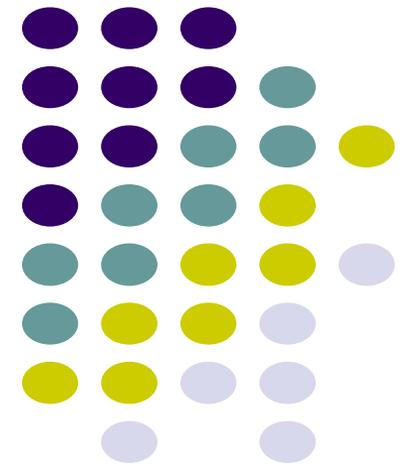
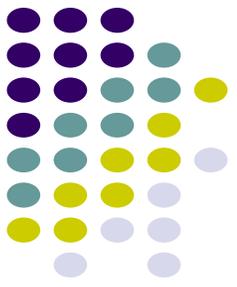


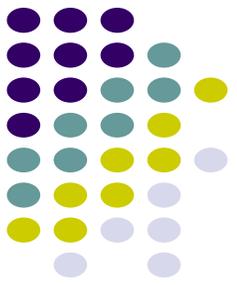
Remote-sensing of plant diseases



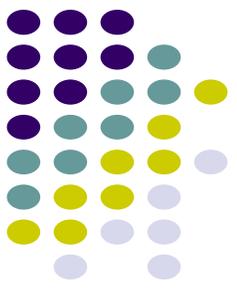
Remote sensing



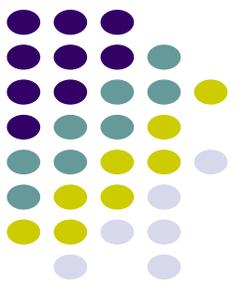
- Remote sensing (RS) is a method used to obtain information from plants or crops without direct contact or invasive manipulation
- It obtain information on an object by measuring the electromagnetic energy reflected/backscattered or emitted by the surface of the Earth
- These measurements are processed and analyzed to retrieve information on the object observed (i.e., plant health, in this case)
- RS is an indirect assessment technique, able to monitor vegetation conditions from distance, and evaluate the spatial extent and patterns of vegetation characteristics and plant health, in this application



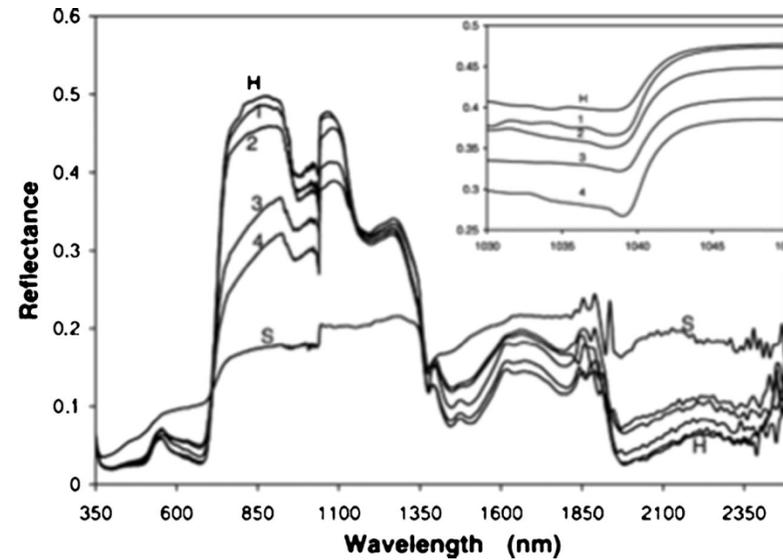
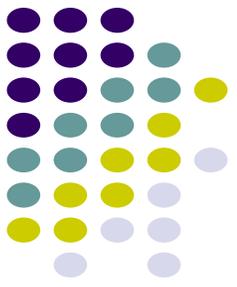
- A plant which is in stressed conditions (induced by the disease) reacts with protection mechanisms that lead to suboptimal growth which show up as changes in variables such as leaf area index (LAI), chlorophyll content, or surface temperature; thus producing a spectral signature that is different from the signature of healthy, unstressed vegetation.



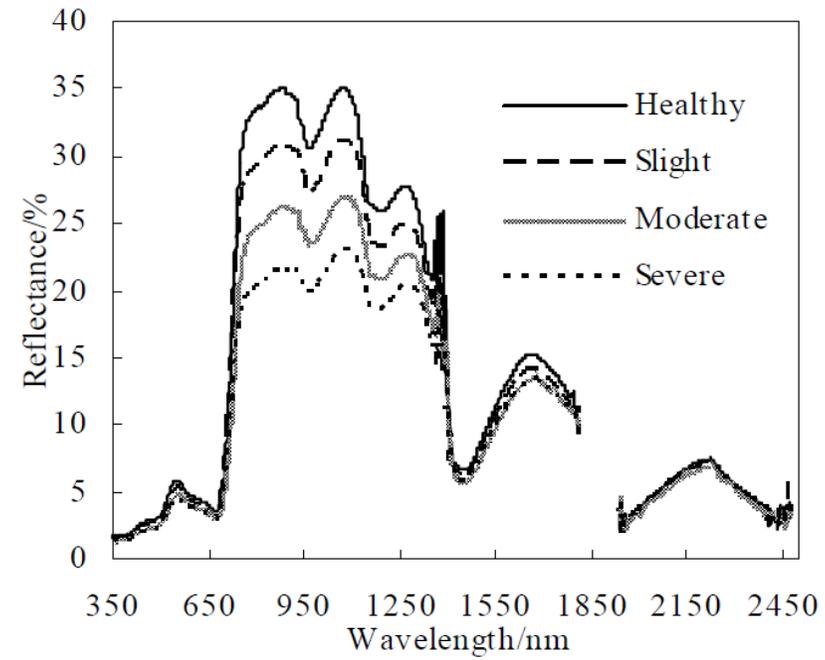
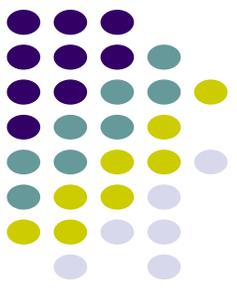
- When plants are exposed to pathogens they activate defense responses whose molecular mechanisms are very complex. At the early stages, when visual symptoms such as lesions on the leaf surface are not present, plants react to the presence of a pathogen with physiological mechanism such as the reduction of the photosynthesis rate, which induces an increase of fluorescence and heat emission
- The presence of stress factors changes the thermal properties of plants, which in turn influence the radiation emitted in the TIR domain of the spectrum, mainly produced by changes of the water content of leaves which can also be detected at the early stage of the disease



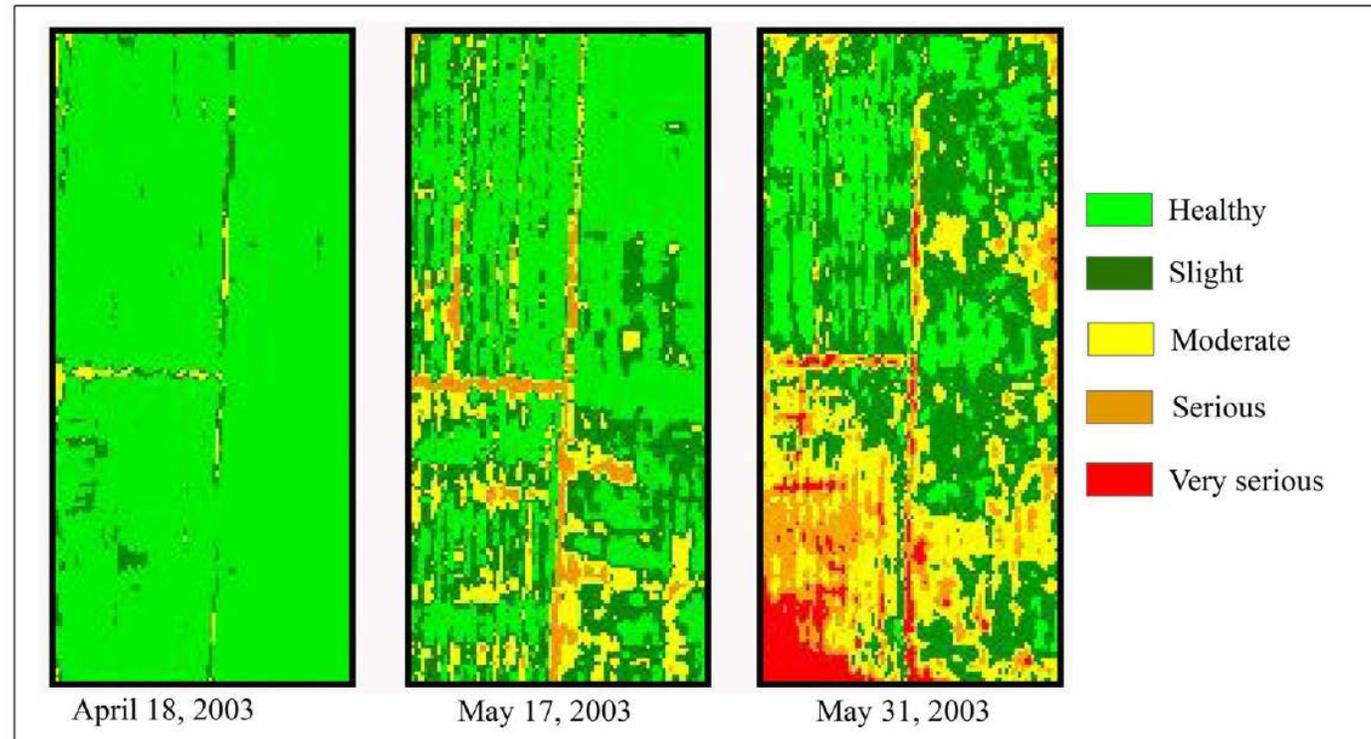
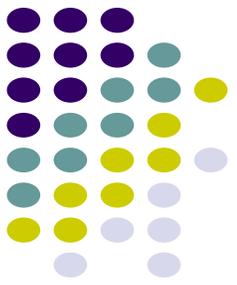
- The RS scientific community defines plant disease monitoring as:
 - detection (deviation from healthy),
 - identification (diagnosis of specific symptoms among others and differentiation of various diseases), and
 - quantification (measurement of disease severity, e.g., percent leaf area affected)
- Different sensors and techniques are required for detecting plant response to various diseases and disease severity.



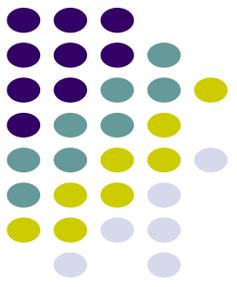
Field reflectance spectra for healthy tomatoes plants (H) and plants infected with late blight disease increasing severity (from 1 to 4). S is the average spectrum for soil.



The spectral reflectance of healthy wheat and wheat infected by leaf rust pathogen at damage levels



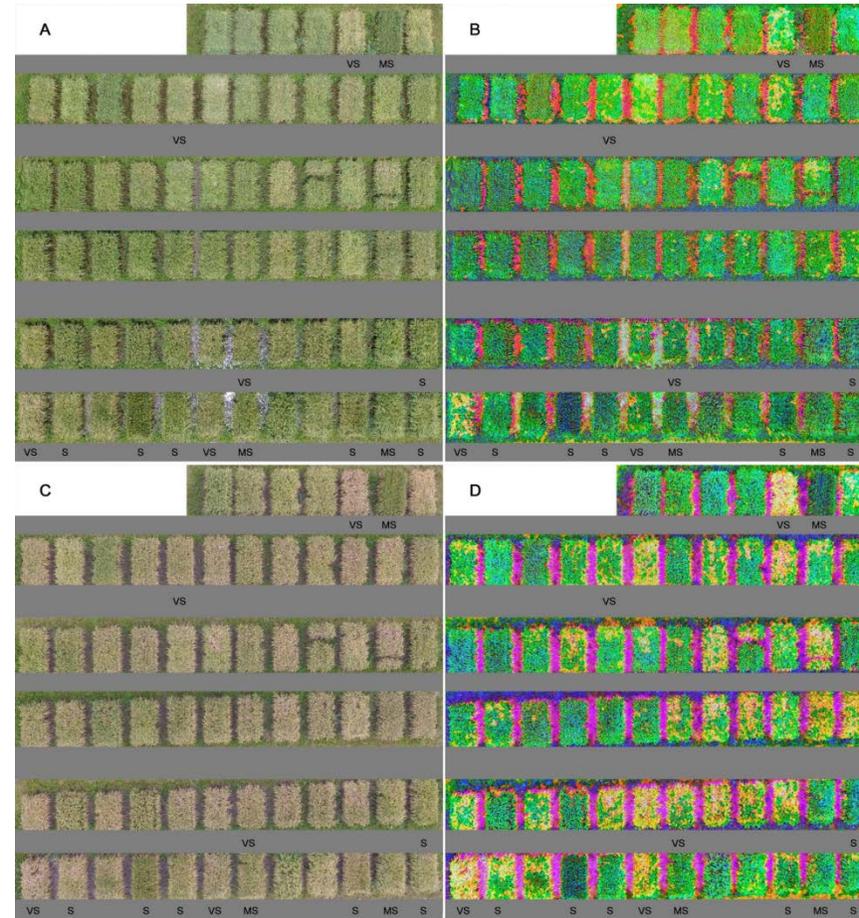
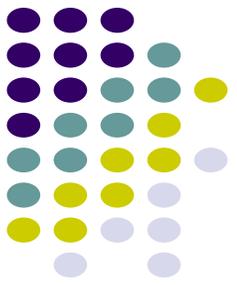
Degree of yellow rust infection in the trial wheat field



Sheath blight (ShB) of rice

- A commercialized quadrotor unmanned aerial vehicle (UAV), equipped with digital and multispectral cameras, was used to capture imagery data of research plots with 67 rice cultivars and elite lines.
- The color transformation could qualitatively detect the infected areas of ShB in the field plots.

Qualitative ShB detection based on high-resolution images



Original RGB and HLS transformation images of 67 field plots on Aug 23rd (A and B) and Aug 30th (C and D). The ratings of resistance to ShB with very susceptible (VS), susceptible (S), and moderately susceptible (MS) were indicated in selected plots (cultivars or lines).