Close range hyperspectral imaging for mapping salinity stress induced by red sea water irrigation in tobacco leaves

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INTRODUCTION

Salinity stress severely affects plants growth and causes significant yield reductions. It is a common environmental condition existing in arid and semi-arid zones either naturally or because of anthropogenic influences such as irrigation with reclaimed water. To treat salinity stress, and to address water quality variability, it is essential to track salinity stress symptoms in plants, and provide relevant information such as location and intensity of stress effects (1).

Typically, due to the presence of various pigments such as chlorophyll, anthocyanin and carotenoid the plants exhibits characteristic spectral information in visible and near-infrared region of light (2). Since, the pigment concentrations are related with photosynthetic activities of plants, therefore, any spectral variation arising due to natural or anthropogenic influences can be understood as change in plant health status.

Hyperspectral imaging (HSI) being a non-destructive and rapid technology provides spatial maps of spectral variations, and can be used to understand and locate the plant health status. Therefore, present study explores the feasibility of VNIR HSI to detect early changes occurring in tobacco leaves due to salinity stress induced by irrigation with red sea water.

MATERIALS AND METHODS

To develop the symptoms of salinity stress, four different Tobacco plants (*Nicotiana tabacum*) were planted in green house with three different levels of water salinity (0, 5, 10 and 15 dSm^{-1}). The images were recorded, after 2 weeks of irrigation, with a HySpex VNIR-1600 (400-1000 nm) line-scan push broom camera by *Norsk* Elektro Optikk, Norway. All images were acquired by plucking a fully grown mature leaf from each plant and placing it flat in the Field of View (FOV) of camera.

All images were radiometrically corrected with help of spectralon. The spectra obtained from the reflectance images were pre-processed with Savitzky-Golay smoothing (15 points window with second order polynomial, no derivative) to remove noise resulting due to physical effects such as light fluctuation and vibration due to the movement of translation stage. Later, a Principal Component Analysis (PCA) was performed to capture the major spectral variation resulting from different salinity treatments. Furthermore, the components extracted from PCA were used to filter the images and spatial maps of stress effects were generated.

RESULTS

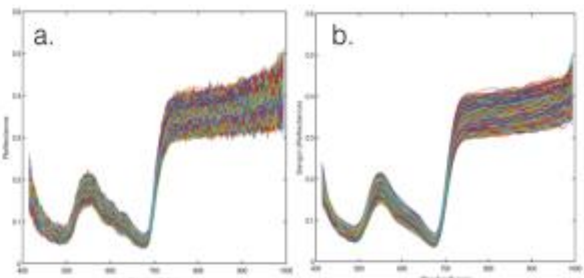

Figure 1: Raw (a) and pre-processed (b) spectra.

The raw (a) and pre-processed (b) reflectance spectra extracted from different location of four leaves are presented in Figure 1. It can be seen that pre-processing removed the random noise present in the raw reflectance spectra leading to smoother spectra. The results from PCA are presented in Figure 2. The first two PC explained 94.61 % of the total variation with PC1 and PC2 explaining 89.35 % and 5.26 % respectively. The variation associated with PC1 was mainly related with the changes in the concentration of various pigments due to salinity stress.

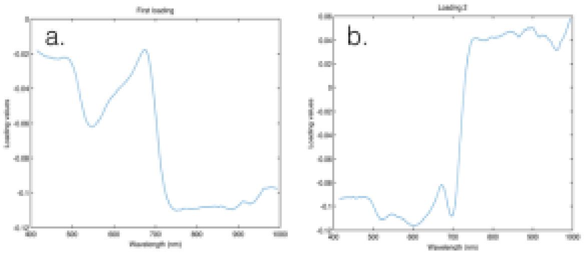

Figure 2: First two PCs (PC1 89.35 % and PC2 5.26 %) obtained from the analysis of pre-processed spectra.

The two clear peaks identified in PC1 indicates that PC1 majorly explains variation in chlorophyll (670 nm) and carotenoid (545 nm) pigments. PC2 explains the effect of accumulation of salts and the water content in the leaves.

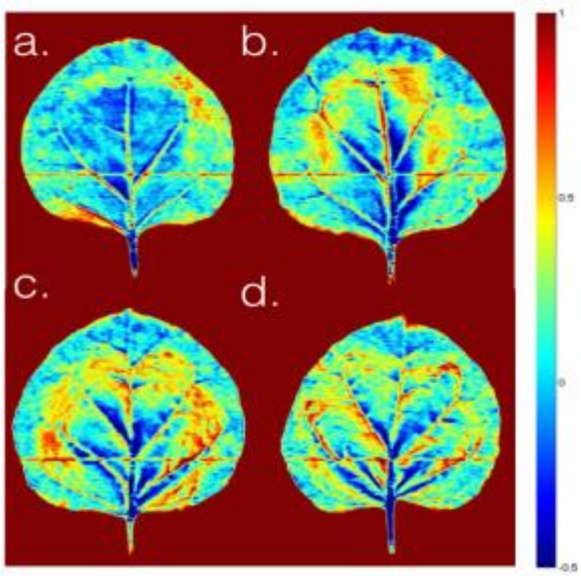

Figure 3: Score images obtained from filtering using PC1. Increasing alphabetical order explain increasing amount of salinity.

The filtered images obtained from PC1 and PC2 are presented in Figure 3 and 4 respectively. Figure 3, shows the effect of increasing salinity over pigmentation. It can be seen that with increasing level of salinity a higher score values were obtained. Higher score values can be understood from the increasing amount of pixels belong to red and yellow colour. The major changes due to salinity stress can be seen in blade, midrib and veins.

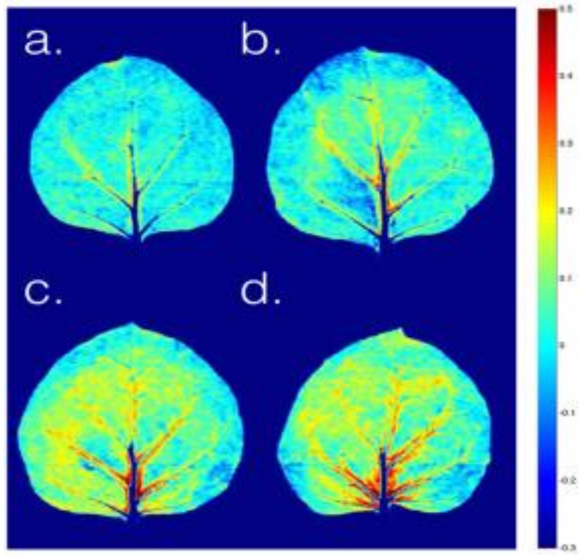

Figure 4: Score images obtained from filtering using PC2. Increasing alphabetical order explain increasing amount of salinity.

CONCLUSION

HSI was successful in capturing the effects of salinity stress in tobacco leaves. A clear mapping of stress symptoms like change in pigments concentration and accumulation of salt was obtained. Increasing salinity level showed an increase in the stress symptoms. HSI proved to be a feasible tool for mapping the salinity stress in plants and can help in quick and non-destructive phenotyping of the plants.

REFERENCES

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