NIR Spectroscopy in Agricultural Production

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Photo by Sebastian Soerensen from Pexels

The future of agriculture and food production will rely heavily on scientific advancement to increase yields and ensure quality. NIR spectroscopy is one advancement that has tremendous potential for agricultural applications. In grain production, NIR spectroscopy is being investigated for its practicality in qualitative and quantitative measurements of a variety of cereal grains.

The Avantes NIRLine spectrometers offer fantastic performance in the NIR from 800-2500 nm with options that include InGaAs (Indium Gallium Arsenide), back-thinned CCD or CMOS detectors, triple-stage Peltier thermoelectric cooling, and next-generation ultra-low-noise electronics for a superior signal to noise ratio. Read more to discover why researchers are turning to Avantes spectrometers for dependable near-infrared detection.

Plant Health Indicators

Close-up of stem rust. Photo by Yue Jin via Wikimedia Commons

Grain producers are very concerned about plant health as it directly affects grain yields and consequently profits. Plant health is also a concern for consumers because grain contamination can potentially have severe health consequences.

NIR Spectroscopy relies on the absorption or reflection of near-infrared light to facilitate qualitative and quantitative analysis of chemical and physical properties of the test sample. NIR spectroscopy is widely used in agricultural operations to determine crop parameters such as water content, sugar content, and other indicators of ripeness, as well as measuring chlorophyll fluorescence to determine the need for nitrogen-based fertilizers, or to look for bruising not visible to the human eye. This non-destructive and fast method of inspection has a place in every step of the food production cycle from production to grading and sorting.

Detecting Fusarium Infection in Barley

A joint research project sponsored by the U.S. Department of Agriculture (USDA) and the National Academy of Agricultural Sciences, Rural Development Administration of South Korea, investigated the use of Near-Infrared Spectroscopy to identify *Fusarium* infection in barley. The fungus *Fusarium* reduces grain yields and generates a toxin that can be harmful to humans and livestock that ingest infected grains.

To measure in the wavelength range of 1175-2170 nm, this group used the AvaSpec-NIR256-2.2-TEC instrument with an InGaAs (Indium, Gallium, and Arsenide) thermoelectric cooled detector with an integration time of 20 milliseconds. Using partial least squares analysis and regression modeling, a discrimination prediction model was developed that offered 98-100% accuracy in identifying grains contaminated with Fusarium spores.

Researchers observed a reflectance peak between 1555-1575 nm for all samples as well as rising peaks at 1305 and 2000 nm and a falling peak in the 1900 nm wavelength range. The largest differences were in reflective intensity. For the normal (uninfected) hulled barley, intensity of reflectivity was 8000 counts while infected grains showed an average intensity of 9600 counts.

To test their discrimination model, researchers tested hundreds of samples. In testing uninfected samples, their model returned only one false positive with a discrimination accuracy of 99.8% and of the infected samples, returned zero false negatives for a discrimination accuracy of 100%. Future researchers will investigate similar models for detecting *Fusarium* infections in other grains as well.

Identifying Rice Blast Fungus

Rice blast is caused by the fungus *Magnaporthe oryzae* and its anamorphs such as *pyricularia grisea*. It is considered a major threat to food safety and stability in many parts of the world due to the severe yield loss that it causes, but until recently, the method used to detect rice blast was a physical inspection on the ground. It was time-consuming and nearly impossible for large-scale operations to perform comprehensive visual inspections. The alternative, the use of large amounts of pesticides and fungicides, has its own risks to health and the environment as well as increasing the costs of production.

Rice Blast Symptoms on Rice Stalks. Photo by Donald Groth via Wikimedia Commons

Near-infrared spectroscopy has been proven a cost-effective and accurate method for detecting other plant diseases at the leaf and canopy levels. Proving a correlation between rice blast disease index and IR spectra can lead to early detection technologies suitable for large-scale operations allowing for more efficient use of agrichemicals and a more sustainable method of crop management.

Researchers at the China National Rice Research Institute and the Academy of Agricultural Sciences in Hangzhou, China employed neural networks to analyze reflectance spectra in the development of their modeling for rice blast detection. Their aim was to detect spectral regions where rice reflectance changed dependent on rice neck blast disease index and to select the key wavelength bands with the sensitivity to analyze disease severity and validated their neural network-based spectral model for qualifying disease severity.

In this study, rice showing a moderate disease index exhibited high raw reflectance in the 805-1000 nm range while rice with a higher disease index demonstrated a lower raw reflectance under 940 nm but higher reflectance in the 960-1000 nm range. This was similar to an earlier study that correlated moderate fungus infection with high reflectance in the SWIR 1135-2400 nm range and low reflectance in the NIR 709-1134 nm range and a more serious fungal infection with low reflectance under 1297 nm and a high reflectance between 1298 and 2400 nm.

The re-engineered AvaSpec-NIR256/512-2.5-HSC-EVO was not available yet at the time this research was conducted but is the ideal instrument for grain analysis available today.

Crop Health Measurements

Yara International ASA has used Avantes spectrometers for years in a module which attaches to farm tractors used with their fertilizer applicators for real-time crop health measurements. The device features two spectrometers focused on the visible and near-infrared to detect chlorophyll in plants during the application of fertilizers. The device uses the sun as a passive illuminant to facilitate the reflection measurement on crops. Based on the spectral measurements, the system regulates the application of fertilizers in real time.

Grain Analysis for Wheat

Yara Grain Analyzer
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Avantes has been working with the US Department of Agriculture on projects to measure grains during harvest. Researchers at the USDA have developed chemometric models to predict protein levels in wheat and other grains. The modeling has used the third overtone of the near infrared (800-1100 nm) which provides for an economical means of analyzing grains. The AvaSpec-ULS2048X16 and AvaSpec-ULS2048XL-EVO are ideal candidates for this analysis.

Proven Use of NIR spectroscopy in disease detection

There are numerous applications for NIR spectroscopy in the detection of plant diseases and biological contaminants in agricultural production. Some examples include the detection of aflatoxins in corn, late blight disease, or yellow leaf curl virus in tomatoes, leaf spot or powdery mildew in sugar beets, yellow rust in wheat, and countless other crop diseases that affect yield and quality.

NIR spectroscopy has a place in human disease detection, as well, with potential for non-invasive diabetes monitoring, and cancer diagnosis and treatment.

The Avantes Edge in NIR

Avantes is advancing the field of NIR spectroscopy with our cutting-edge instruments. Integration of the low-noise, high-speed communication AS7010 electronics throughout the NIRLine of spectrometers offers faster signal processing. Paired with the 256 pixel or high-resolution 512-pixel TE Cooled InGaAs detector array and high-sensitivity 100mm focal length optical bench with NA of 0.13, the AvaSpec-NIR family of instruments offer the best balance between sensitivity and resolution for analysis of grain, polymers, and process monitoring in the NIR 1000-2500 nm wavelength range.

To learn more about the newest NIRLine releases, contact your certified sales engineer for support.