Assessment of cercospora leaf spots development on sugar beet leaves by near infrared hyperspectral imaging

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Introduction

The damage caused by cercospora leaf spot (Cercospora beticola) on sugar beet leads to a yield reduction. The method to assess the necrosis level on leaves consists of visual observations. The current work, carried out in collaboration with SESVANDERHAVE N.V/S.A., aims to assess by NIR hyperspectral imaging spectroscopy the development of cercospora on sugar beet leaves in the framework of a breeding program for tolerant lines. The objective of the study is to discriminate between cercospora leaf spots and health leaf as well as to quantify the disease area.

Material and methods

Figure 1: Cercospora susceptible plant at a early stage of the plant development.

For this experiment, 4 tolerant and 4 susceptible to cercospora leaf spot sugar beet plants were grown in plastic pots in a greenhouse (Figure 1). The plants were infected by spraying with cercospora beticola. Then, some leaves were analysed using a linescan NIR hyperspectral imaging system (Burgermetrics) during 6 days from the moment that the first symptoms were visible. This system includes a SWIR ImSpector N25E spectral camera from Specim Ltd, using a cooled, temperature stabilized MCT (Mercury-Cadmium-Telluride) detector, combined with a conveyor belt. All images consist of lines of 320 pixels that are acquired at 209 wavelength channels: 1100-2400 nm at 6.3 nm intervals with 32 scans by image. The acquisition is done using the software HyperPro (Burgermetrics). The samples are spread on the conveyor belt (Figure 2).

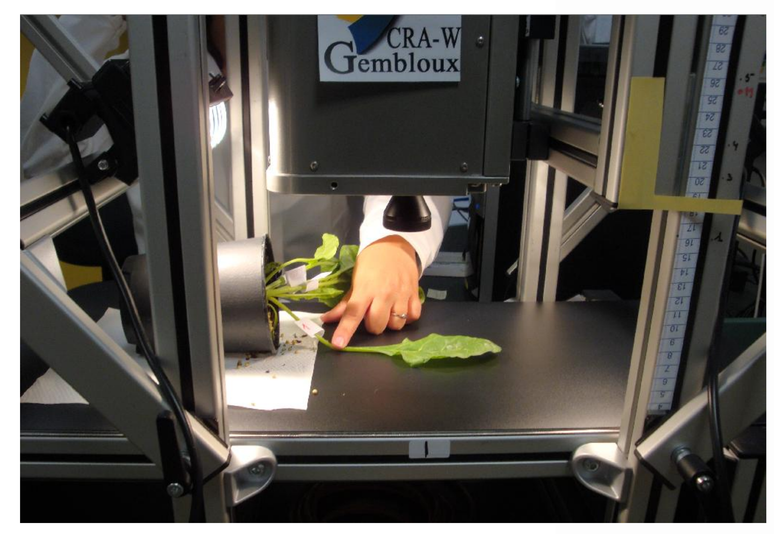

Figure 2: Image acquisition of sugar beet leaves using a line scan hyperspectral imaging system instrument.

For the necrotic area assessment, discrimination models were built using two spectral libraries corresponding to the cercospora leaf spots and the health leaves. Partial Least Squares Discriminant Analysis (PLSDA) and Support Vector Machines (SVM) were used as classification methods for the construction of these models. These models were applied to all the individual pixels in the images of the leaves in order to isolate and quantify the cercospora leaf spots. Figure 3 shows RGB pictures, SVM results using a program developed in Matlab and PLSDA results using the Hyperanalysis software (Burgermetrics) obtained by analyzing at 3 dates (6/8/2010, 9/8/2010, 12/08/2010) the same leaf from a tolerant plant (DQ100742-02) using the line scan hyperspectral imaging system. The data treatment using SVM model on each image consists of 3 steps (a to c). Figure 3a shows the image at 1000 nm. Figure 3b shows the pixels detected as health leaf or cercospora leaf spots after "background *vs.* leaf" equation application on the image of Figure 3a. Pixels corresponding to background (conveyor belt) are displayed in white color. Figure 3c shows the pixels detected as cercospora leaf spots after "health leaf *vs.* cercospora leaf spots" equation application on the not white pixels of Figure 3b. Pixels classified as cercospora leaf spots are displayed in black. The data treatment using PLSDA model shows in green the conveyor belt, in blue the health leaves and in red the cercospora leaf spots. As it can be observed, the cercospora leaf spots became detected by the discrimination models only when they are visually observed on the leaves.

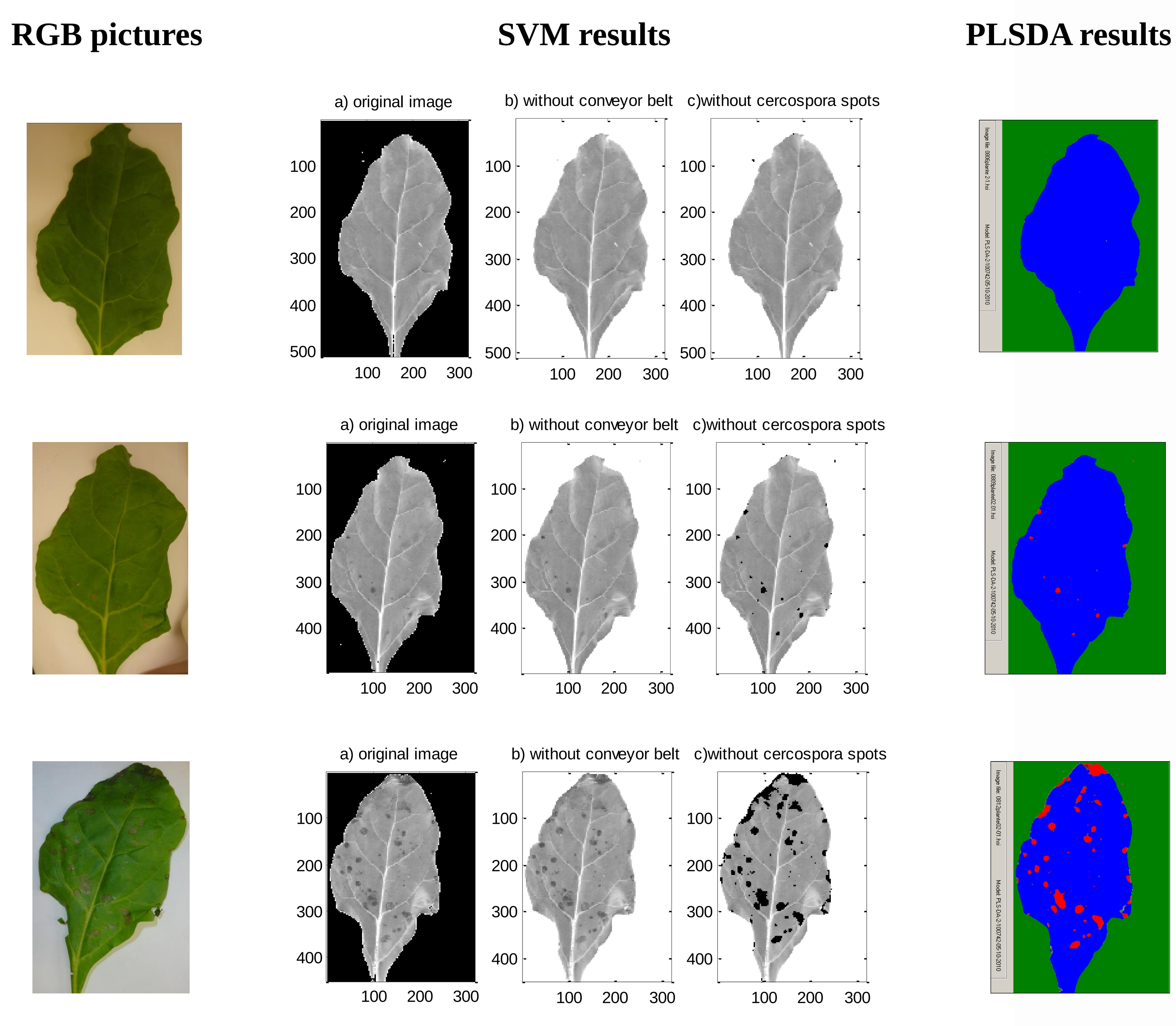

Figure 3: RGB picture, SVM and PLSDA results, showing the cercospora leaf spots observed at three dates (3 days before the first symptoms, the day of the first symptoms and 3 days after the first symptoms) on a leaf from a tolerant plant inoculated by spray with cercospora and analysed using the line scan hyperspectral imaging system.

Results

The results show clear differences between tolerant and susceptible plants (Figure 4). The disease development is slower on tolerant plants and the necrosis covers less than 20% of the leaf area. For the susceptible plants, the infection is faster and 100% of the leaf area can be infected on the same time. Similar conclusions were achieved using PLSDA or SVM models.

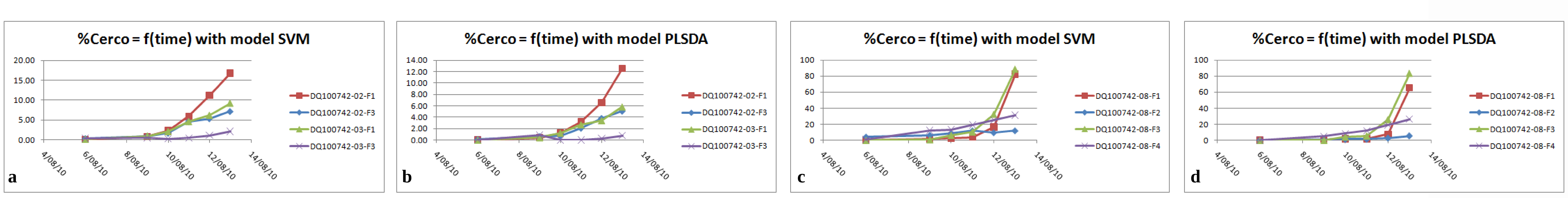

Figure 4: Cercospora development on leaves from tolerant (a,b) and susceptible (c,d) plants using SVM (a,c) and PLSDA (b,d) models.

Conclusion

This study has shown the potential of the NIR hyperspectral imaging to discriminate cercospora leaf spots from the health leaf and to follow the disease development. Chemometric tools and NIR hyperspectral imaging data could be used by the breeders in a sugar beet breeding program to select tolerant from susceptible plants, based on the leaf area infected with the cercospora leaf spot.

Reference

Baeten, V., Fernandez Pierna, J.A. & Dardenne, P. (2007). *Hyperspectral imaging techniques: an attractive solution for the analysis of biological and agricultural materials.* In: Techniques and Applications of Hyperspectral Image Analysis, Editors, Hans F. Grahn & Paul Geladi.

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