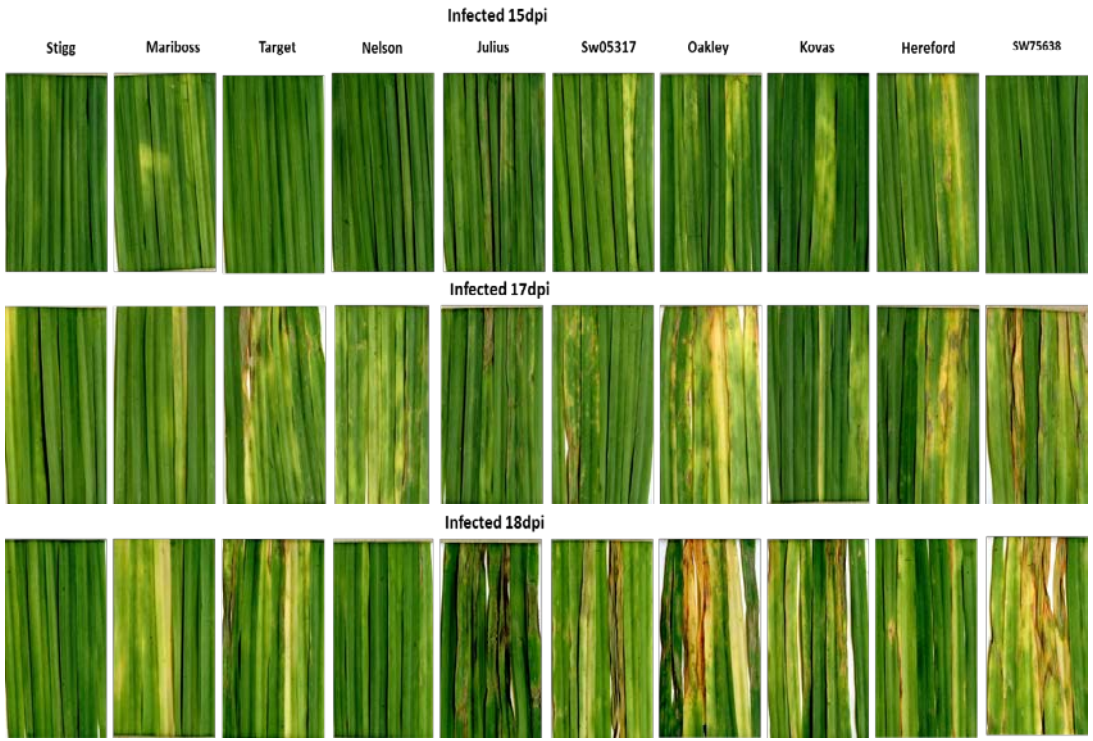
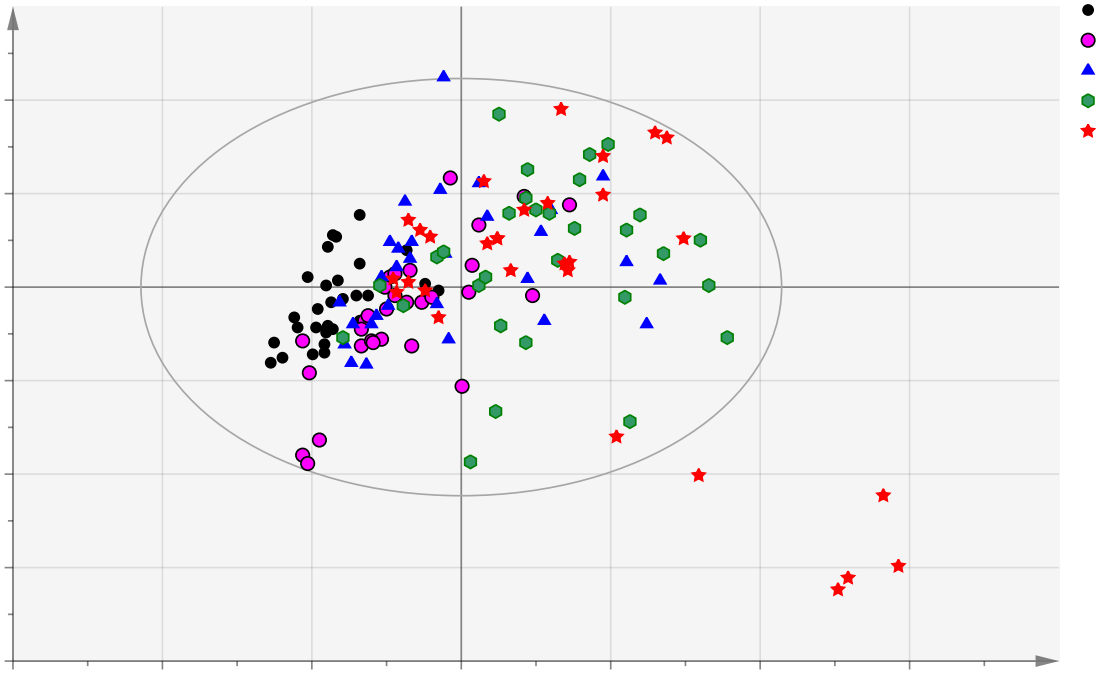


Sensors used:

Chlorophyll Fluorescence

Spectroradiometer

Surface temperature



- Chlorophyll fluorescence measurement provides the earliest detection of disease symptoms
- Surface temperature of foliage increases upon infection
- Machine learning by integrating data from various different sensors

Odilbekov et al. 2018

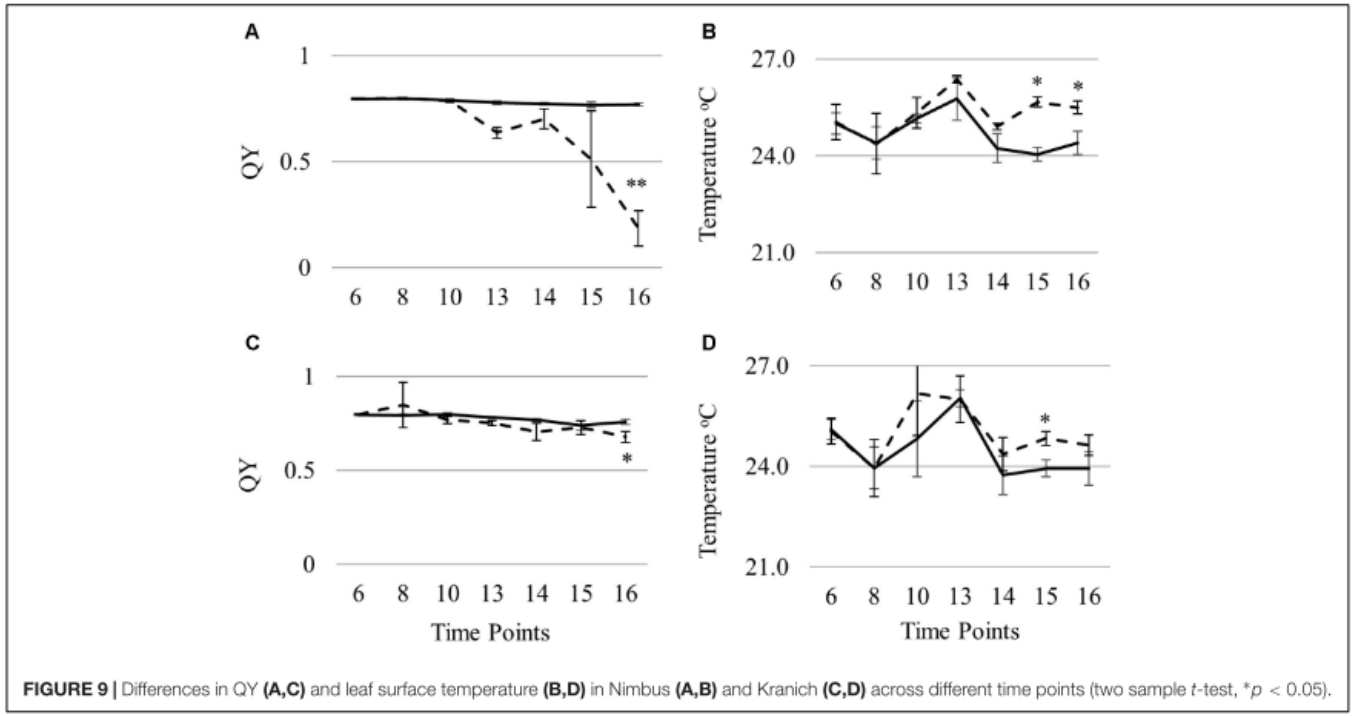


FIGURE 9 | Differences in QY **(A,C)** and leaf surface temperature **(B,D)** in Nimbus **(A,B)** and Kranich **(C,D)** across different time points (two sample *t*-test, $*p < 0.05$).

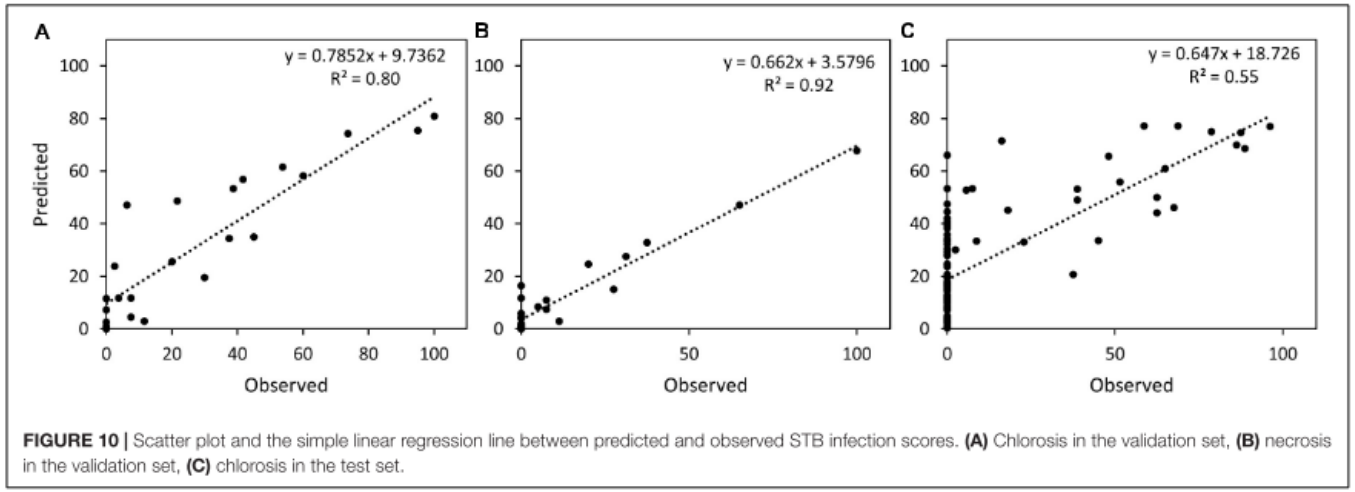
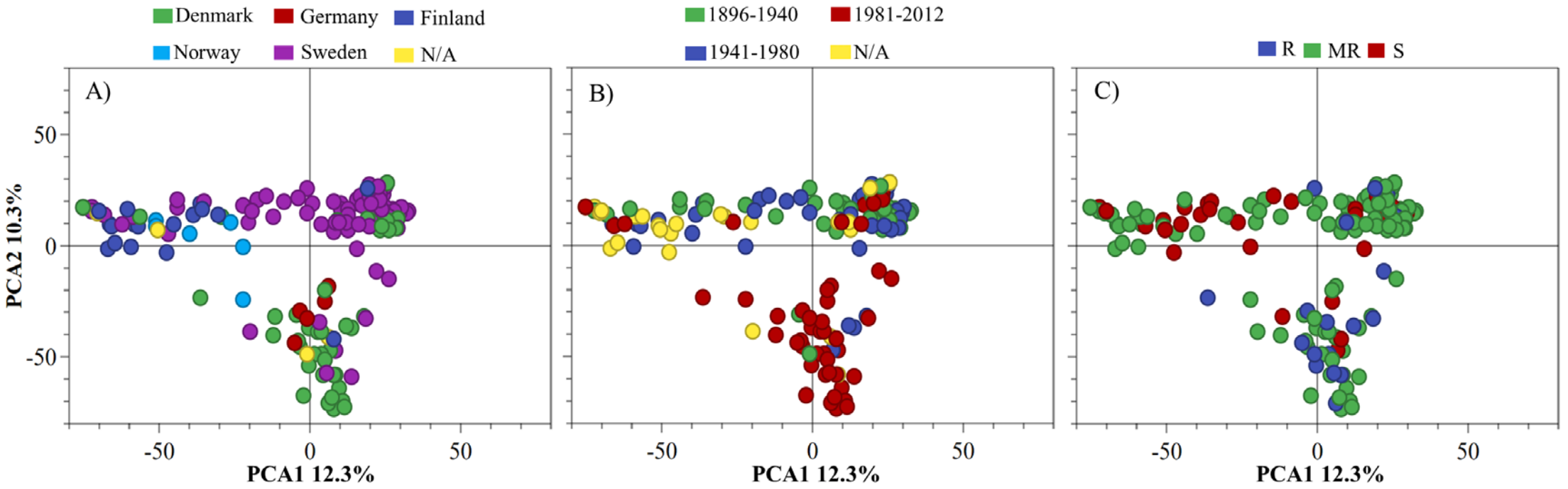


FIGURE 10 | Scatter plot and the simple linear regression line between predicted and observed STB infection scores. **(A)** Chlorosis in the validation set, **(B)** necrosis in the validation set, **(C)** chlorosis in the test set.

Field trial in 2018

- Aim: To identify most useful sensors for detecting wheat diseases
- 200 Winter wheat landraces from NordGen genebank
- Trial in Svalöv by Lantmännen
- Phenotyping with PhenoCart with multiple sensors

Population structure
20k SNP chip
Odilbekov et al. 2019



Odilbekov et al. 2019

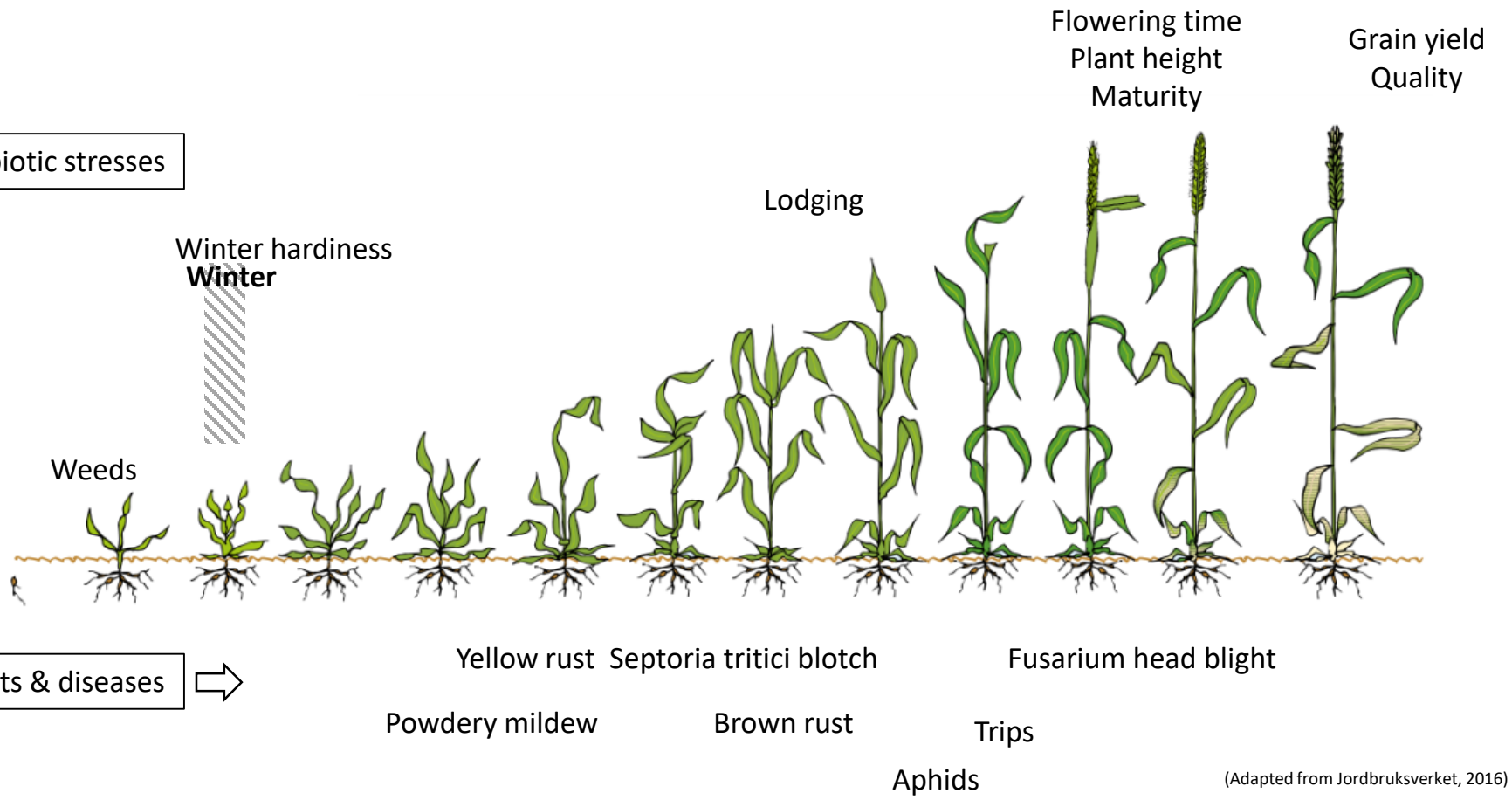
Low-cost high-precision imaging in the field

Phenocart

Sensors:
RGB camera
NIR camera
3D camera
Hyperspectral sensor
Custom scripts

Lantmännen field trials

Winter wheat growth stages



(Adapted from Jordbruksverket, 2016)

But the mother nature had other plans in 2018 ☺

Early vigour

Stem Elongation

Heading

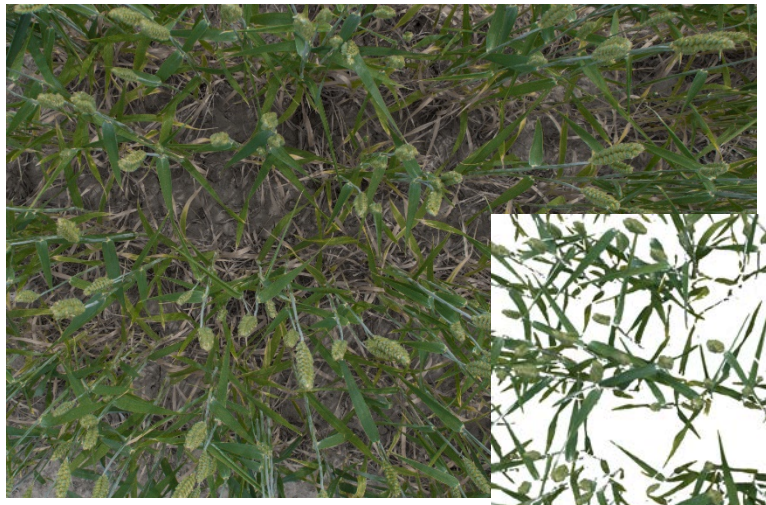
Grain filling

Ripening

RGB imaging: GSD 0.02 cm/px

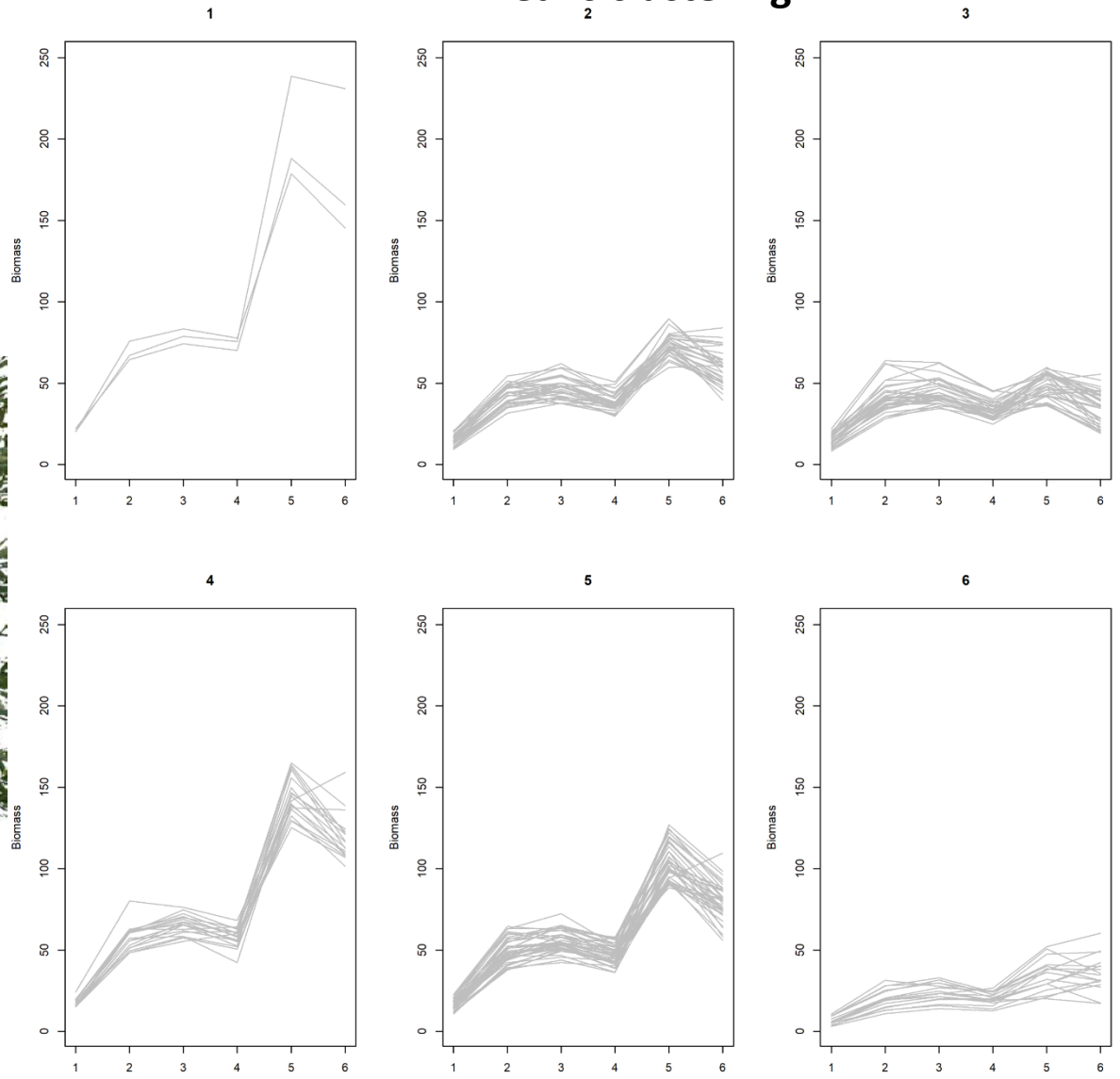
Six Timepoints (April – July)

200 winter wheat landraces



Analysis: PlantCV

Clustering of genotypes based on growth curves of genotypes
K means clustering

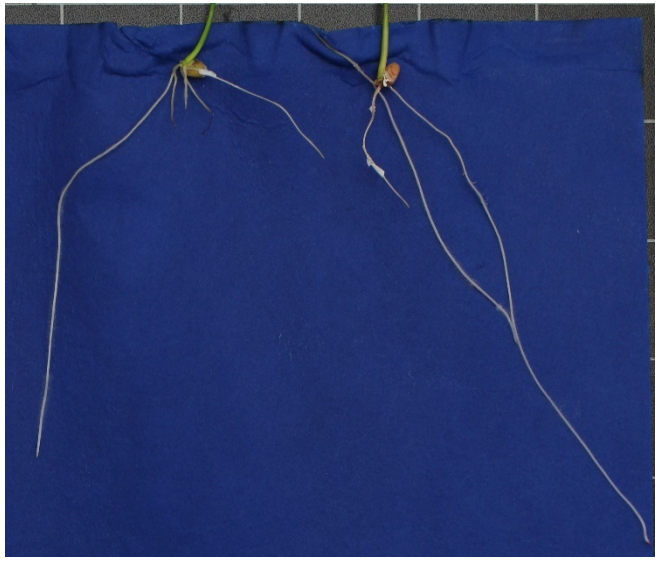


Six Timepoints (April – July)

Shoot phenotyping at seedling stage

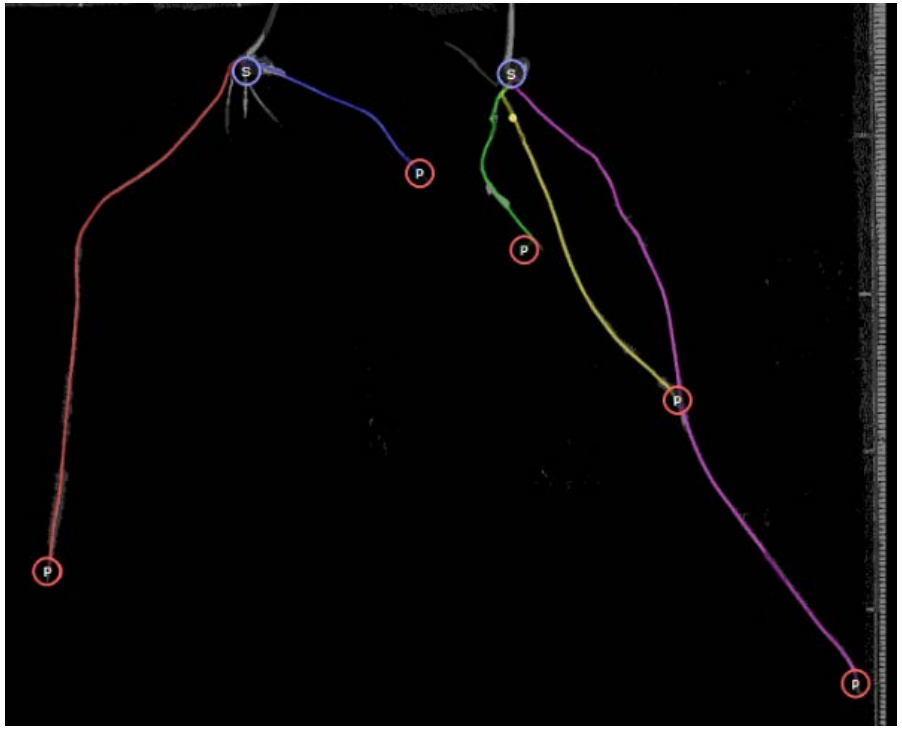
Armoniene et al. 2018

Root phenotyping at seedling stage



Biotron: Growth rooms

- 200 winter wheat accessions
- RootNav software
- Early vigour of roots
- Root angle



Field work in 2019

Two big improvements in 2019

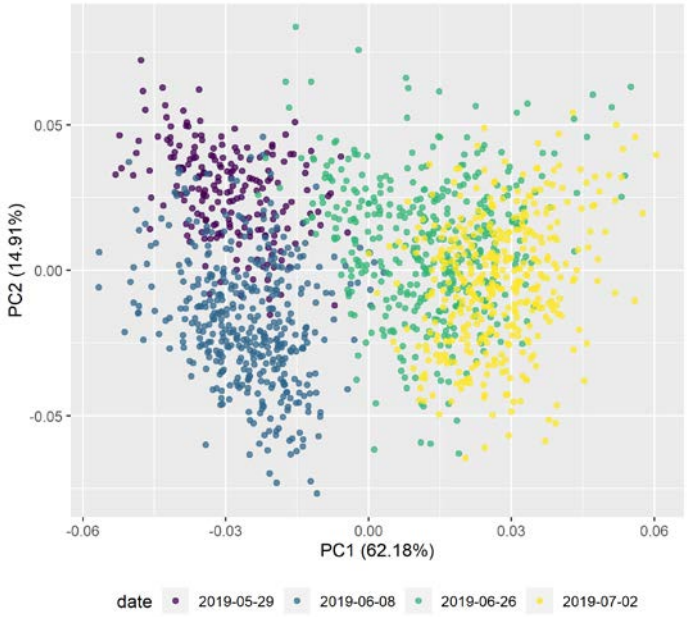
a) There were diseases in the filed ☺

b) Two spectral sensors

c) Same material planted in four countries

Collaboration: SLU, Lantmännen, LAMMC, Copenhagen Univ., ETKI, NordGen

- 20 timepoints between April and July
- Data analysis being done by Alexander Koc



Spectra reflectance data 2019

4 time points

Field work in 2020

- Same material planted in three countries
- Drone and proximal phenotyping

Phenotyping with drones

Lantmännen field trials

Summarizing thoughts…

- Phenotyping for pre-breeding vs commercial breeding
  - High-throughput or high-precision
  - Indoors or outdoors

- Empirical gain from selection is the only true measure, and predictions must be validated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SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE
Thank you!