On-line Yellow rust identification in winter wheat

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Conventional farming relies upon unsustainable external inputs and high-yield varieties susceptible to disease to achieve higher yields. With the world's population estimated to reach 9 billion by 2050, sustainable approaches to increase crop yield are a necessity. When left untreated, cereal crops in Europe are vulnerable to fungal infections, For example, yellow rust infection can result in 40% yield reductions along with reduced quality leading to significant financial losses. Molecular techniques are a reliable application for confirming the presence of plant pathogens. However, these techniques are costly and labour-intensive. There is a demand for an automated approach in crop disease detection. Hahn (2009) argues that spectroscopic and imaging techniques could be integrated with agricultural vehicles; providing non-invasive, non-destructive, rapid, disease-specific and reliable systems for monitoring and mapping crop health, with further potential for both disease and early disease detection. Optical sensing provides non-destructive measurements, allowing repeated data acquisition throughout the growing season. Hyperspectral imaging (HI) takes near simultaneous spectral measurements along a series of spatial positions, providing spectral curve shape and features at higher resolutions and with improved understanding of the target than multispectral imagery. Spectroscopic imaging technologies are well established for industrial applications, such as quality control for pharmaceuticals, food and tobacco. There has been a recent effort to apply this technology in-situ to a crop stand, but is still an underdeveloped subject.

This study uses an experimental, tractor-mounted, hyperspectral imager which is a passive sensor, with an external halogen light source that captures spectra between 300nm (ultraviolet) to 1000nm (shortwave infrared) (but only spectra between400 nm and 750 nm was found useful) at 0.6 nm intervals capturing line images with a pixel resolution of 1,608, over a one-second interval which is subsequently logged and geo-located using a global positioning system. On-line field measurement was conducted in a 9 ha field at Duck End farm, Wilstead, Bedfordshire, UK, 52° 5' 36.5994 W" 0° 26' 56.673 N", with an average annual rainfall of 598 mm. Images and disease assessments (percent coverage at the flag, upper and lower leaves) were taken at the same time, at a frequency of 5 per hectare (allowing for cross validation), along with crop NDVI measurements for the field. Edaphic properties were also established throughout the field, with the use of the on-line visible and near infrared sensor, and assessed for their impact. A spectral data bank was assembled from disease assessments and hyperspectral images taken under laboratory conditions, of representative of healthy and water stressed winter wheat crops. Linear regression models were created from the laboratory and 80% of the field scans. Resultant data was then interpolated and mapped, and the accuracy assessed.

The results presented here provide an optimal configuration for a hyperspectral imager to be established for the best quality of on-line spectra collected for a wheat canopy. Accuracy assessment of the linear regression models for yellow rust identification, also highlighting the spatial distribution in the field and potential for the hyperspectral imager with a spectral library for mapping yellow rust infection in winter wheat.