Phenotyping with drones

An overview of activities

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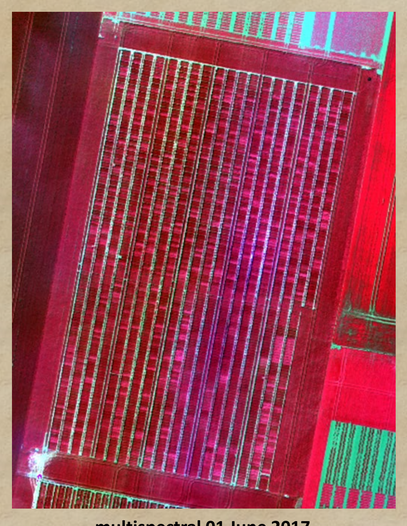
IPPS 2022 PLANT PHENOTYPING FOR A SUSTAINABLE FUTURE

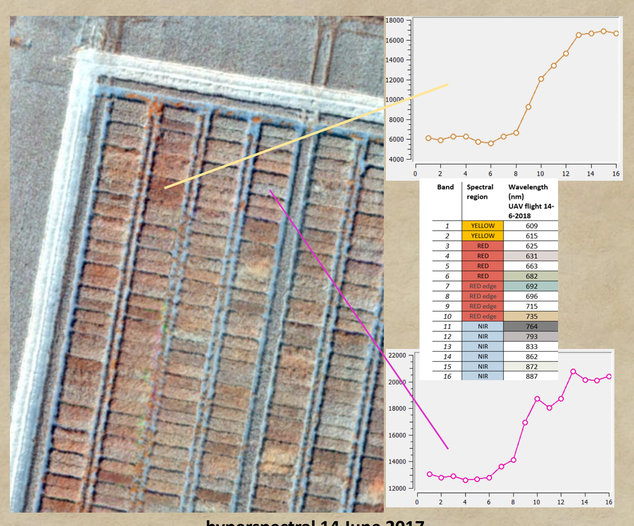
From 2017 onwards we have carried out several projects in which we have acquired imagery with a wide range of drone camera systems. The aim was to develop methods that enable phenotyping with drones for different crops. Experiments were done on quinoa, maize, winter wheat, spinach and potatoes. Field measurements were taken during these experiments. Next to RGB cameras, also multispectral, hyperspectral, thermal and LiDAR cameras have been used. Determined plant traits were for example vegetation structure (height, volume), lodging, ripening and diseases. This poster shows a few examples of completed and ongoing projects. Details can be found in the mentioned publications.

Detecting brown rust in winter barley with UAV-derived hyperspectral imagery

RGB 01 June 2017



multispectral 01 June 2017



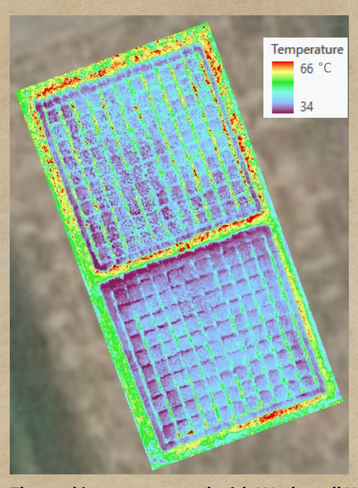
hyperspectral 14 June 2017

RGB 26 June 2017

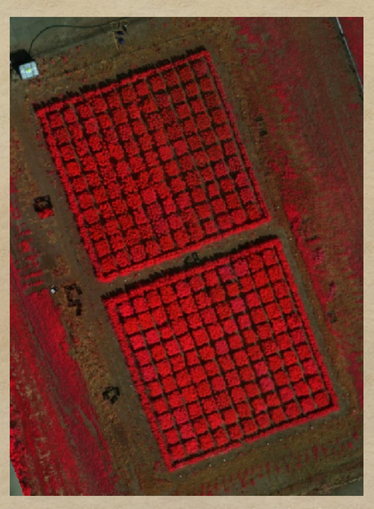
Crop height from LiDAR 26 June 2017

Indices from multispectral and hyperspectral data were used to explore correlation with validation brown rust scores. LiDAR data was used for selecting test plots without lodging.
MSc thesis "next generation phenotyping with uavs, field phenotyping of winter barley with drones detecting brown rust ", Jonker, F.A., GIRS-2019-28. https://edepot.wur.nl/517955

Experiment on salt tolerance of quinoa crop at Nergena test field in Wageningen 2017



Thermal image, captured with Workswell WIRIS 640 camera

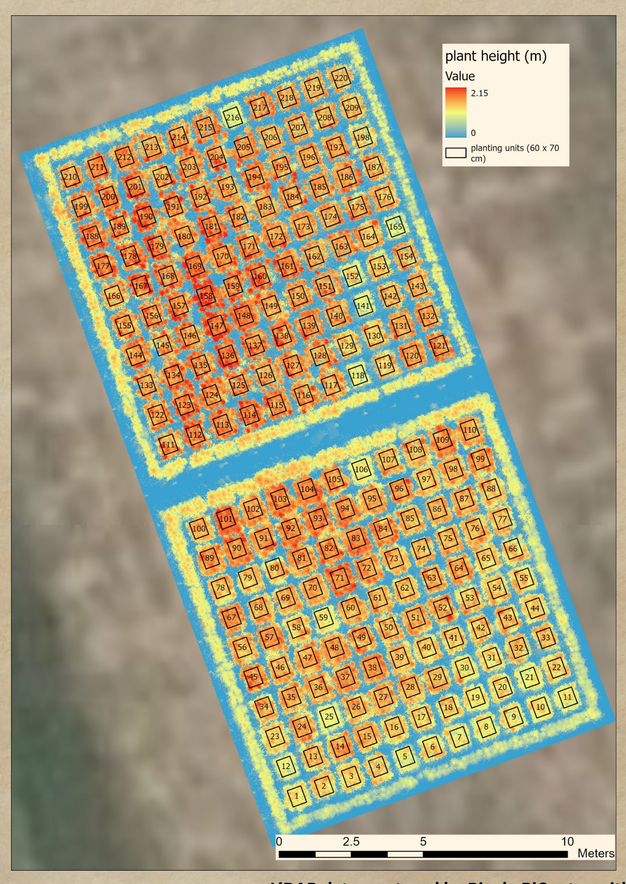


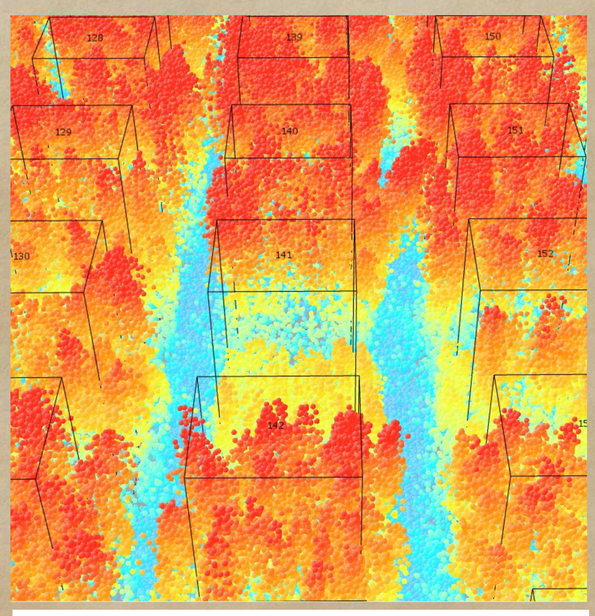
False color view
R = 800 nm
G = 670 nm
B = 550 nm

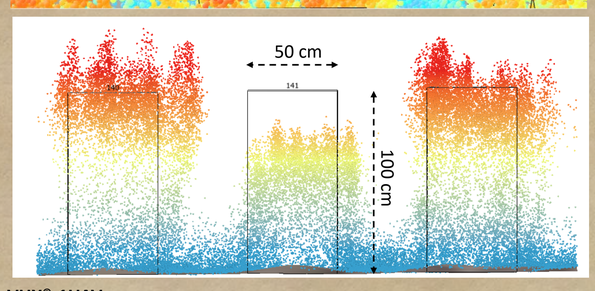
Hyperspectral image, captured with Rikola 16 band camera

Plant height, temperature and NDVI measurements per planting unit were used for a study on UAV based soil salinity assessment of cropland.

Ivushkin et. al. 2018, UAV based soil salinity assessment of cropland. https://edepot.wur.nl/461792

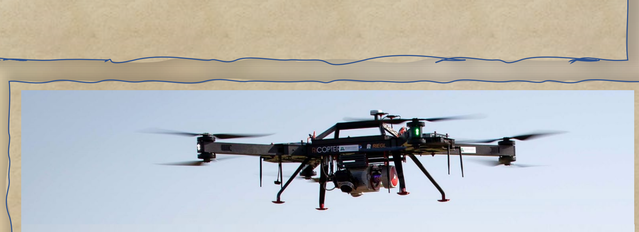






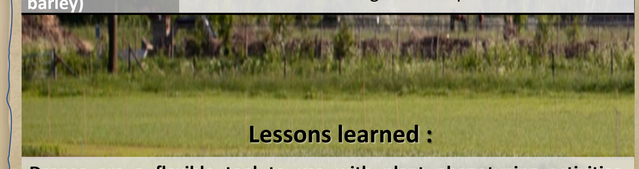
LiDAR data, captured by Riegle RiCopter with VUX®-1UAV scanner

Test field with quinoa crop



Goals achieved :

plant traits	preferred sensor	remark
counting & emergence	RGB	high resolution imagery enables automated plant counting
height, volume	LiDAR	accurate measurements of plant structure
lodging	LiDAR	accurate measurements of plant height
	RGB	adequate for capturing lodging
senescence	RGB / multispectral	high resolution imagery preferred
diseases (eg brown rust in barley)	hyperspectral	results show moderate relationship, requirements for hyperspectral range to be explored



Lessons learned :

Drones are a flexible tool to use with plant phenotyping activities. Different types of sensors are available to capture the properties of plants in the field at multiple scales. High resolution optical cameras can capture the smallest plants, multispectral and hyperspectral cameras record spectral signatures of plants. This enables research into a wide range of plant characteristics like ripening, stress, senescence, health, disease and more. Thermal cameras provide information on plant temperature.

However fully automated processing procedures remain a challenge. Achieving sufficiently accurate geolocation is possible but still requires some manual operations. Capturing imagery on partly cloudy moments, what occurs in The Netherlands, results in imagery with areas of different illumination. These must be processed separately.

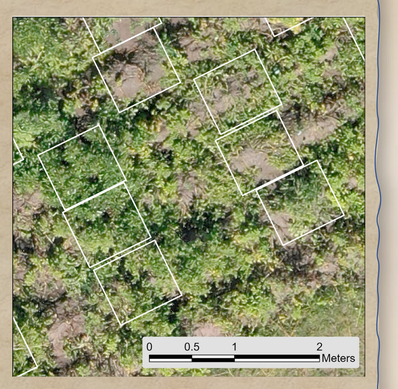
When designing a test field, it is also important that the aspects of image interpretation are taken into account. When a plant in its lifecycle grows outside the plot boundaries, automated interpretation cannot link the results to the original plot directly, which could be done with manual fieldwork. A good design of the test setup can prevent this.

Ongoing development of drones and all kinds of sensors will expand the research possibilities and offer many opportunities for phenotyping research.

Plant emergence, senescence scoring and QTL mapping at WUR campus test field

06 June 2020
emergence

10 July 2020
before senescence

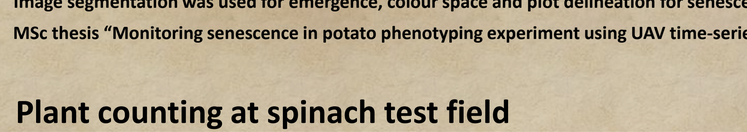


07 August 2020
after senescence

Image segmentation was used for emergence, colour space and plot delineation for senescence scoring and QTL mapping.

MSc thesis "Monitoring senescence in potato phenotyping experiment using UAV time-series data", Pakachaipong V., GIRS-2022-01.

Plant counting at spinach test field

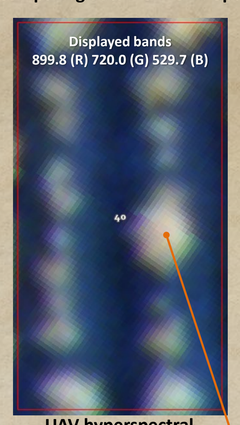


Valente et. al. 2020, Automated crop plant counting from very high-resolution aerial imagery. https://edepot.wur.nl/524283

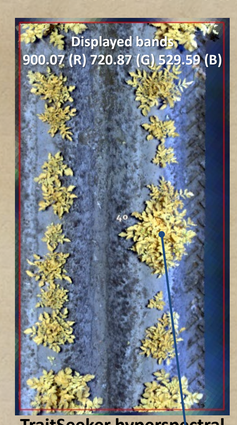
Potato experiment at WUR test field 2022

geo-matching and comparing data from UAV optical and LiDAR sensors with TraitSeeker optical and LiDAR sensors

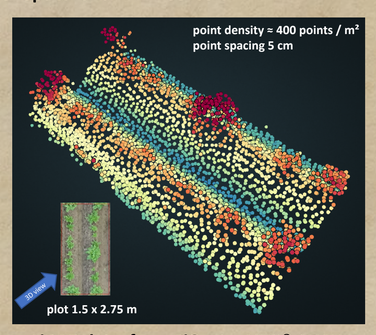
RGB 09 June 2022,
7 mm detail



UAV hyperspectral
09 June 2022, 30 mm detail



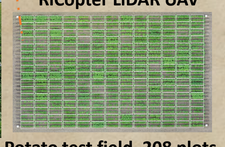
TraitSeeker hyperspectral
10 June 2022, 3 mm detail



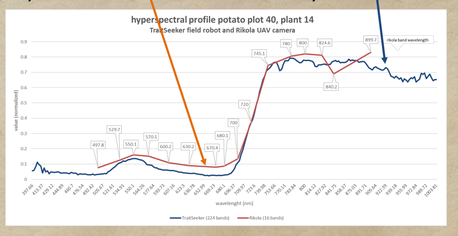
LiDAR data, from RiCopter VUX®-1UAV,
09 June 2022, plot 40

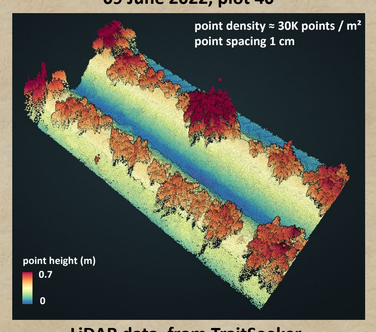
TraitSeeker
field robot

RiCopter LiDAR UAV



Potato test field, 208 plots
40 x 24 meters





LiDAR data, from TraitSeeker,
10 June 2022, plot 40

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Drone Team
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