Monitoring agricultural crops using a light-weight hyperspectral mapping system for unmanned aerial vehicles

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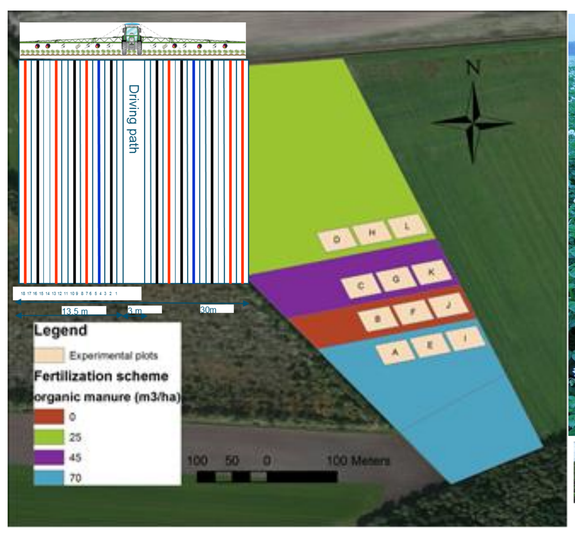
Introduction

This poster presents the results of a crop monitoring experiment for a potato field using a light-weight hyperspectral mapping system (< 2 kg) suitable to be mounted on small UAVs. The objectives of the experiment were:

- to assess the radiometric and geometric quality of the UAV based hyperspectral system;
- to evaluate relations between vegetation indices from UAV acquired imagery and crop properties like chlorophyll and leaf-area-index;
- to prepare crop property maps applicable for precision agriculture management activities.

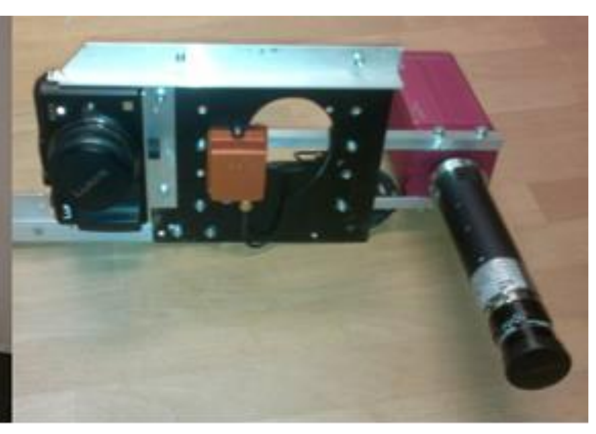
Field experiment

- Experiment field (12 ha) with potatoes (Fontana) and 4 levels of initial fertilization;
- 12 plots of 30*30 m (36 rows each) with 4 measurement rows;
- weekly measurements of chlorophyll (Minolta SPAD), leaf-area-index (LI-COR LAI-2000) and spectral reflectance with Cropscan Multispectral Radiometer (MSR16R).

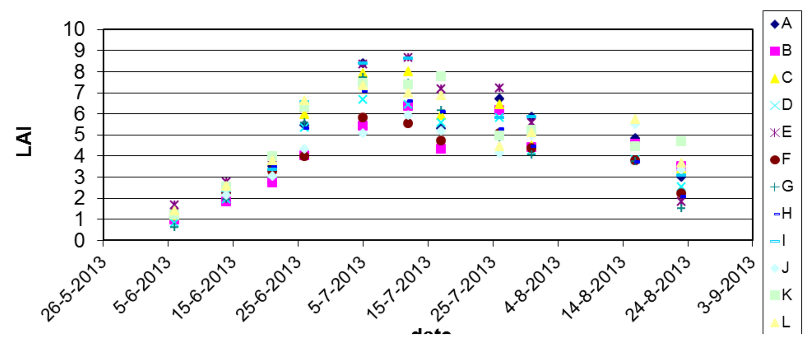


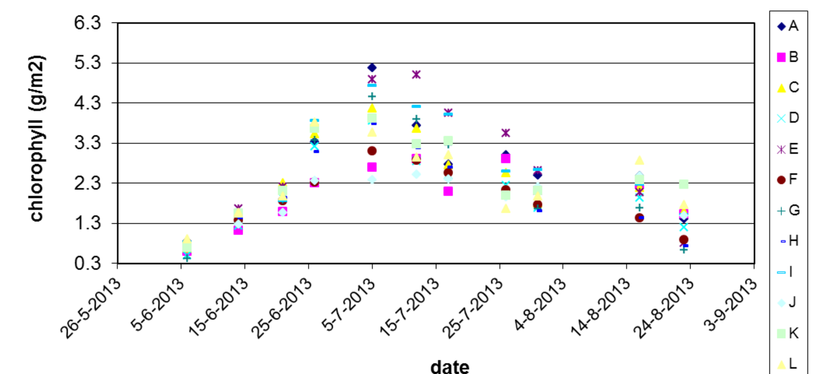
Hyperspectral mapping system on UAV

- As UAV an octocopter based system (Aerialtronics Altura AT8) has been used. The hyperspectral camera system (2 kg) is composed of: a spectrograph; an industrial camera with integrated Digital Signal Processor (DSP) based frame grabber and computer; a GPS inertia navigation system and a photogrammetric camera.
- A processing chain for radiometric and geometric processing of photo and hyperspectral data was developed.
- Data acquisition: June 6 and 14, and July 5 and 17.

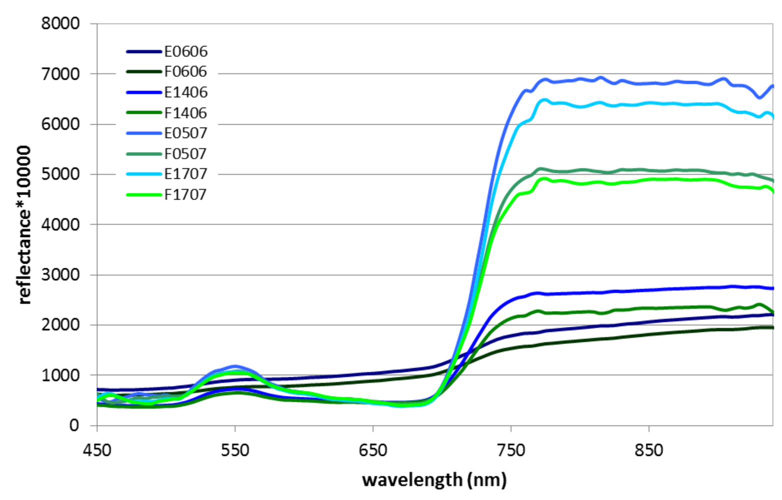


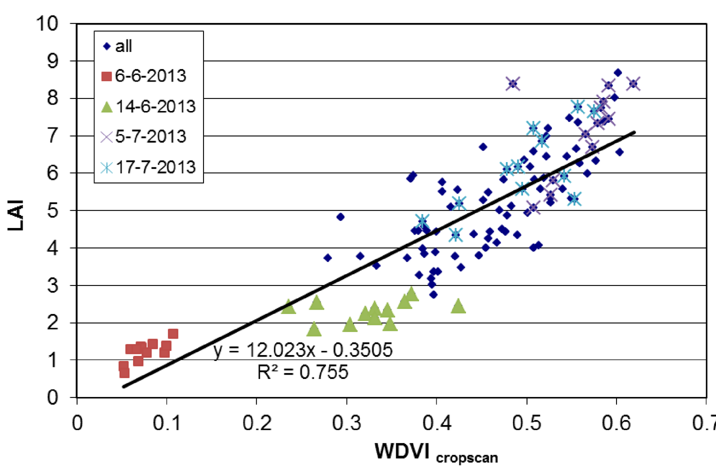
Crop development over the growing season

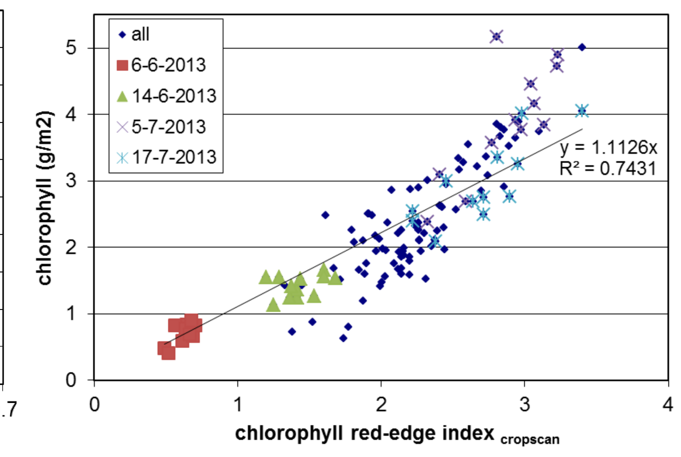


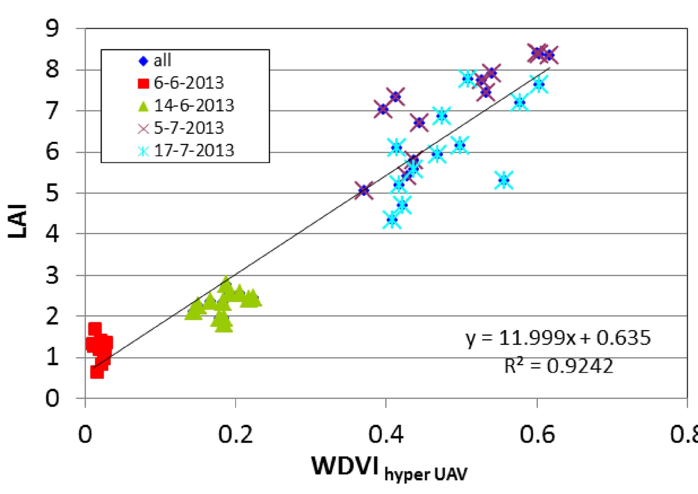


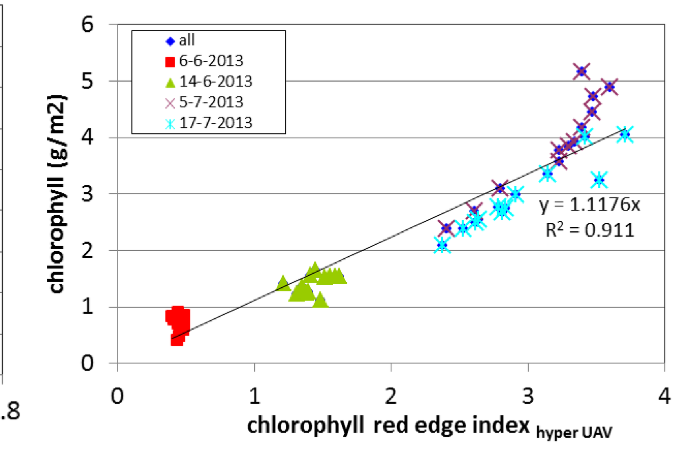
Crop growth was influenced by relatively cold spring causing a two weeks delay in emergence. Initially, differences between the plots were relatively small, from July clear deviations between fertilization levels due to low soil nutrient pools (plots B, F and J) hampering above and belowground growth.







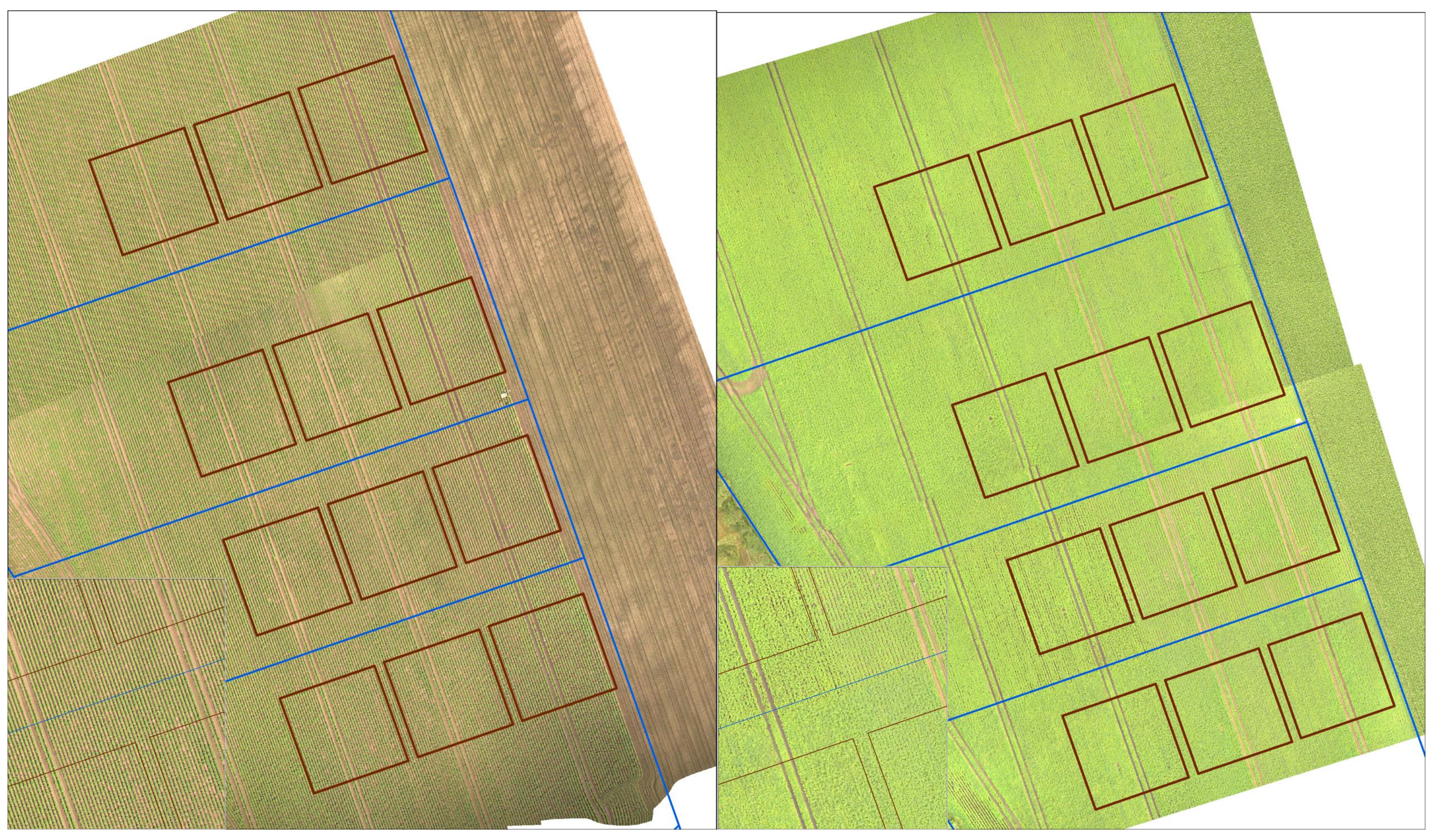




Vegetation indices were evaluated for the remote estimation of canopy chlorophyll content. Clear relations are found for Cropscan (upper figures), according to their R^2 values: e.g., 0.678 for CI_{green}, 0.503 for NDRE, 0.712 for REP and 0.483 for TCARI/OSAVI. The latter two are influenced by soil background.

Relations with hyperspectral system derived VIs even improved (lower figures) with 0.887 for CI_{green}, 0.753 for NDRE, 0.871 for REP and 0.935 for TCARI/OSAVI.

Clear differences can be observed for the temporal development of the spectra (left figure). The spectral quality is good, some variation can be observed in the shoulder of NIR and in the blue band.



The high resolution ortho-mosaic images (up to 25 mm) acquired with the photo-grammetric camera for two points within the growing season: June 14 (left) and July 17 (right). Differences in canopy coverage are related to crop development stage, fertilization level, driving path and irrigation activities. For July 17, the tractor path for the left plots was irrigated the day before image acquisition resulting in relatively darker soils, while the path for the plots in the middle would receive irrigation after image acquisition, resulting in relatively dry and bright soils.

Regression models for the chlorophyll red-edge index were used to calculate continuous chlorophyll maps for the images acquired with the hyperspectral scanning system. The maps show the overall increase in canopy chlorophyll content from June 14 (left) to July 17 (right) and the more pronounced differences at the peak of the growing season

Future research

- Complete radiometric and geometric assessment of system and re-design for next flight season
- Improve retrieval of crop parameters: remove soil and shadow influence, evaluate use radiative transfer models
- Development of (semi)-operational products and services for precision agriculture.

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