QUANTIFICATION OF ROOTS AND CROP RESIDUES BY THE USE OF NEAR INFRARED HYPERSPECTRAL IMAGING AND CHEMOMETRIC TOOLS

Gembloux Agro-Bio Tech
Université de Liège

D. Eylenbosch[a], J.A. Fernández Pierna[b], V. Baeten[b], B. Bodson[a]

[a] Gembloux Agro-Bio Tech, University of Liège, Temperate Crop Science Unit, Belgium. E-mail: d.eylenbosch@ulg.ac.be
[b] Walloon Agricultural Research Centre, Valorisation of Agricultural Products Department, Food and Feed Quality Unit, Belgium.

cra-w

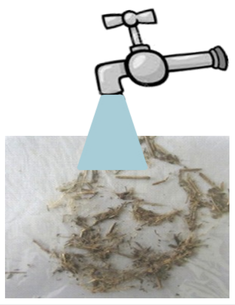
Context: In studies on root system development in fields, manual sorting of roots and crop residues extracted from soil samples before quantification is a tedious and time consuming step. Discrimination of roots and crop residues based on their Near Infrared (NIR) spectral signature was tested as a new rapid and reliable method.

Methodology

1 Sampling

Field sampling of soil cores

Extraction of roots and crop residues from soil with tap water



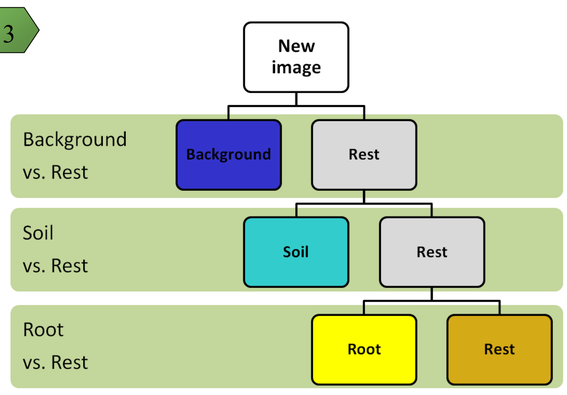
Drying of washed samples

2

Image acquisition

NIR images are acquired with a **NIR hyperspectral line scan** (= push-broom) (Vermeulen et al., 2012). Samples are laid on a conveyor belt placed under the NIR camera. For each pixel of the NIR image, a complete spectrum including 209 wavelengths (1100-2498 nm) is saved.

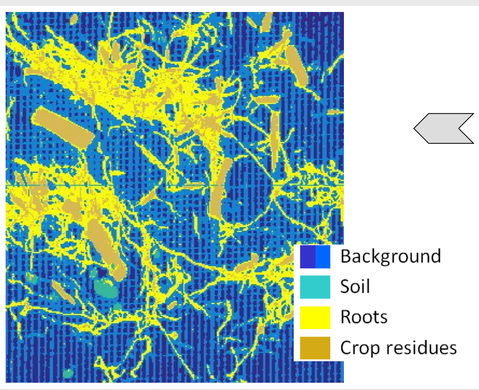
3



Spectra discrimination

A **dichotomist classification tree** based on **successive discriminant analysis models** is used to separate spectra into **distinct classes**: background, soil, roots, crop residues... (Eylenbosch et al., 2014; Fernández Pierna et al., 2004).

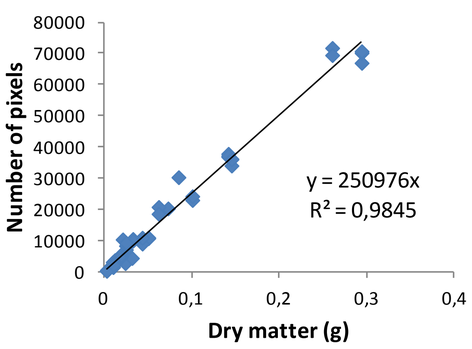
4



Prediction and quantification

A color is assigned to each class allowing the creation of **prediction images**.

Roots quantification is based on the number of pixels predicted as roots which is converted in an amount of dry matter thanks to a regression line.

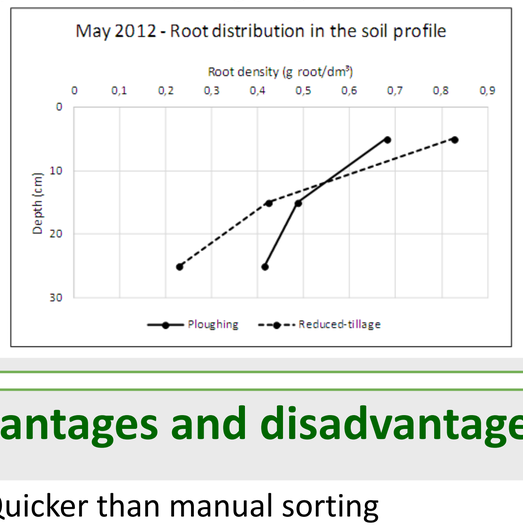


Results and applications

Detection and quantification of roots and crop residues of winter wheat

Applied on NIR images of roots and crop residues of winter wheat, models correctly discriminate 92% of roots and 80% of crop residues, some confusion appearing on the border of crop residues, in the shadow area.

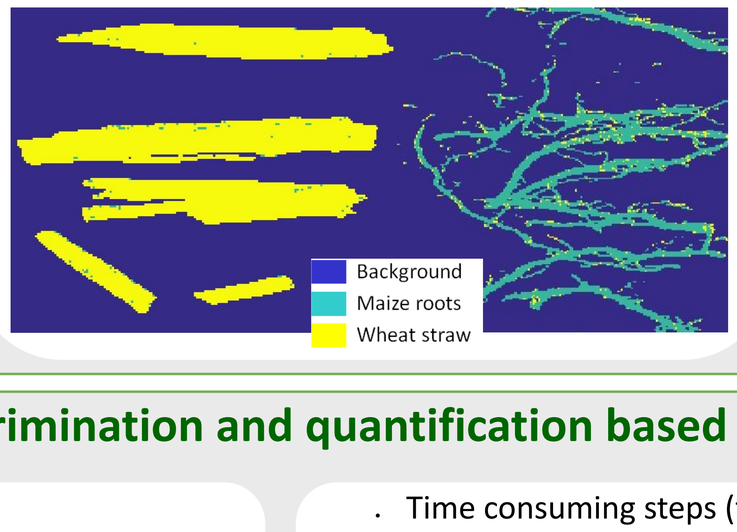
The quantification method was applied on soil samples taken in a long term trial on tillage under winter wheat. It was clearly observed that root system had a higher development in the top soil horizon (0-10 cm) in reduced tillage and a deeper development with ploughing.



Quantification of maize roots *(in development)*

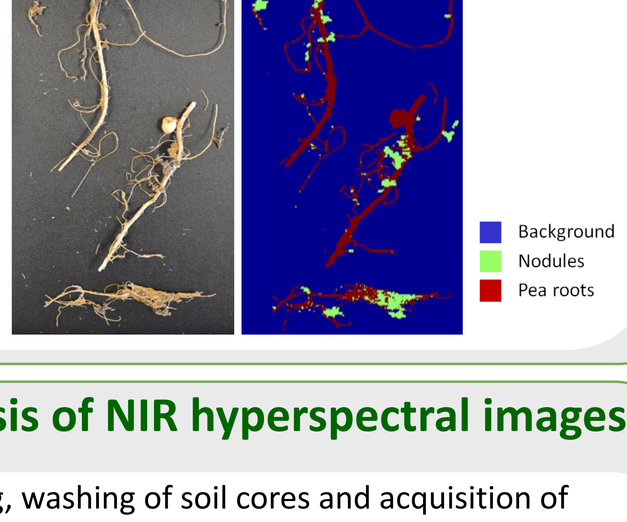
In 2015, a maize crop was sowed in a long term experiment comparing winter and spring ploughing, strip-till and soil decompacting. Soil cores were sampled around the crop flowering. A model allowing the discrimination of maize roots and crop residues of wheat, the previous crop, is currently in calibration.

First results obtained on 6 NIR images of maize roots and 13 of wheat residues show good discriminations: for maize, 91% of pixels are well predicted and for wheat residues, this number reaches 98%.



Discrimination of roots of winter wheat, roots of peas and nodules *(in development)*

When winter wheat and peas are cultivated in intercropping, the discrimination of roots of the two species is difficult. NIR hyperspectral imaging coupled with statistical models could be a useful tool. This method could also be used to discriminate (and quantify) nodules on peas roots. A first validation on 2 NIR images of nodules and 4 NIR images of peas roots showed a very good discrimination (> 97% pixels were well predicted).



Advantages and disadvantages of discrimination and quantification based on analysis of NIR hyperspectral images

\+
- Quicker than manual sorting
- No operator subjectivity during sorting
- Possible discrimination of roots from different species
- No destruction of samples
- Spectral data can easily be re-analysed when models are improved

\-
- Time consuming steps (field sampling, washing of soil cores and acquisition of NIR images)
- Some spectral confusion between the elements of the samples in shadow areas
- Underestimation during quantification if elements overlap on images
- Models need to be regularly recalibrated

References:

- Eylenbosch, D., Fernandez Pierna, J. A., Baeten, V., Bodson, B., 2014. Detection of wheat root and straw in soil by use of NIR hyperspectral imaging spectroscopy and Partial Least Square discriminant analysis, in: *proceedings of the ESA XIIIth Congress*, Debrecen, Hungary, pp. 237-238.
- Fernández Pierna, J. A. , Baeten, V., Michotte Renier, A., et al., 2004. Combination of support vector machines (SVM) and near-infrared (NIR) imaging spectroscopy for the detection of meat and bone meal (MBM) in compound feeds. *J Chemometr.* 18, pp. 341-349.
- Vermeulen, P., Fernández Pierna, J. A., van Egmond, H. P., et al., 2012. Online detection and quantification of ergot bodies in cereals using near infrared hyperspectral imaging. *Food Addit Contam A*, 29(2), pp. 232–240.