Field phenotyping

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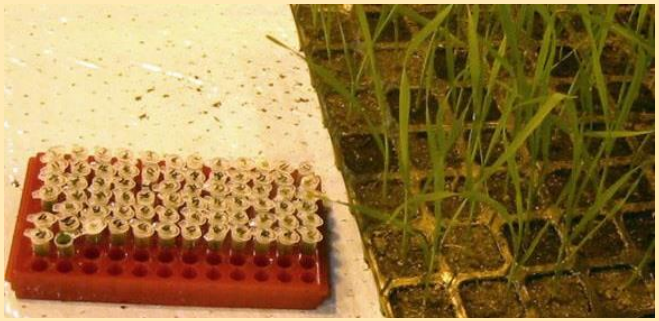
NordPlant kick-off, Helsinki, 24.-25.10.2018

How to produce more food with limited resources?

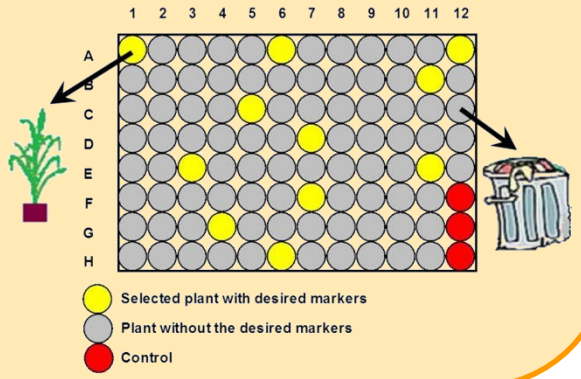
- Improved agronomy

Precision agriculture

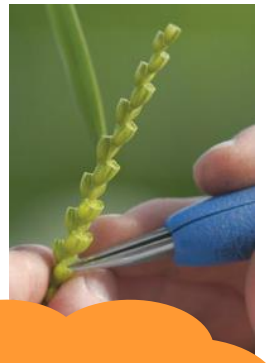
- Improved varieties – plant breeding



Precision genetics



Classical wheat breeding



Year 1	Parent 1 x Parent 2	Crossing
Year 2	F_1	Bulk seed
Year 2	F_2	Space pla
Year 3	F_3	Head rows
Year 5	F_4	Small plots, s
Year 6	F_5	Small plots, select the best families
Year 7	F_6	Small plots, pick heads within selected familes
Year 8	F_7	Head rows, select the best lines
Year 9	F_8	Unreplicated yield trial
Year 10-11	F_9-F_{10}	Replicated yield trials
Year 12-14	F_{11}-F_{13}	Official variety testing
Year 15		Cultivar release

Can we do this more effectively?

Plant selection tools

Visual selection

Sensors

Genetic markers

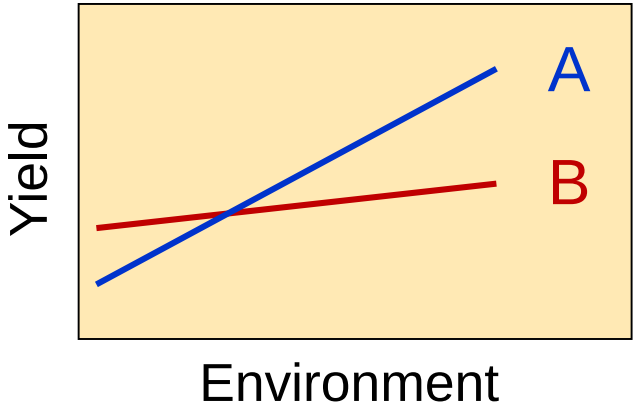
NMBU strategic alliance

- Faculty of Biosciences (BIOVIT)

- Faculty of Mathematical Sciences and Technology (RealTek)

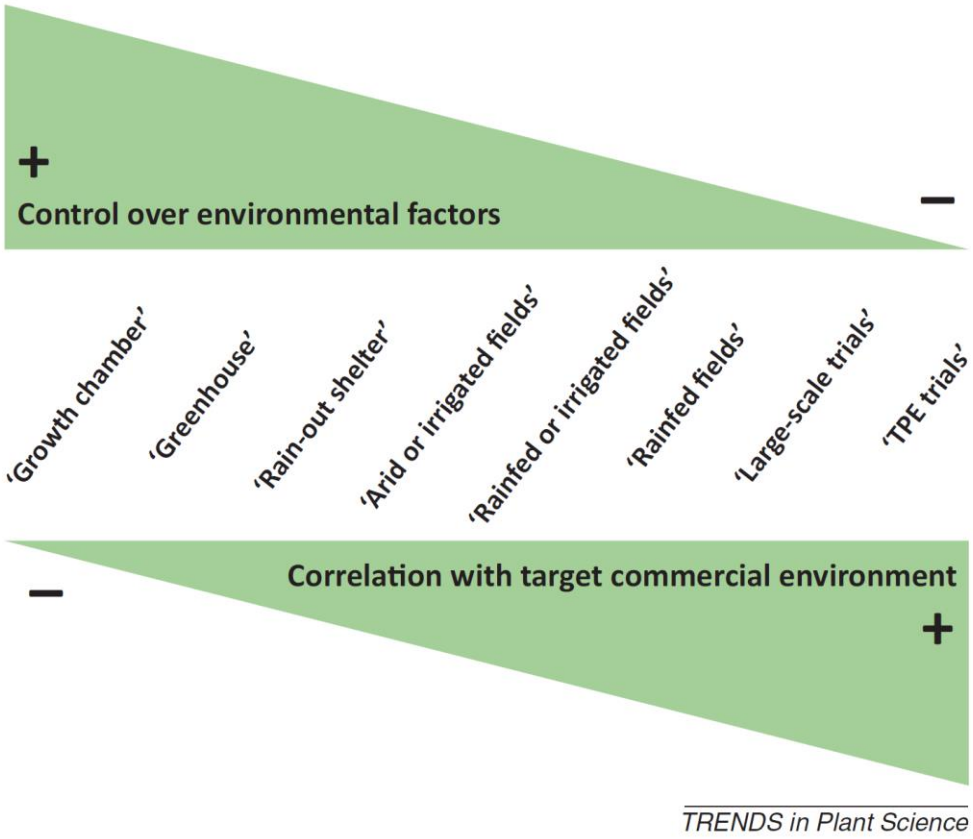
$$P = G + E$$

$$+ GxE$$



Every year is different

Environmental control *vs* relevance to field conditions

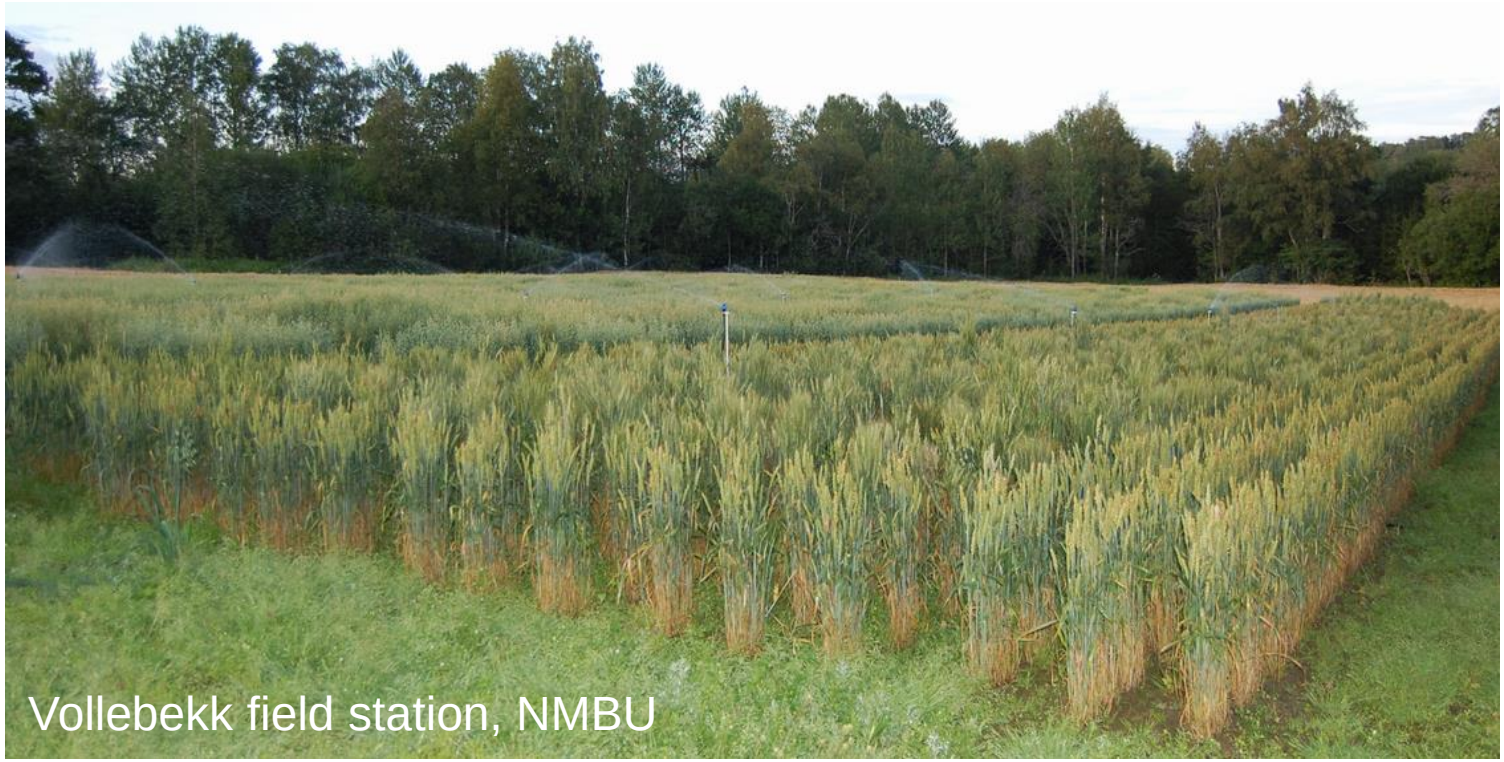


Control of field environments

- Polytunnels for controlling rain (and temperature):

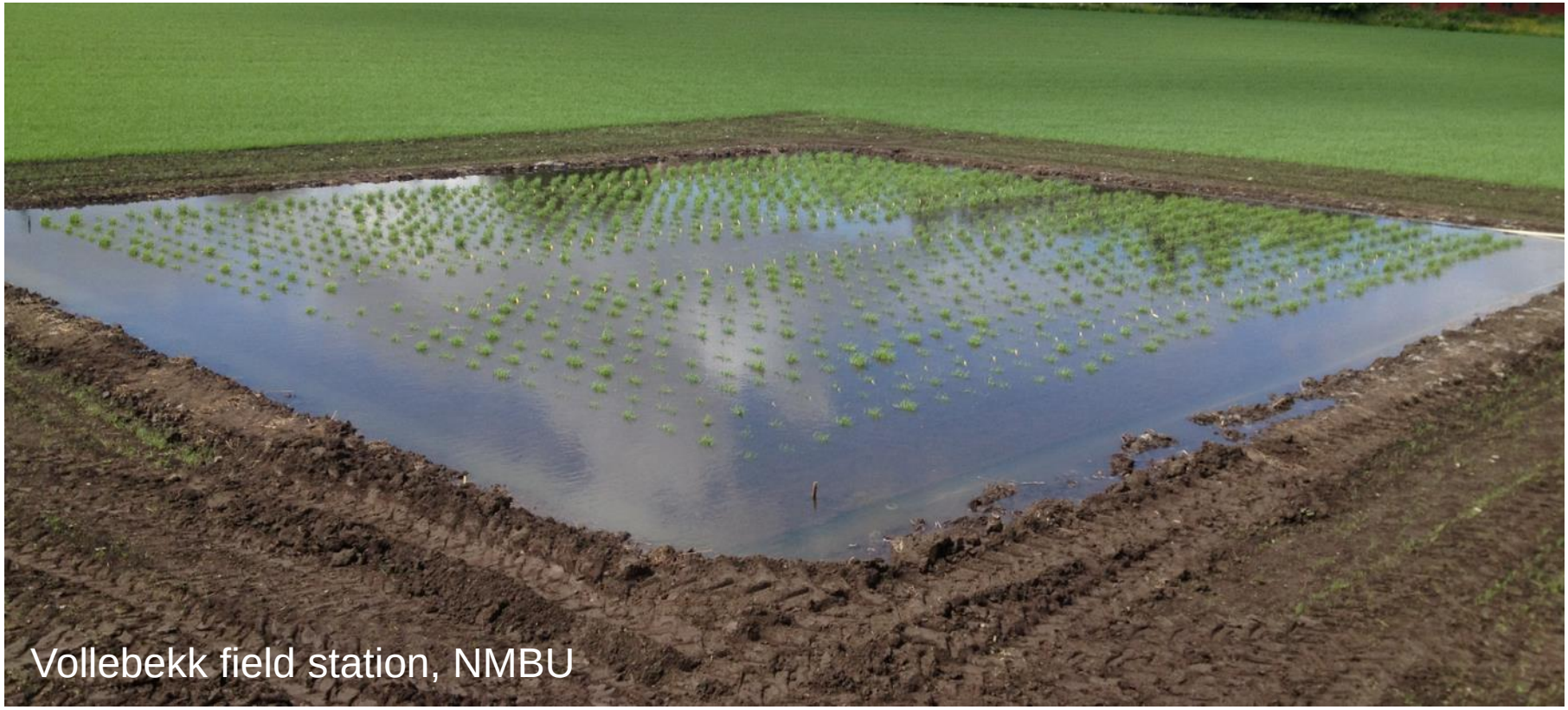
Control of field environments

- Mist irrigation for control of humidity (promotion of plant diseases):



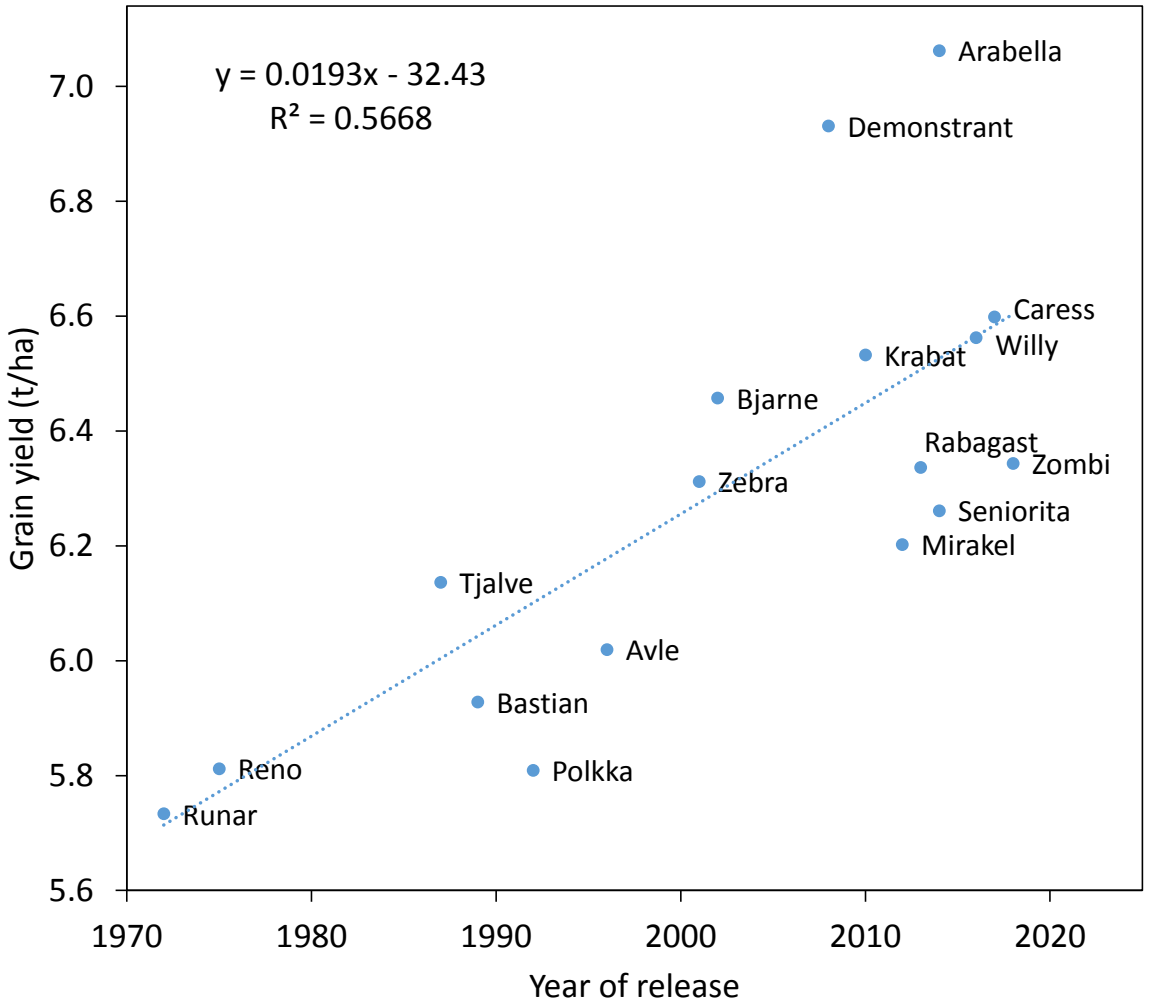
Control of field environments

- Evaluation of waterlogging tolerance:



Examples of field phenotyping at NMBU

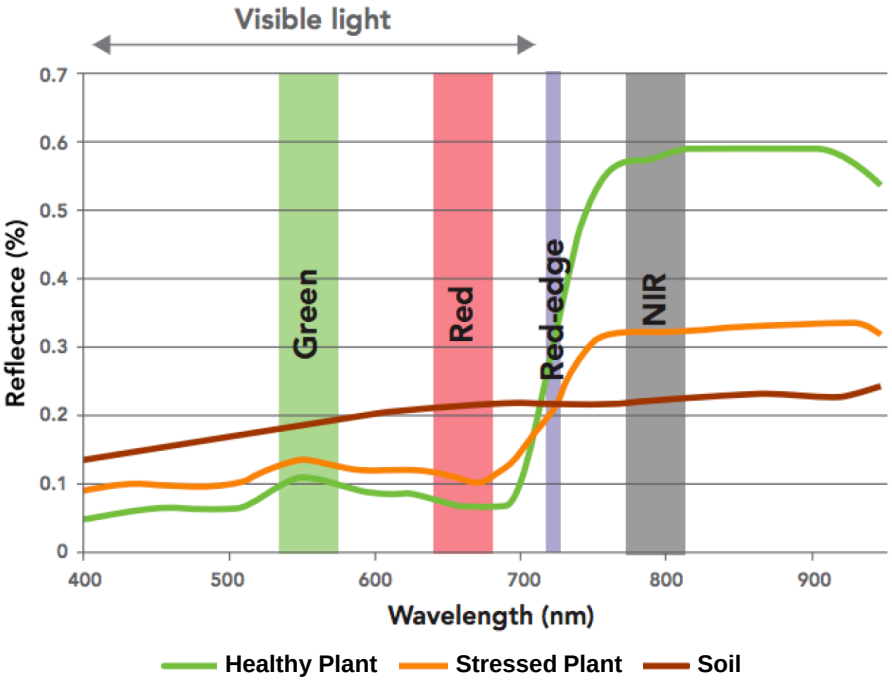
Plant breeding has increased wheat yields



- What is the physiological basis of this yield increase?

Multispectral imaging

Parrot Sequoia

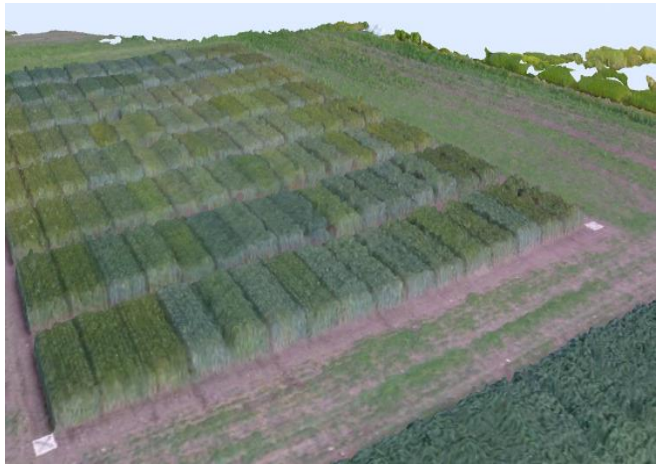


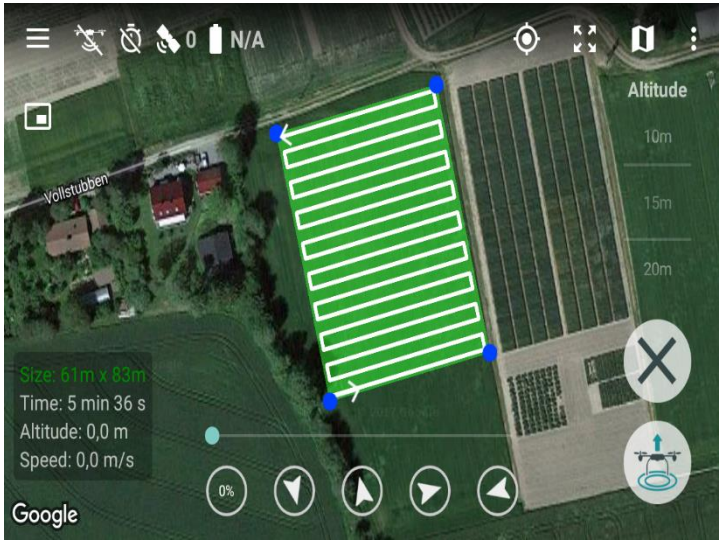
DJI Phantom 4

Thorvald II

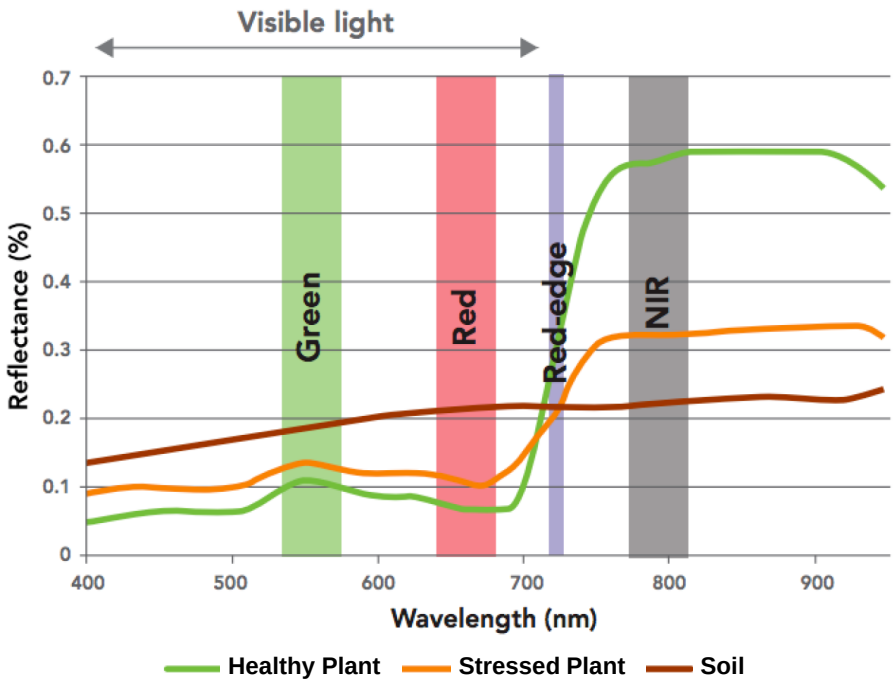
Phenotyping with drone

- DJI Phantom 4
- Multispectral camera
- Using Pix4d to stitch the images together
- Generating 2D and 3D maps
- Python code for extracting field plot data





Estimation of healthy biomass



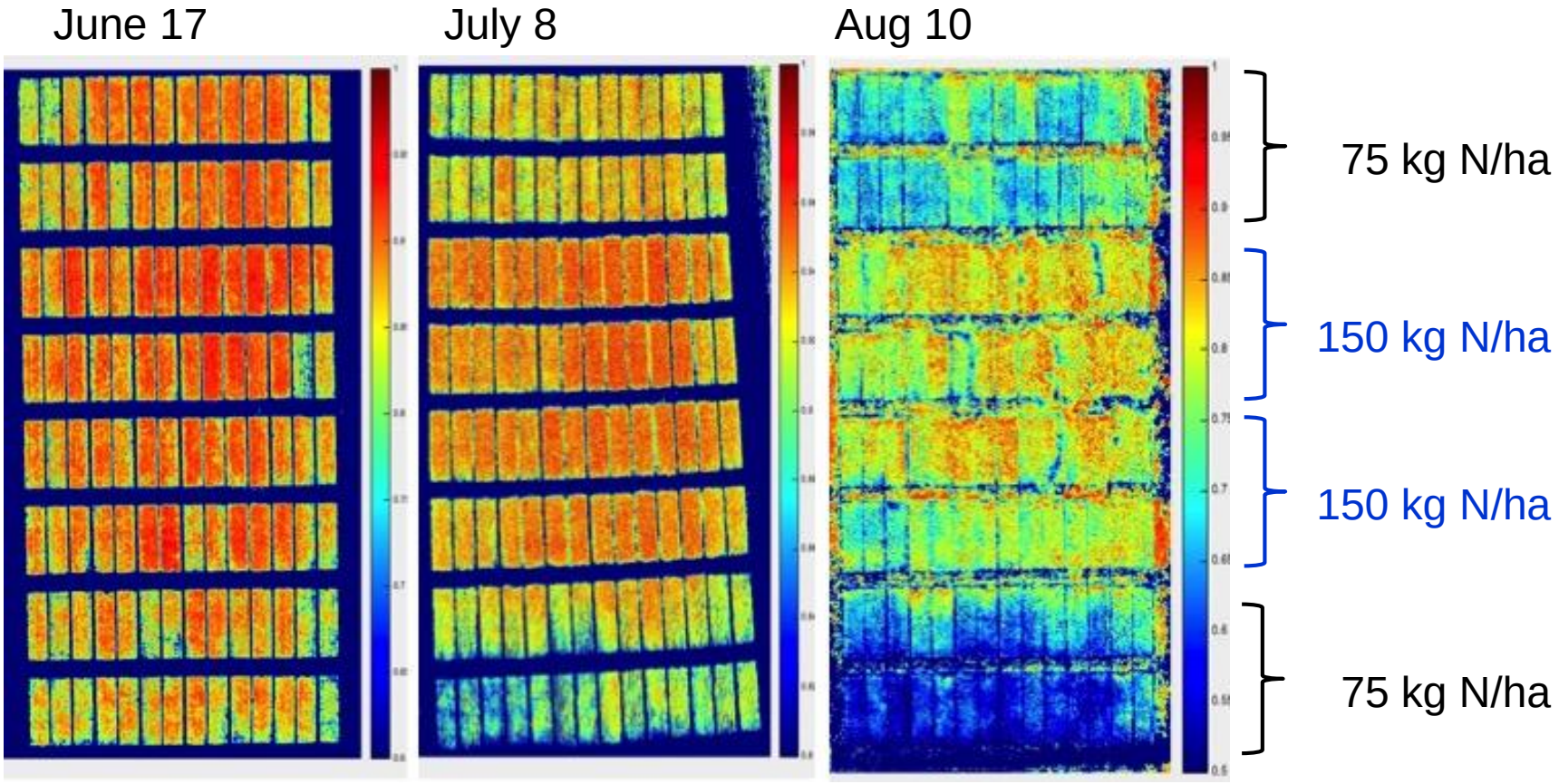
- Normalized Difference Vegetation Index (NDVI):

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

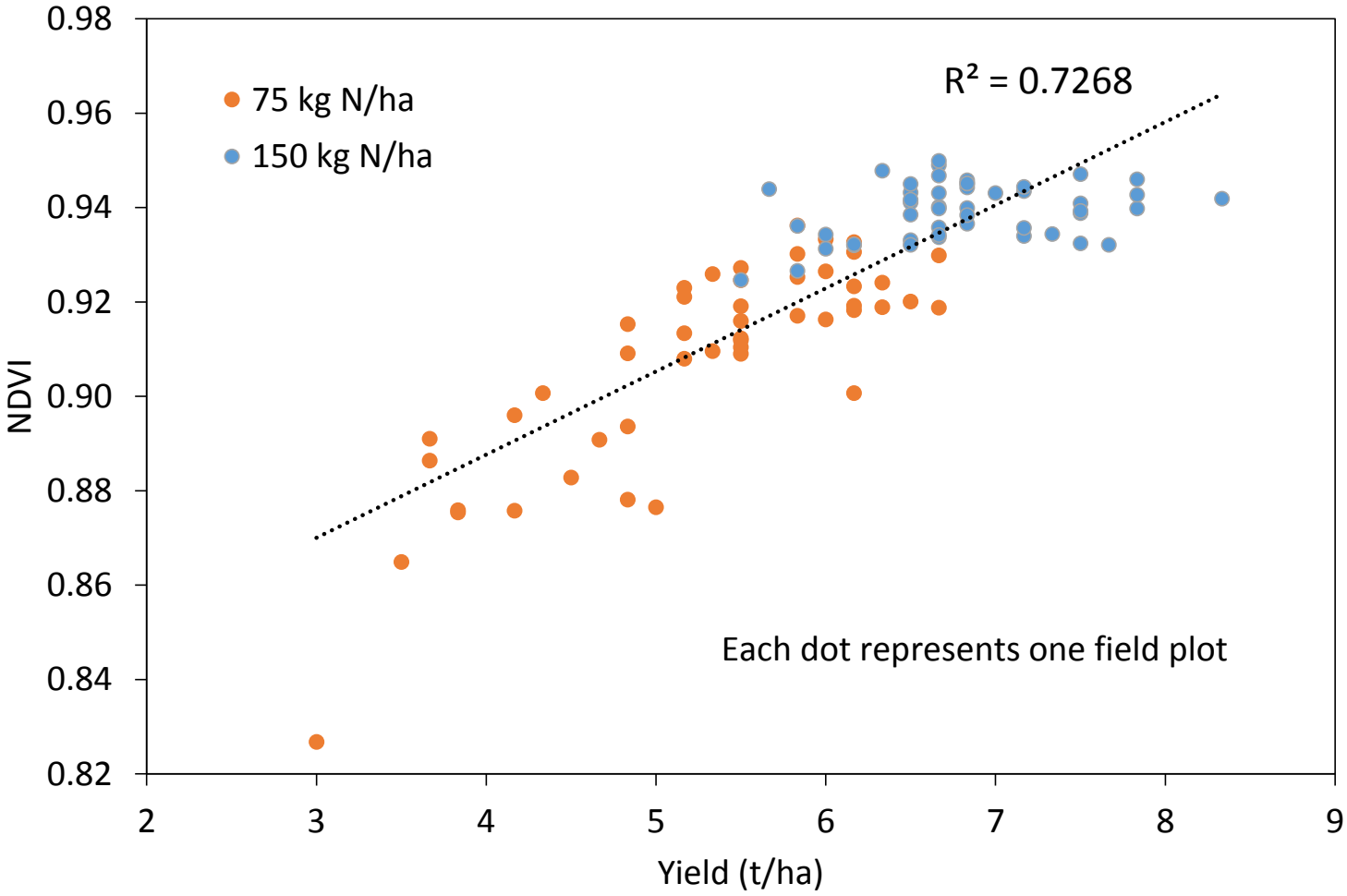
- MERIS Terrestrial Chlorophyll Index (MTCI):

$$MTCI = \frac{NIR - Rededge}{Rededge - Red}$$

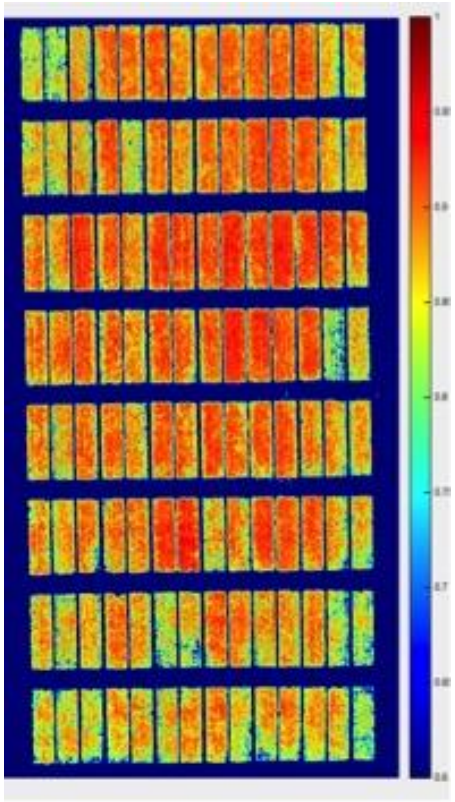
NDVI maps based on drone images



NDVI just after heading correlates with yield



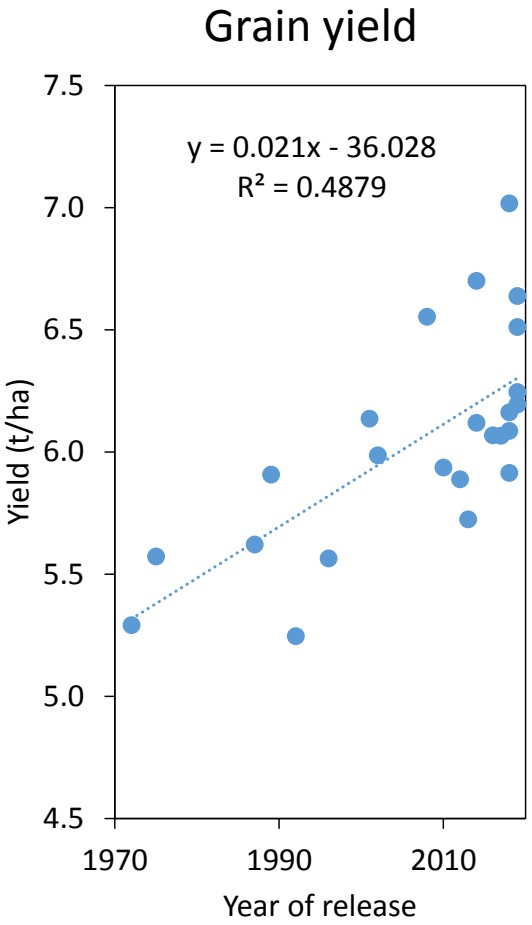
Can vegetation indices explain cultivar differences in yield?

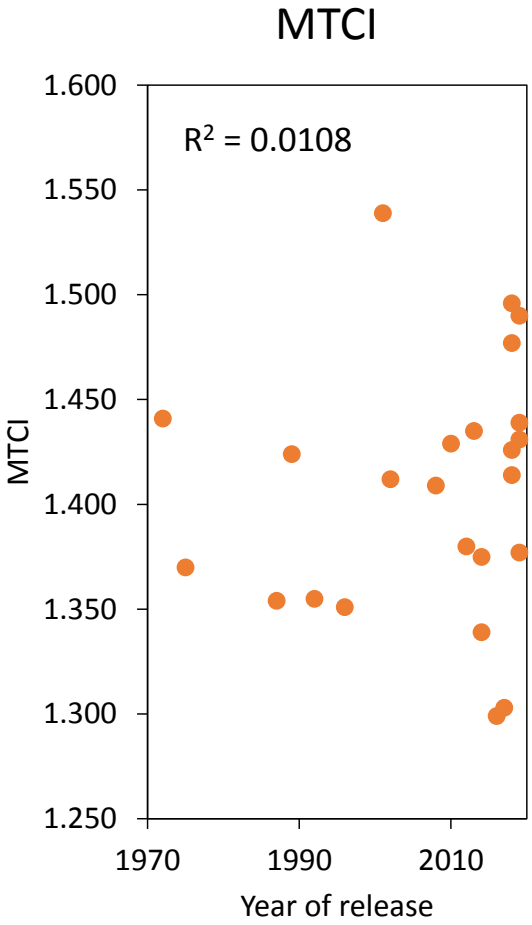


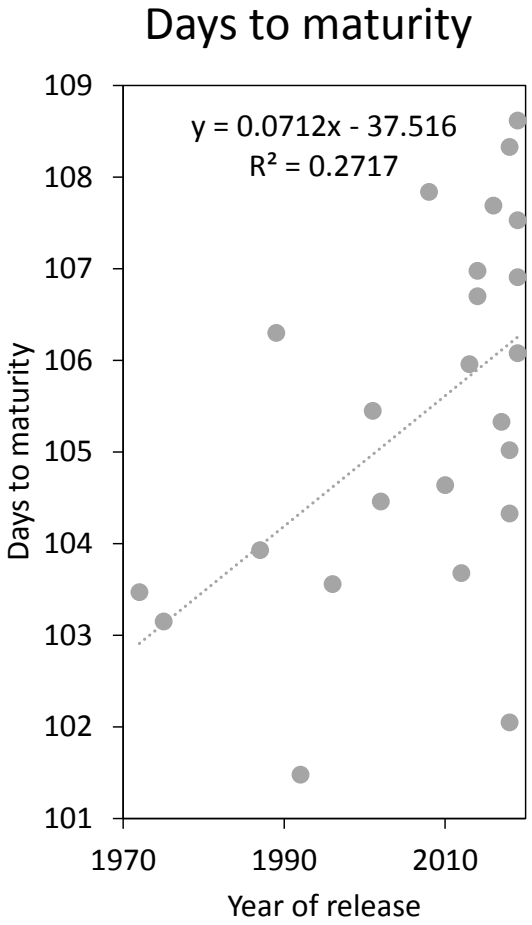
		NDVI	MTCI
Grain yield	75 kg N/ha	0.37	0.39
	150 kg N/ha	0.08	0.20

Eivind Bleken MSc thesis 2017

Cultivars by year of release







Plant physiological studies

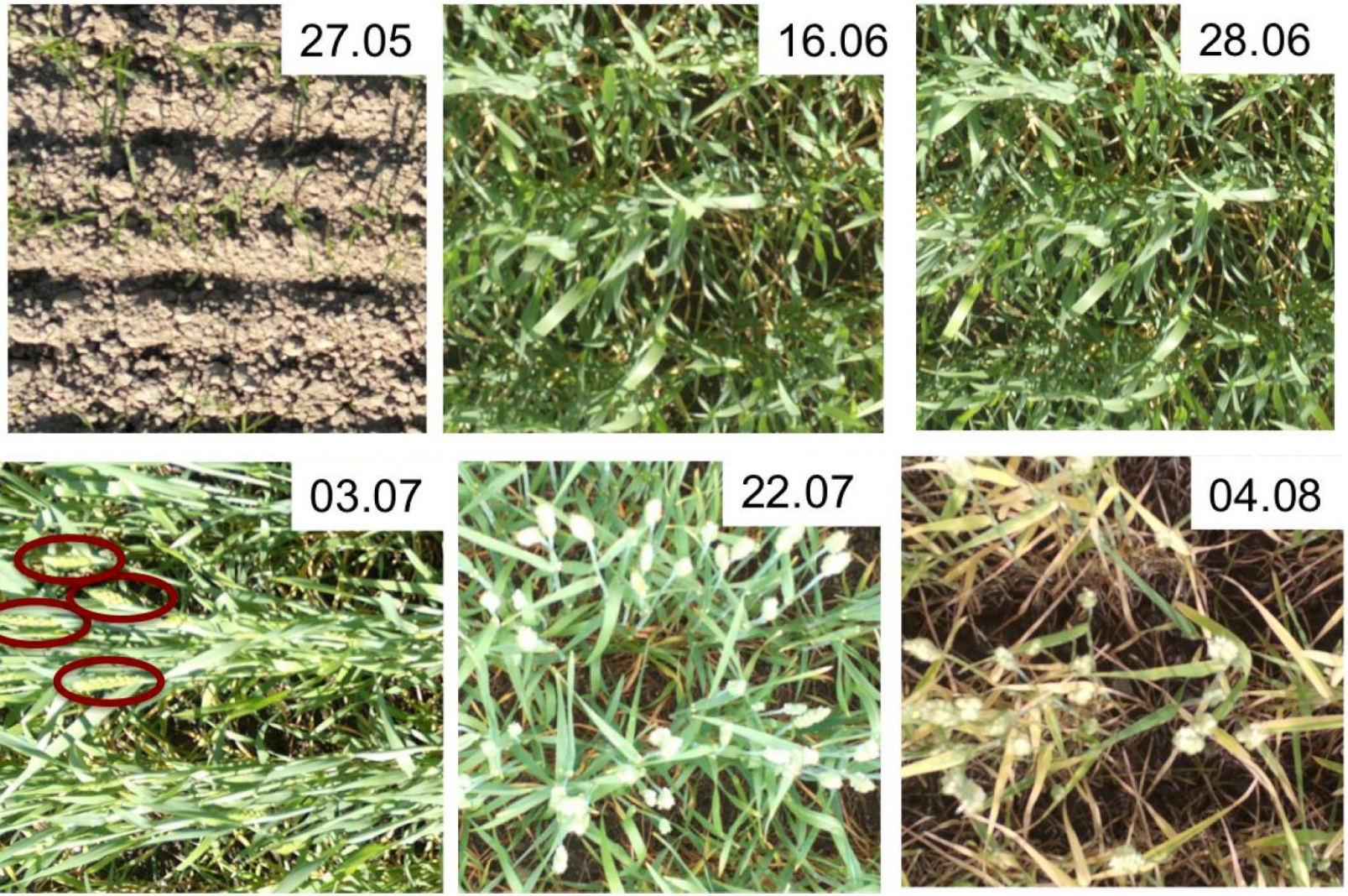
Light interception

Chlorophyll content

Bless Kufoalor MSc thesis 2018

Phenotyping with robot

Close-up images from robot



Virtual phenomics project (vPheno)

4-year industrial innovation project, 2017-2021

Graminor

MAKING VIEW

BOSTON UNIVERSITY

CIMMYT
International Maize and Wheat Improvement Center

Forskningsmidlene for jordbruk og matindustri

Research objectives

- Comparison of platforms:
  - Ground cover/early vigour
  - Heading date
  - Biomass (VIs)
  - Plant height
  - Maturity date

- Can we predict yield from these measurements?
- How can HTP data improve genomic prediction models?
- Can we use VR to take the field to the breeder?

Plant breeding and virtual reality

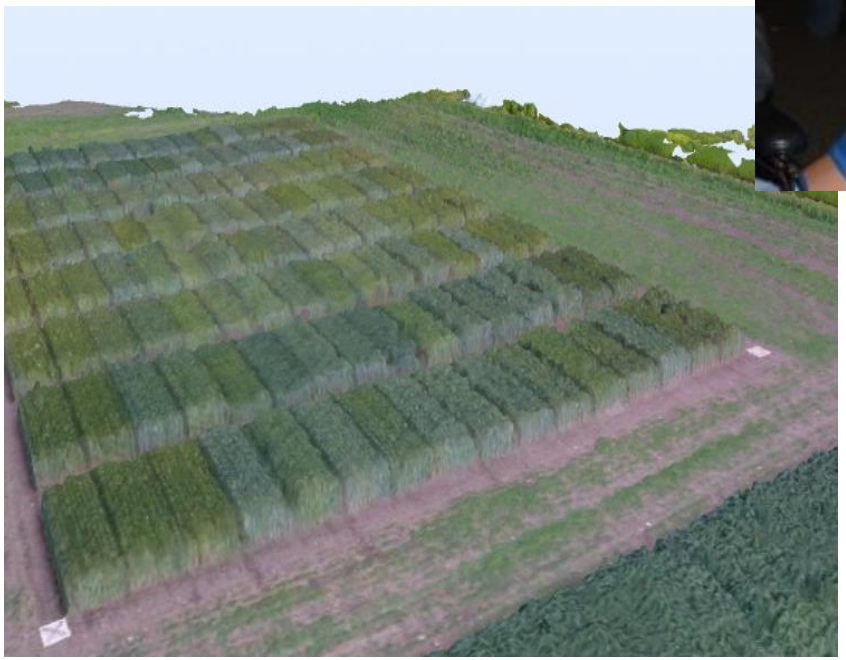
Graminor

MAKING VIEW

Genomic prediction and data management

$$y_{ij} = \mu + E_i + L_j + g_j + a_j + Eg_{ij} + Ea_{ij} + e_{ij}$$

BOSTON UNIVERSITY

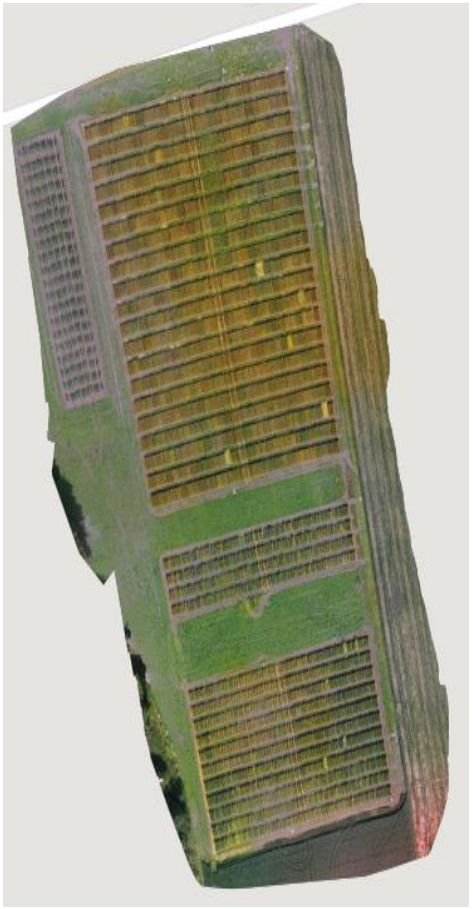


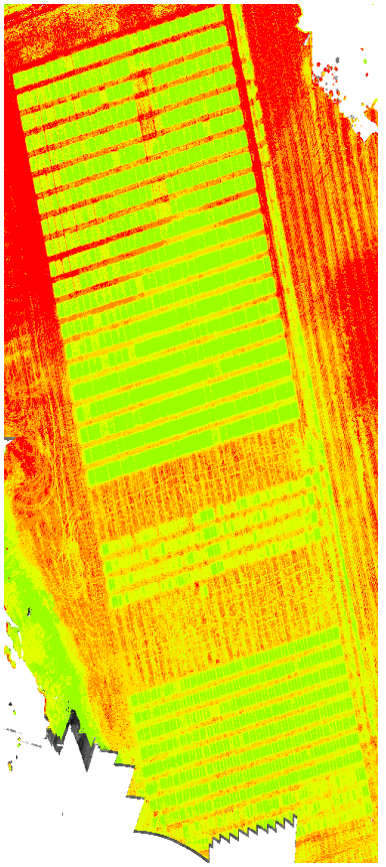
CIMMYT
International Maize and Wheat Improvement Center

300 spring wheat lines tested in 2017

- Correlations with grain yield:

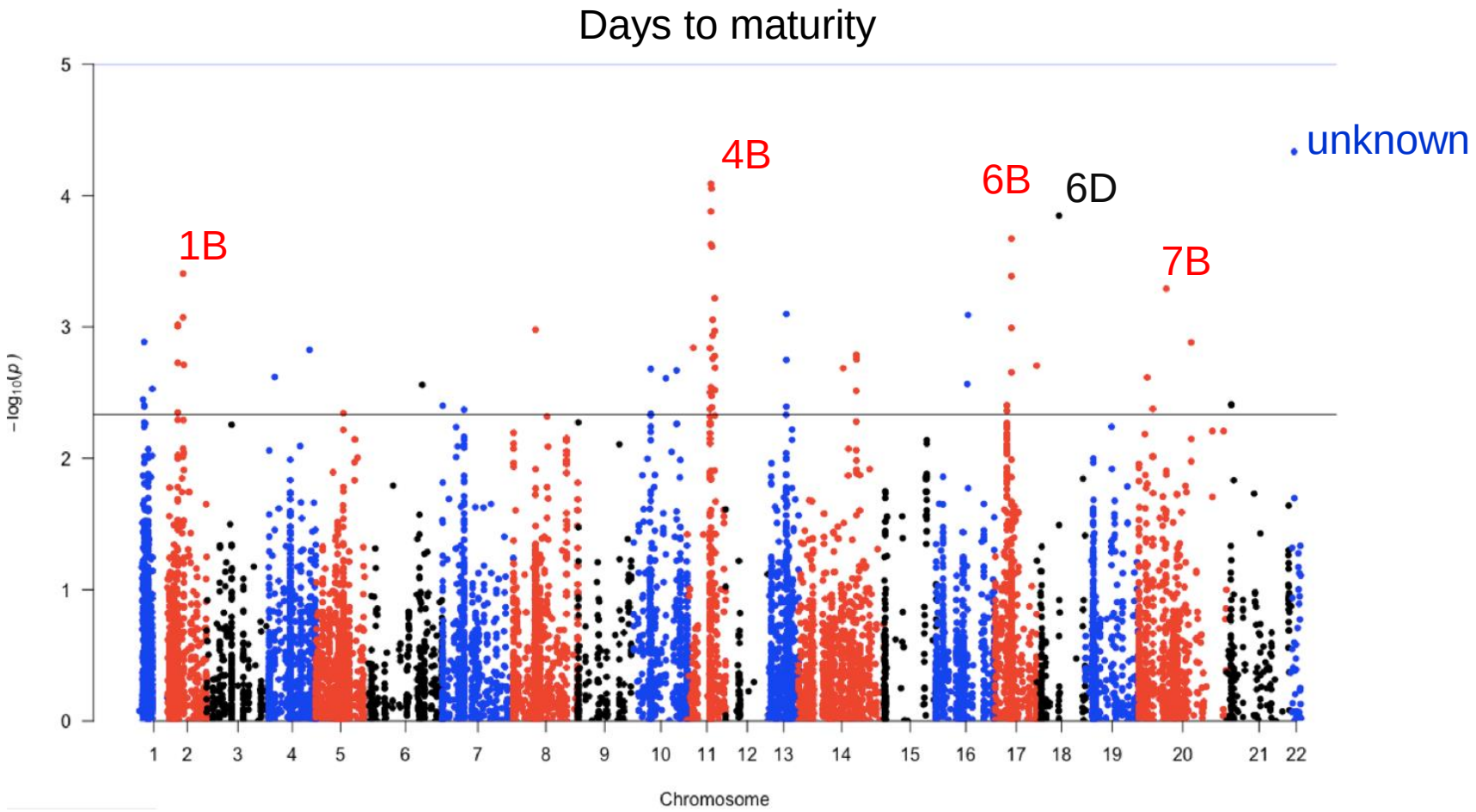
NDVI	0.335**
MTCI	0.490**
Days to maturity	0.161**





Ole Kristian Grindbakken
MSc thesis 2018

Genome-wide association mapping based on 35K markers



Camille Branchereau MSc thesis 2018

Combining multispectral data with genomic prediction

Canopy Temperature and Vegetation Indices from High-Throughput Phenotyping Improve Accuracy of Pedigree and Genomic Selection for Grain Yield in Wheat

Jessica Rutkoski,*,†,‡,1 Jesse Poland,§ Suchismita Mondal,‡ Enrique Autrique,‡ Lorena González Pérez,‡ José Crossa,‡ Matthew Reynolds,‡ and Ravi Singh‡

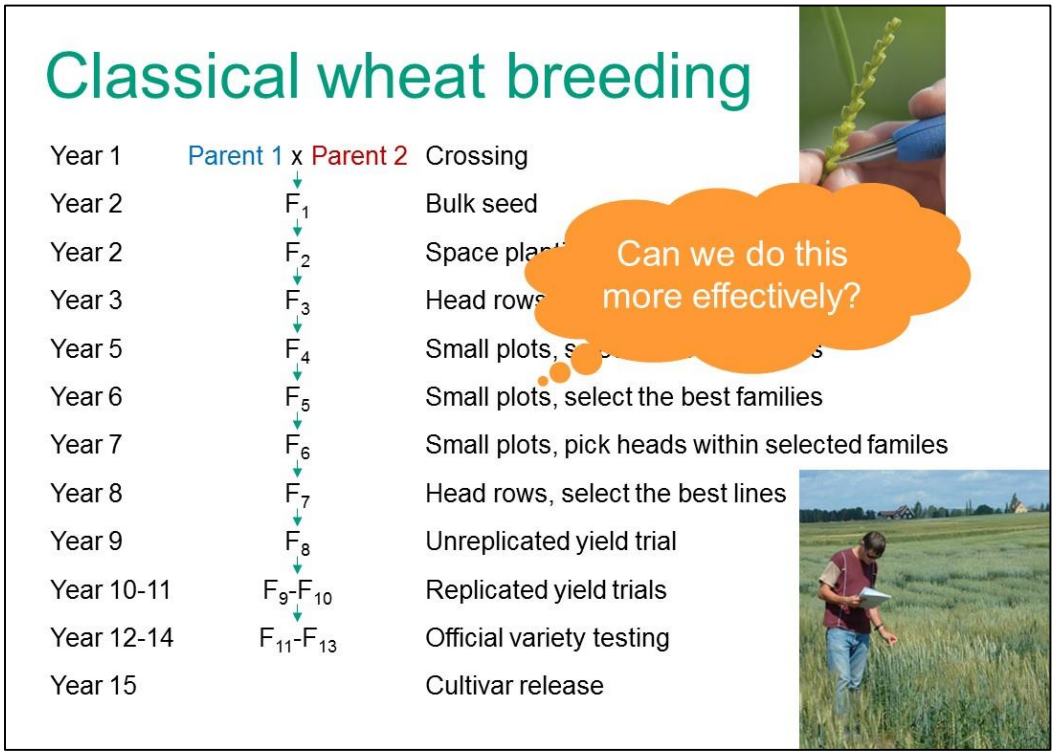
*International Programs, College of Agriculture and Life Sciences, and †Plant Breeding and Genetics ... School of Integrated Plant Sciences, Cornell University, Ithaca, New York 14853, ‡Global Wheat Program, In... Maize and Wheat Improvement Center (CIMMYT), Ciudad de Mexico, 06600, Mexico, and ...partment ... gy, K... State University, Manhattan, Kansas 66506

G3 6 (2016): 2799-2808

Now being tested on Norwegian spring wheat

CIMMYT
International Maize and Wheat Improvement Center

Field phenotyping - is it useful?



- As a direct selection tool
- Traits we cannot see with the eye
- Improved genomic prediction
- Enhanced insight into physiological and genetic mechanisms

vPheno project group

NMBU – Biovit

Morten Lillemo

Bless Kufoalor

Sahameh Shafiee

++

NMBU – RealTek

Ingunn Burud

Erik Solberg

Pål Johan From

Lars Grimstad

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MAKING VIEW

BOSTON UNIVERSITY

CIMMYT

International Maize and Wheat Improvement Center

Plant breeding for sustainable plant health management

NOVA PhD course of 5 ECTS

27 Jan - 1 Feb 2019, in Dombås, Norway.

Further info: www.nmbu.no/nova

or morten.lillemo@nmbu.no

Application deadline: November 13

http://www.clipartkid.com/