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Hyperspectral imaging as a potential tool for high throughput in-field phenotyping at leaf scale

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Spectrometric data in the visible and near-infrared domain, associated with multivariate regression techniques, are a very valuable tool for the non destructive assessment of chemical components in biological objects. However, such an approach is usually limited to remote-sensing or laboratory imager instrumentation, or non-imager field spectrometers.

We present here an original approach in which short-range hyperspectral images are collected in outdoors conditions in order to provide spectral information at the leaf scale in field crops. Its main advantage is to provide an accurate cartography of the chemical components under study, thus avoiding the averaging effect of integrative spectrometric measurement (e.g. soil influence), as well as the tedious task of individual leaf measurements using a leaf-clip spectrometer device.

For this purpose, a push-broom hyperspectral camera is set on a motorised rail about one meter above the crop. Until now, we have applied this approach to nitrogen content cartography in durum wheat and sugar beet crops in experimental micro-parcels. Reflectance images were obtained by using a reference surface in the scene for radiance correction, and a Standard Normal Variate (SNV) preprocessing was applied to overcome the effect of random leaf orientation. Finally, a Partial Least Square regression (PLS) was used for model calibration and N content assessment.

Though satisfactory results were obtained, with R² values above 0.85 in each case, several bottlenecks are still to be addressed in order to achieve a robust high throughput in-field phenotyping tool: image acquisition time, practical calibration procedure, robustness toward physical plant structure and secondary light reflections, etc. We will discuss all these issues and our present perspectives and developments regarding them, including 3D plant modeling to analyze and overcome spectral measurement perturbations due to lighting effects.