Work Package 5

Modelling activities to support plant breeding

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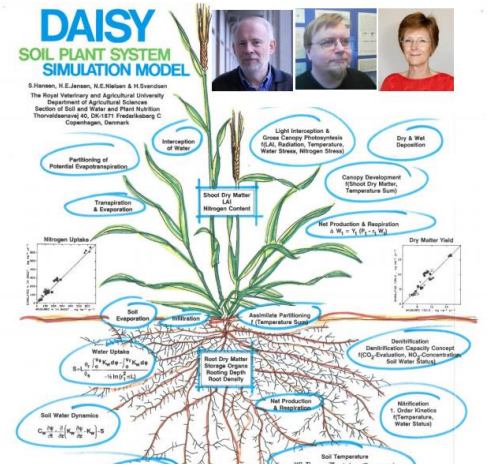
Work Package 5:
Modelling activities to support plant breeding

Main research question

Will mechanistic modelling improve the understanding of relationships between crop traits and environment?

Activities

- Environmental characterization of all breeder sites
- Test experiment with spring barley at three sites (Graminor, Sejet and Lantmannen)
- Integration of UAV data collected by breeders with the Daisy model.

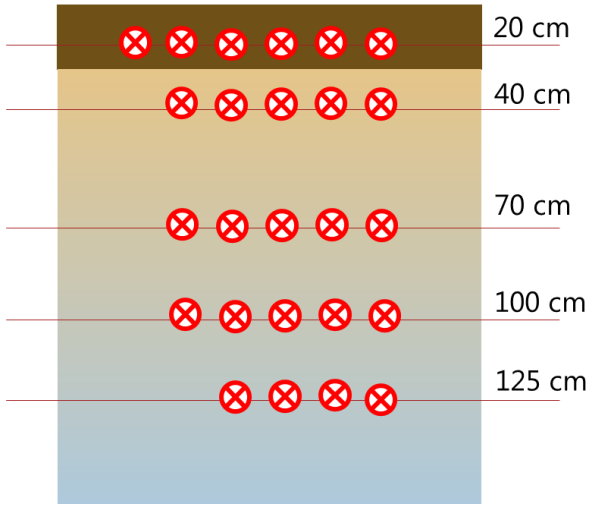


Open Source:
Mechanistic simulation of agricultural fields

Environmental characterization (soil data)

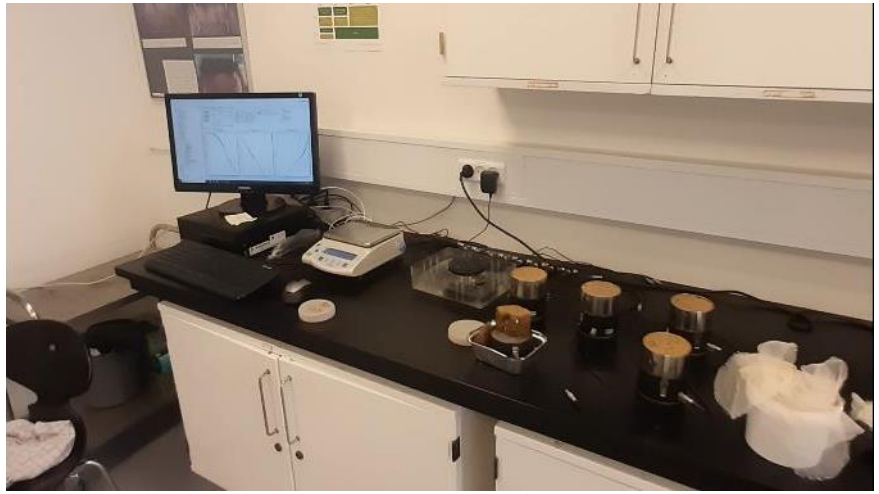
Soil profile investigation

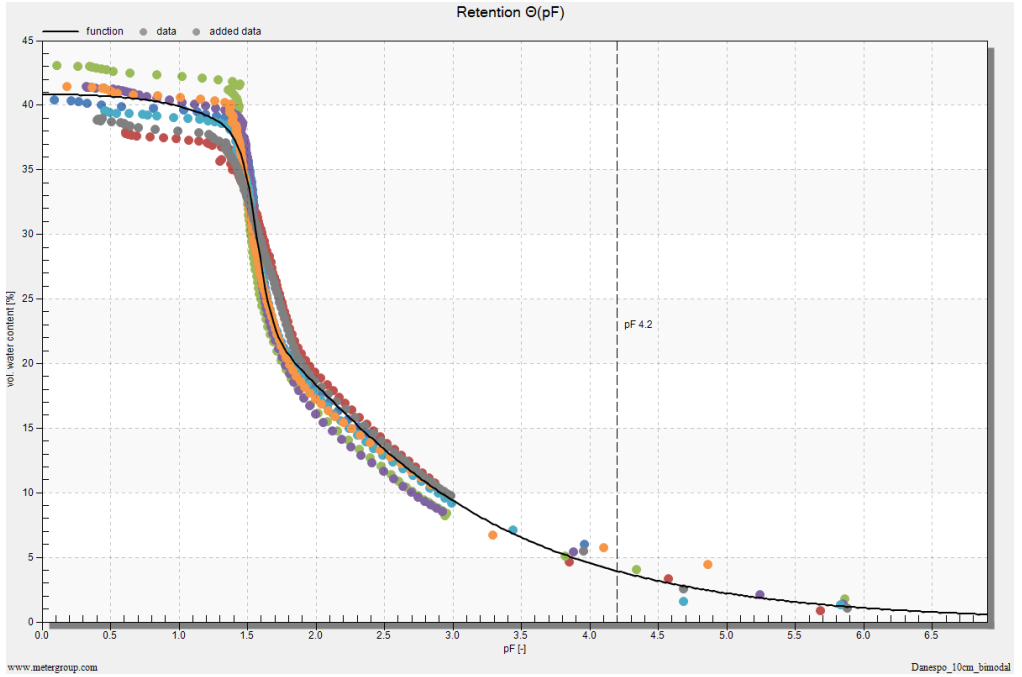
- Soil horizon description
- Ring coring at each layer
- Soil texture data
- P,Mg and K content
- Soil (pH)
- Soil water retention
- Soil hydraulic conductivity



Environmental characterization (soil data)

Measurement of soil physical properties using the hyprop system





Data fitted using bimodal constrained Van Genutchen model (Durner 1994)

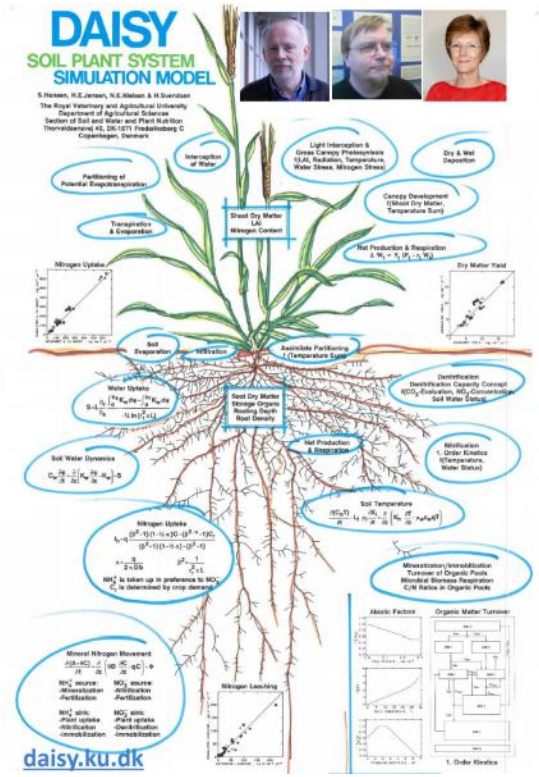
Environmental characterization (soil data)

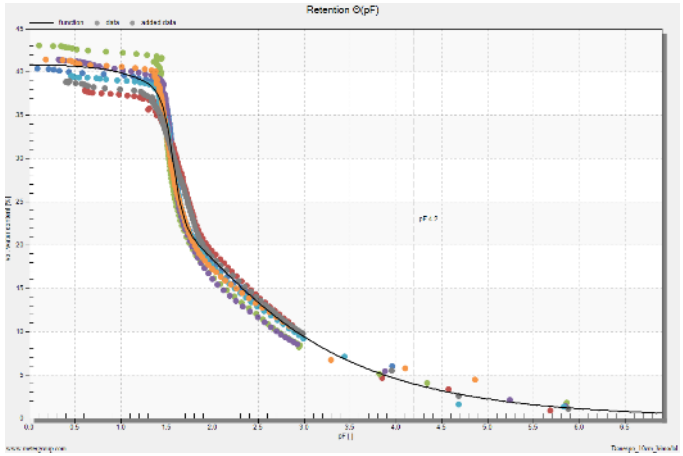
Daisy soil column files made for all sites

```
;;Description of the soilprofile
(defcolumn "Profile" default
    (Soil
    (MaxRootingDepth 100.00)
          (horizons (  -30.00 Ap)
                    (  -40.00 Bs_plowPan)
                    (  -60.00 Bs)
                    (  -200.00 C)))
  (Groundwater deep)
    (Chemistry low_denit))
```

```
(defhorizon Ap USDA3 (normalize true)
;0-30 cm
          (clay 3.9 [%])
          (silt 6.4 [%])
          (sand 87.0 [%])
          (humus 2.8 [%])
          (C_per_N 14.2)
(dry_bulk_density 1.47)
(root_homogeneity 0.5)
(hydraulic M_BivG
                    (alpha1 0.026 [cm^-1])
                    (n1 1.315 [])
                    (Theta_res 0.000 [])
                    (Theta_sat 0.409 [])
                    (alpha2 0.0277 [cm^-1])
                    (n2 7.689 [])
                    (w2 0.357 [])
                    (K_sat 200 [cm/d])
                    (l 1.509 []))
)
```

Ap





Environmental characterization (weather data)

Weather data obtained from various sources

Different ontology and large variation in data quality

Norway
DMI/FieldSense/Breeder stations

Danish Meteorological Institute - Open Data

Created by DMI Bruger, last modified on Jan 19, 2022

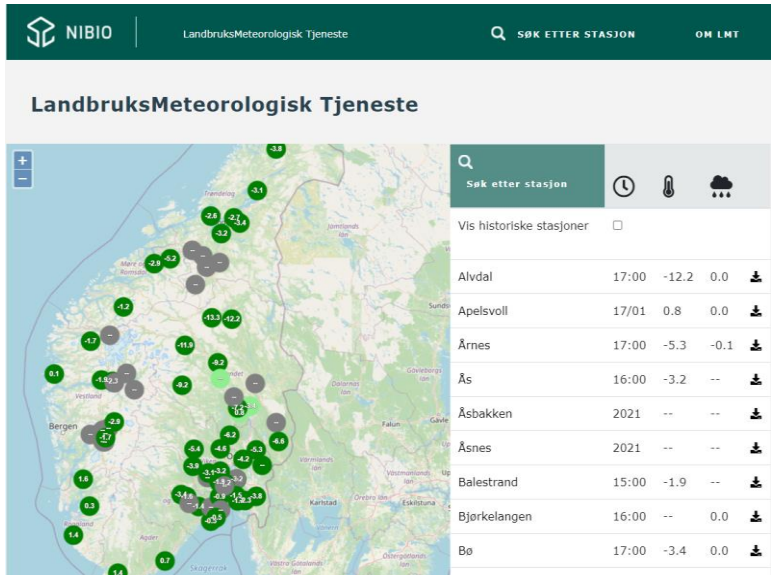
The Danish Meteorological Institute's (DMI) Open Data API provides free and open access t

This site provides all the information you need to register as a user and start using the API. specification of the web services currently available.

Please also visit www.DMI.dk/friedata

DMI Open Data

Norway
LandbruksMeteorologisk Tjeneste



Sweden
SMHI/Lantmet

Välkommen

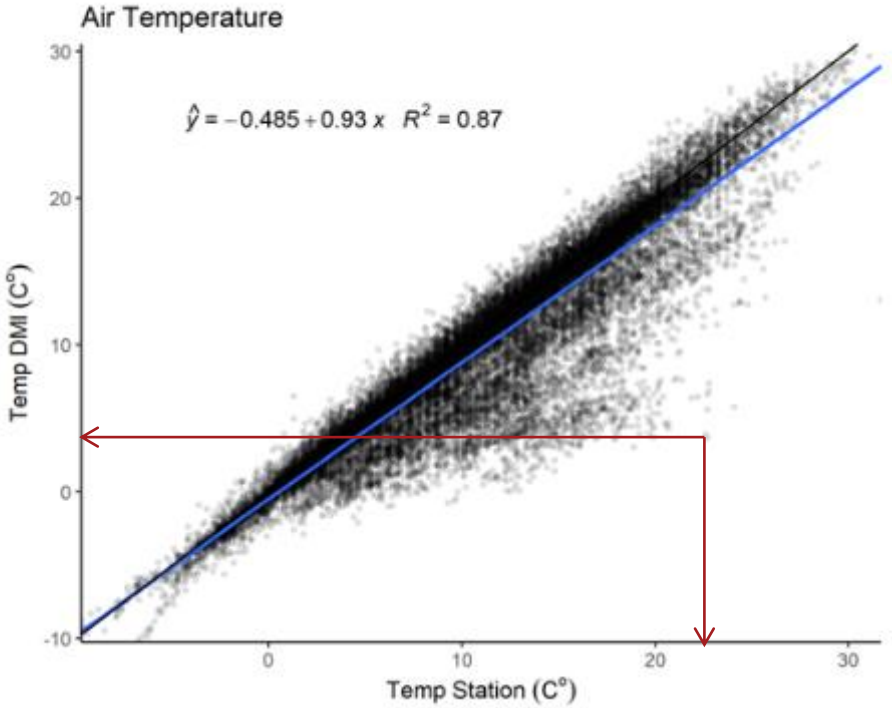
Välj bland följande tjänster:

KLIMATDATA
Presentation av klimatdata i form av rådata, timvärden och dygnsvärden - i tabeller eller diagram.

TILLÄMPNINGAR
Tjänster baserade på klimatdata, såsom modeller och beräkningar. Uppdateras f.n.

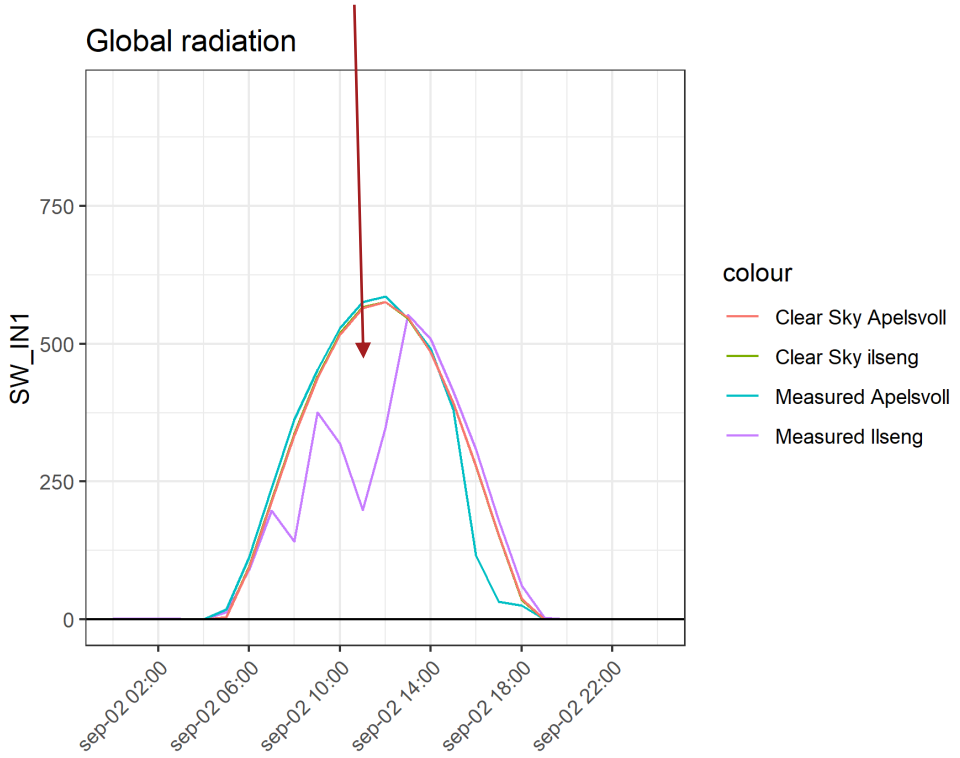
Quality control of weather data

- Data comparison to nearby stations
- Some sensors at breeder stations were unreliable
- Bad data and missing values were replaced with data from nearby stations



Difference of 19 C° (Distance 16 km)

Mowing shadows from trees



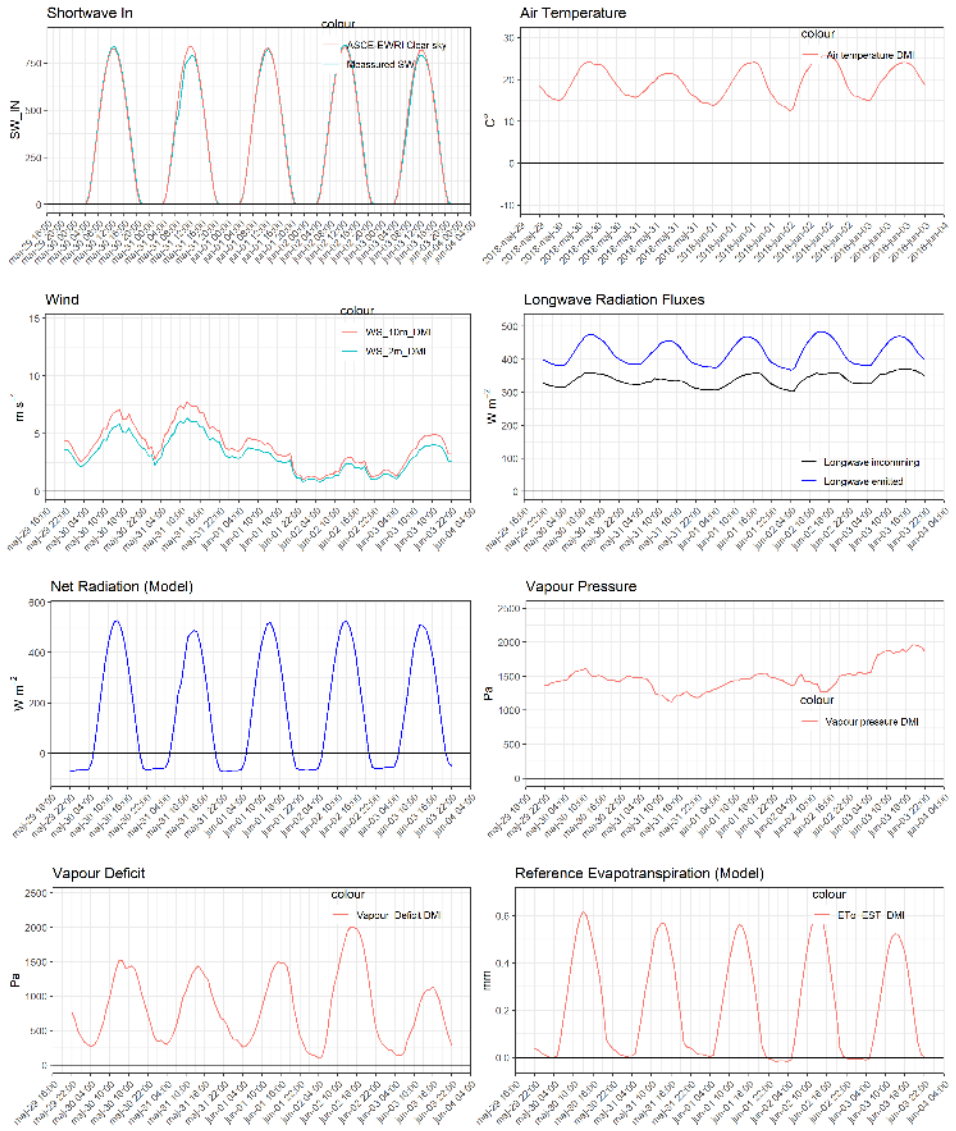
Environmental characterization (weather data)

Daisy hourly weather files created for all sites

Reference Evapotranspiration Method:

- FAO-penman method for hourly data (Allen et al. 2006)
- Net-radiation estimated according to (ASCE 2005)
- Cloudiness function for Sub-humid climates (Kjærsgaard et al. 2008)

Year	Month	Day	Hour	AirTemp	RelHum	Wind	GlobRad	Precip	RefEvap
year	month	mday	hour	dgC	%	m/s	W/m^2	mm/h	mm/h
2011	1	1	0	2.8	90.3	7.731	0	0.1	0.005932
2011	1	1	1	3.1	92.8	8.63	0	0.1	0.004012
2011	1	1	2	3.2	94.3	7.731	0	0.2	0.002151
2011	1	1	3	3.4	90.5	7.641	0	0	0.005222
2011	1	1	4	3.2	82.5	7.91	0	0	0.012
2011	1	1	5	3.1	80.7	8.27	0	0	0.01351
2011	1	1	6	2.9	82.2	8	0	0	0.01163
2011	1	1	7	2.7	82.5	6.652	0	0	0.009822
2011	1	1	8	2.6	81.5	6.203	3	0	0.009964



spring barley demonstration experiment

Providing information of “E” and “M” in “GxExM” interactions

Modelling water and nitrogen stress

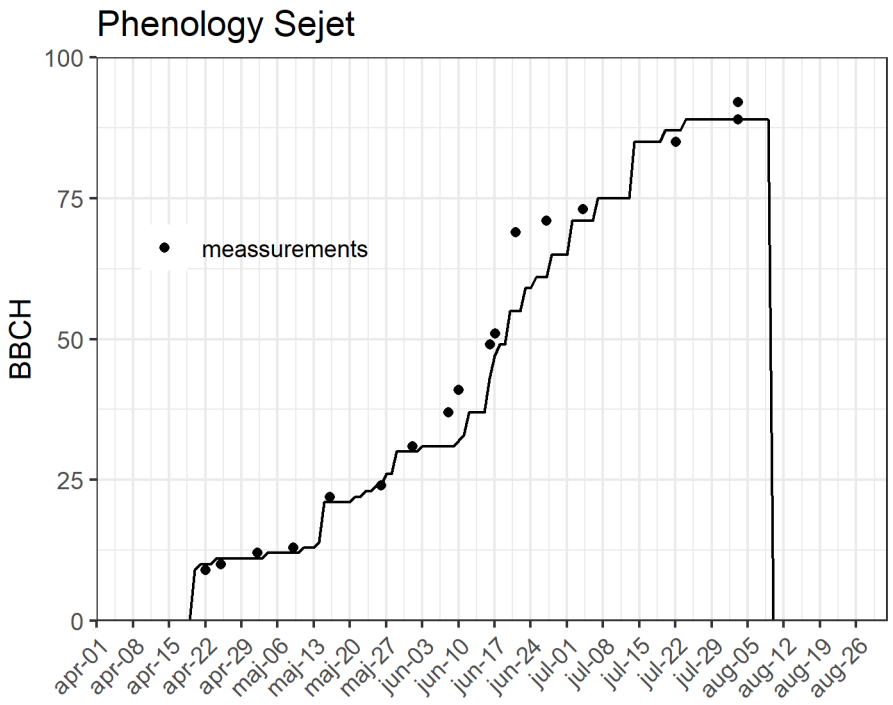
Six cultivars, at three sites, in 2 seasons.

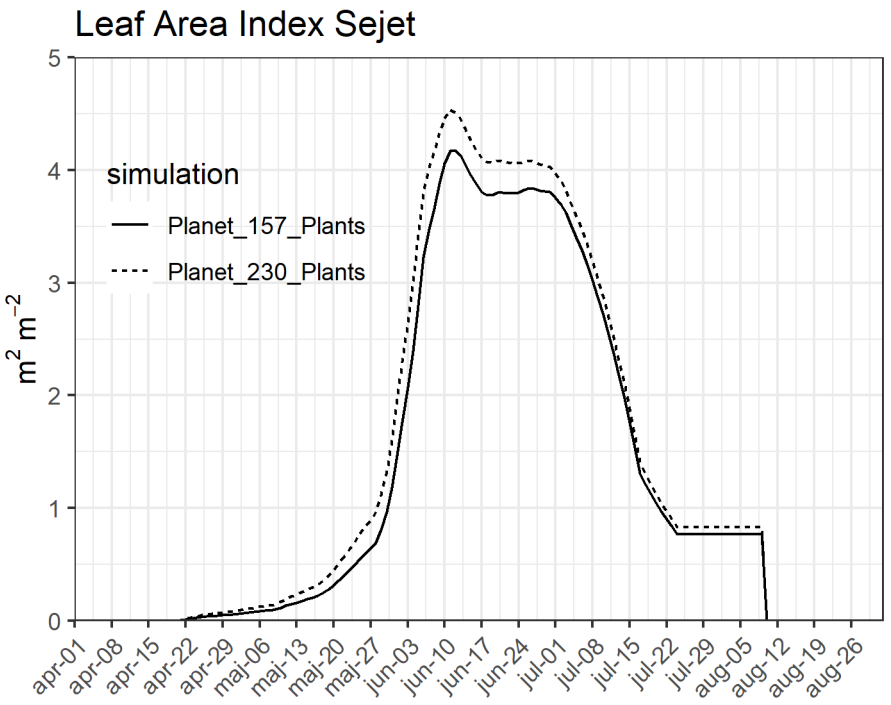
- Plant count
- Phenology observations
- Weekly UAV imaging
- Grain Yield
- At some locations measurements by sensors (Water potential/groundwater)

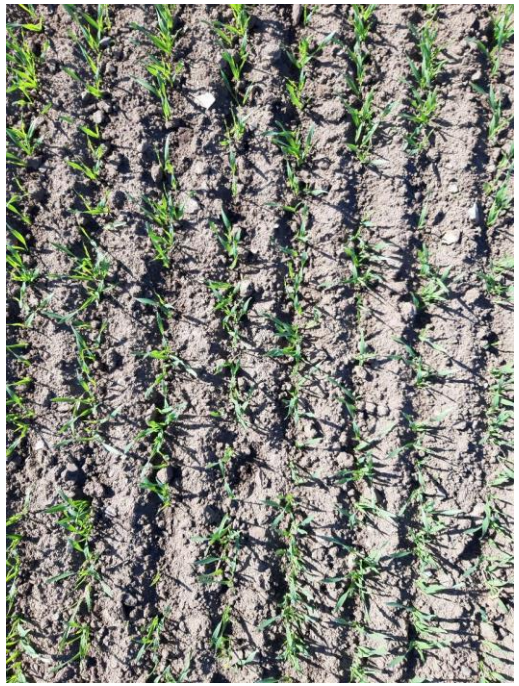
Modelling spring barley development using Daisy

Example with different plant densities (Sejet)

RGT Planet grown at 157 and 230 plants/m^2

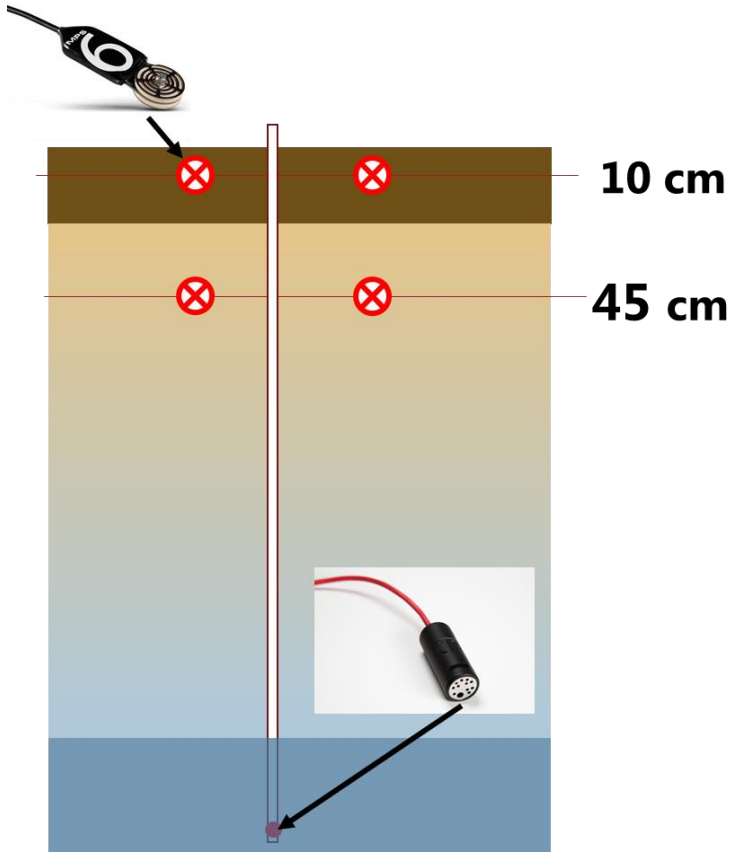


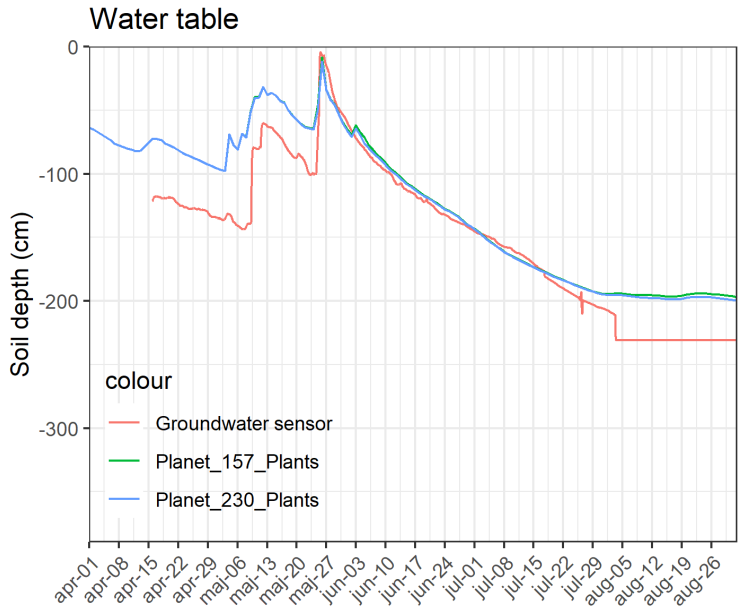


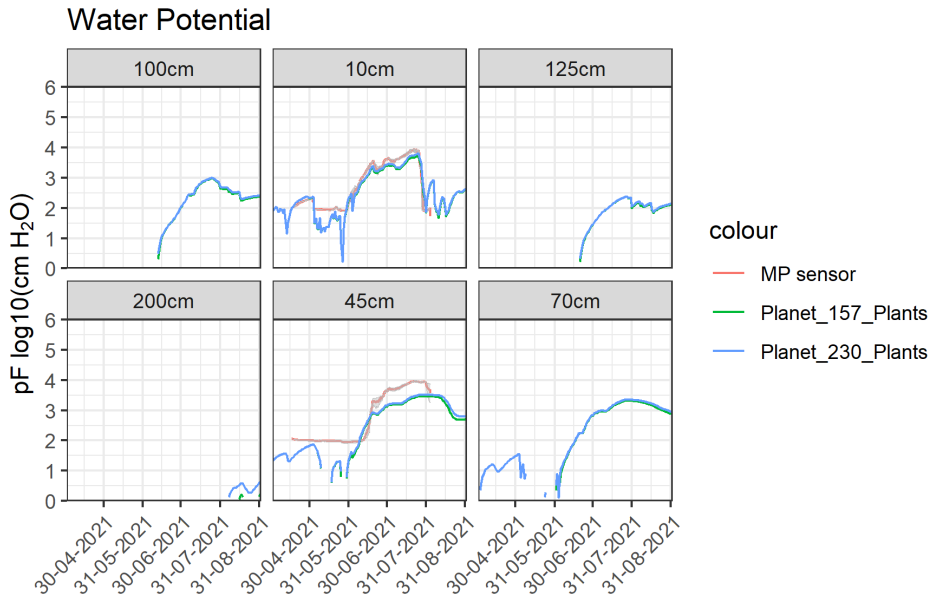


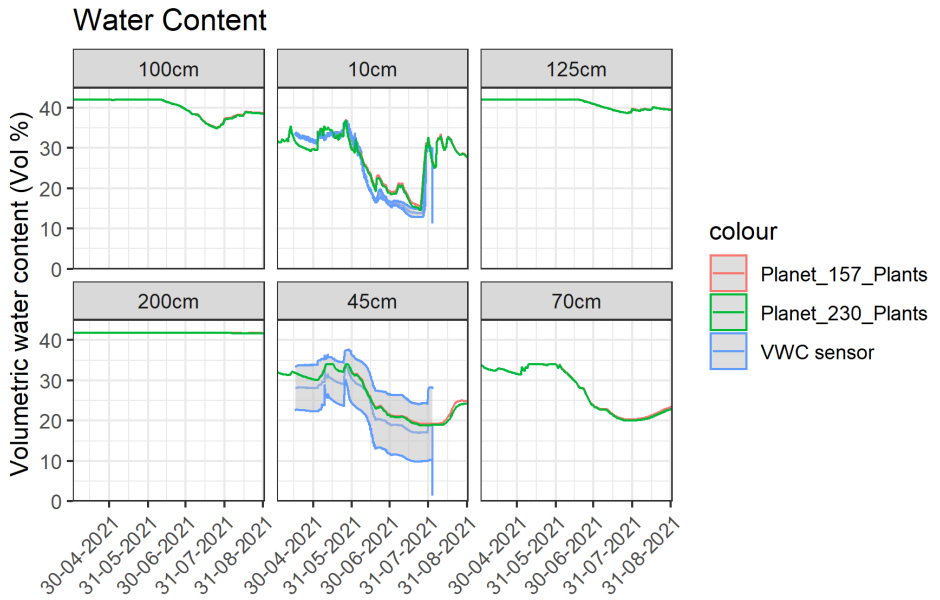
Environmental characterization (Modelling)

Validating model using soil water sensors (Sejet)



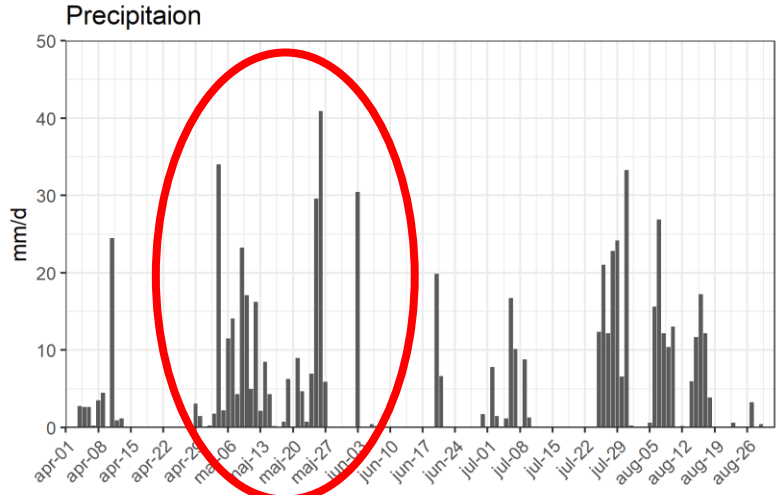


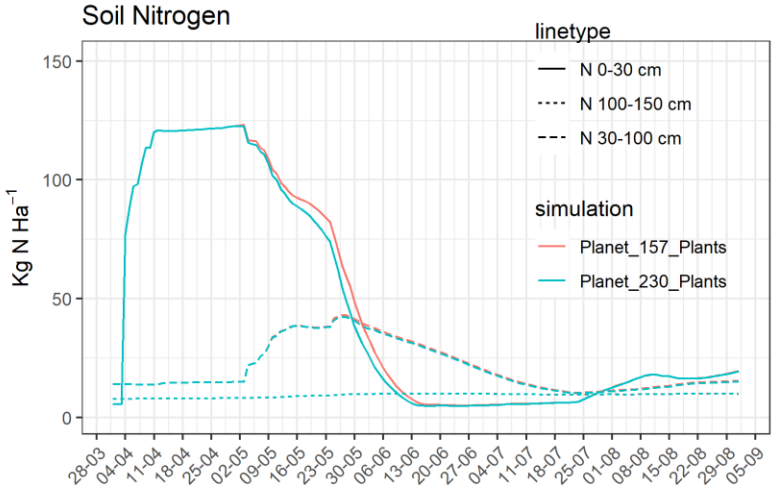


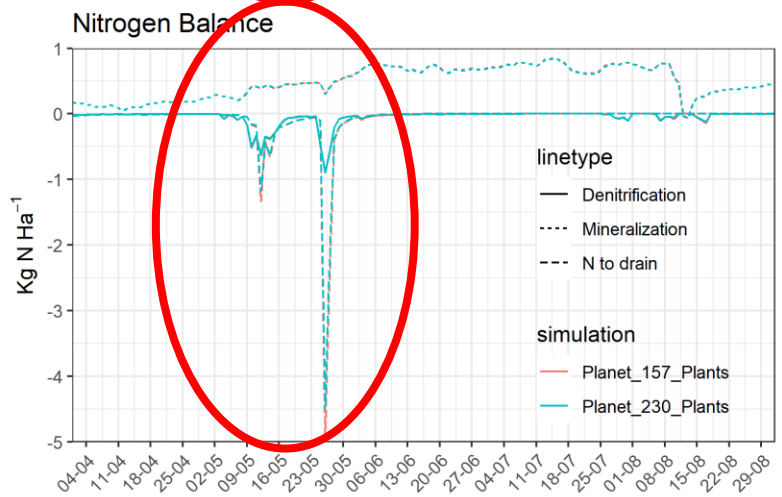


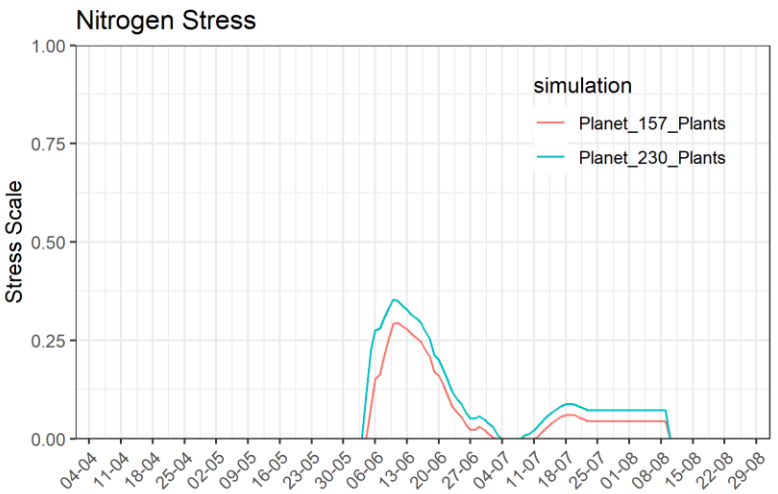
Environmental characterization (Modelling)

Wet and cold May! Risk for early nitrogen leaching (20 kg N ha^{-1} lost)



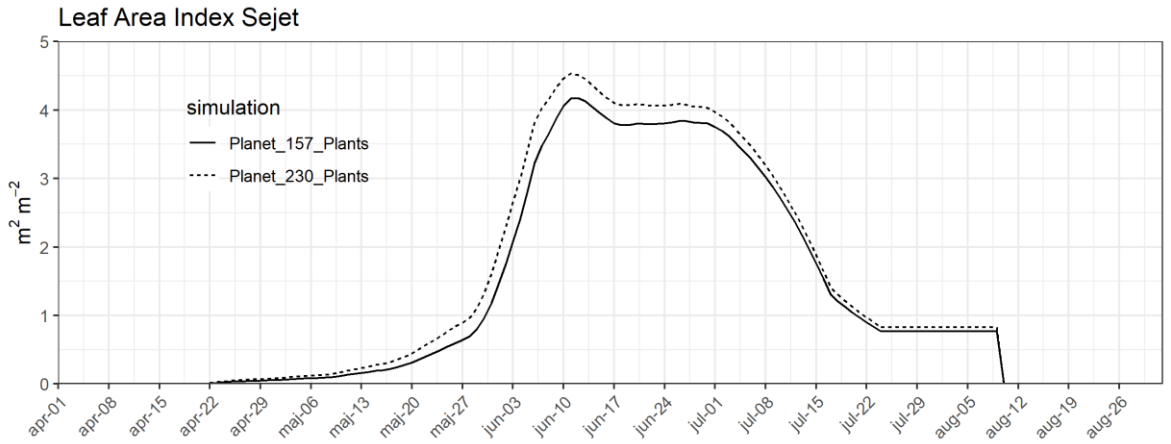


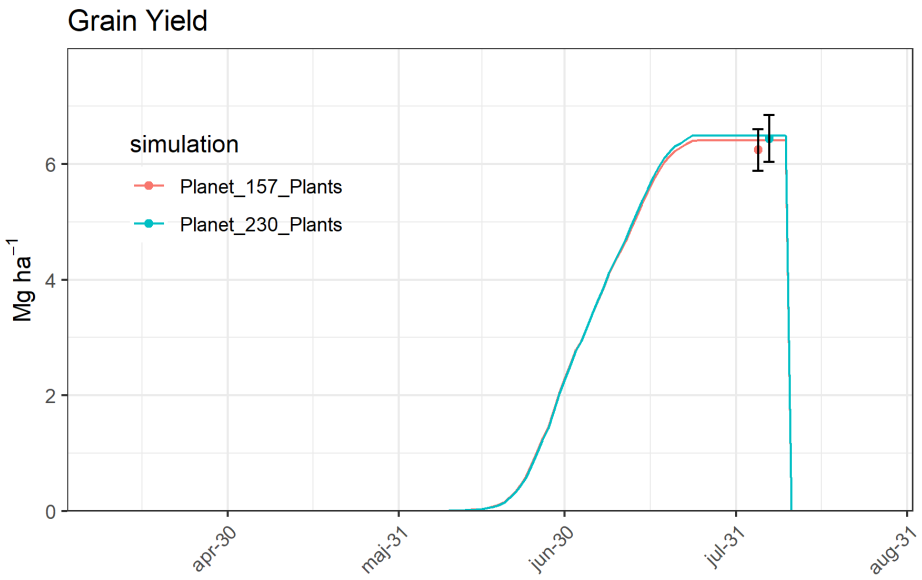


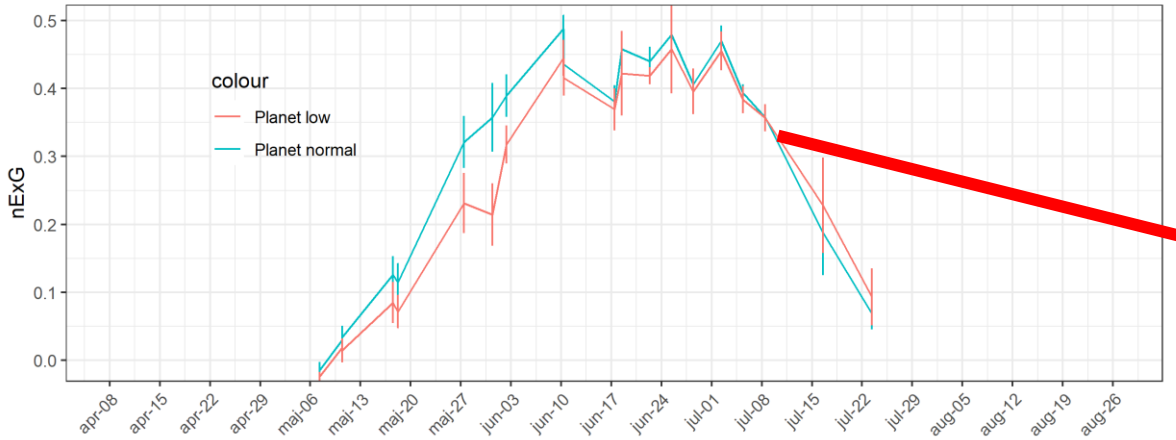


Environmental characterization (Modelling)

Plant density had an large effect on early growth but limited effect on yield.
Model and measurements agree!

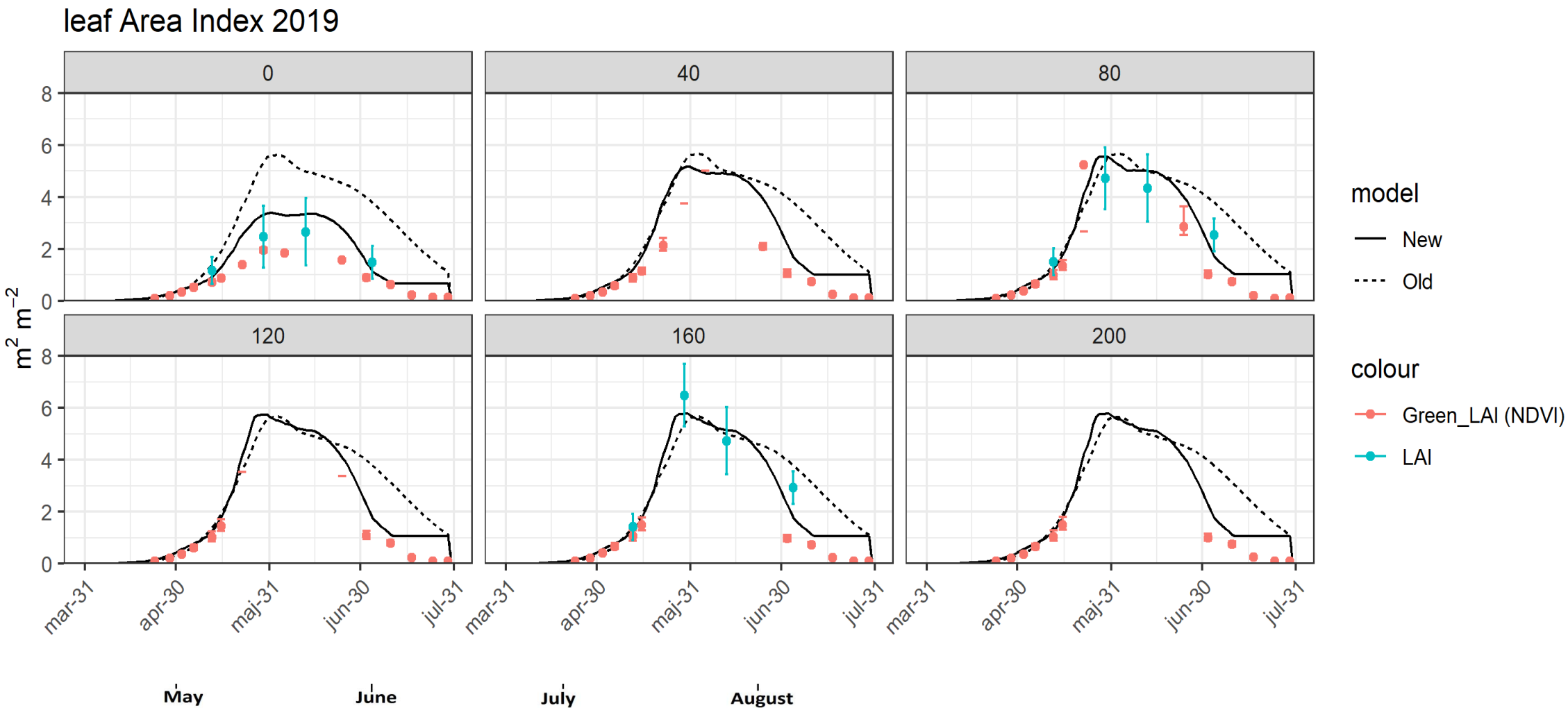






Coupling of UAV data collected by breeders with the Daisy model

The handheld NDVI SpectroSkye sensor have previously been used with good results



Coupling of UAV data collected by breeders with the Daisy model

- Need of method to estimate LAI from RGB imaging. Maybe deep learning could help?
- Drone NDVI imaging are preferred for LAI estimation but was unstable (At least in one case). P4M seems promising!
- Using deep learning, plant and head count will be valuable for integration with Daisy.
- Practical problem: A good plot cover/plant count estimation requires low height when flying. Hard to cover extensive experiments.

Deep learning and Daisy

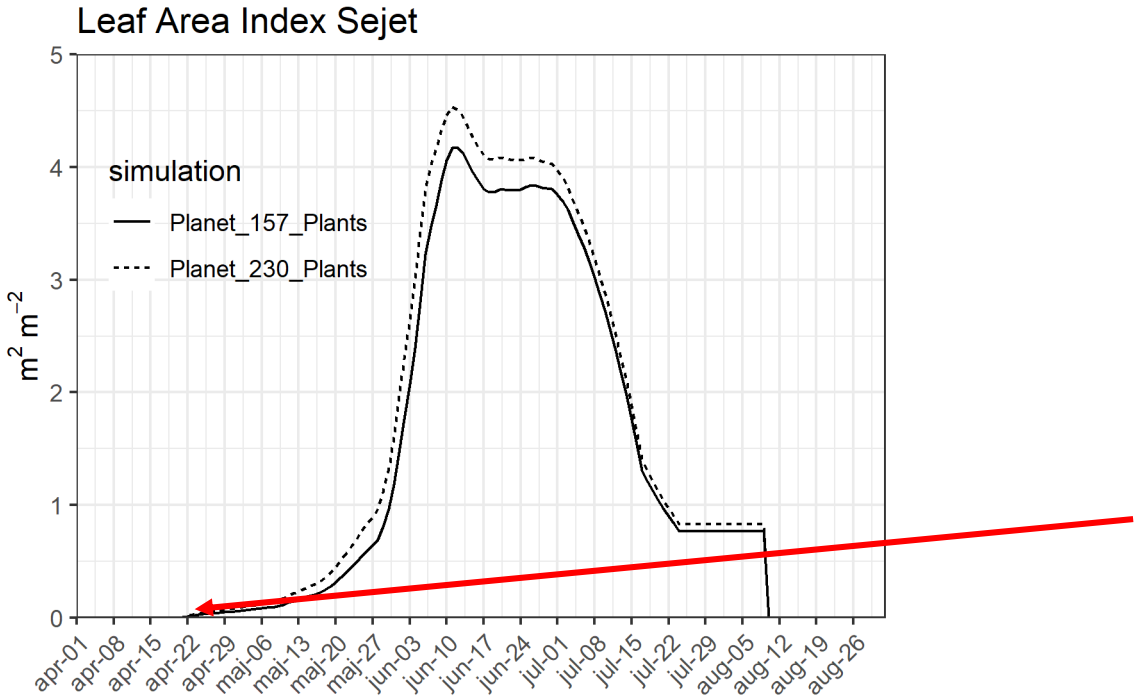
First attempt to estimate plant density using root painter

Ph.d. Abraham George Smith (UCPH-DIKU)
Janus Asbjørn Schatz-Jakobsen (Sejet)

RootPainter: Deep Learning Segmentation of Biological Images with Corrective Annotation

Abraham George Smith, Eusun Han, Jens Petersen, Niels Alvin Faircloth Olsen, Christian Giese, Miriam Athmann, Dorte Bodin Dresbøll, Kristian Thorup-Kristensen

doi: https://doi.org/10.1101/2020.04.16.044461



Work Package 5: Modelling activities to support plant breeding

Deliverables

- D5.3.1 Implemented DAISY model columns for each of the five field sites.
- D5.3.2 A comparison of the local environment ('E' in G*E*M-models) for modelled field sites.
- D5.3.3 Demonstration of model test platform for interpreting collected sensor data. The first test of novel trait combinations ("ideotypes") for present and future climate conditions.

Milestones

- M5.1.1 Installation of soil monitoring equipment and soil sampling completed.
- M5.1.2 Hyprop measurements completed.
- M5.2.1 Weather, Crop and Soil monitoring data delivered to the common database for the 2021-season.
- M5.2.2 Weather, Crop and Soil monitoring data delivered to the common database for the 2022-season.

Daisy Workshop

Common RadiBooster – 6P3 Daisy Workshop

Tomorrow 2/2-2022 at 09.00

Online Zoom workshop

- Calibrating the daisy phenology function to measured data
- The value of deep rooting, hypothesis testing