Applying Single Kernel Sorting Technology to Developing Scab Resistant Lines

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Introduction

We have developed technology to automatically separate healthy kernels from Fusarium-damaged kernels (FDK). This system automatically scans and sorts kernels based on their near-infrared (NIR) spectra. We are working with various breeding programs to apply this technology to developing scab-resistant lines. Current applications include:

1) Separating FDK from healthy kernels for related deoxynivalenol (DON) and nivalenol (NIV) studies;
2) Separating FDK from healthy kernels to enrich breeding populations;
3) Rapidly evaluating samples to determine the number of FDK for subsequent studies that relates Fusarium head blight to quality factors.

Materials and Methods

The automated single-kernel near-infrared (SKNIR) system (Figure 1) separates seeds based on specific quality attributes (Dowell et al., 2006). This instrument was developed by the USDA ARS Engineering Research Unit and commercialized by Perten Instruments. The SKNIR system uses a NIR spectrometer (950-1650 nm) to measure reflected energy from kernels illuminated by a white light source via fiber-optic bundles. Kernels are individually placed in a viewing area where their characteristics are measured, and then the kernels are sorted by solenoid-driven gates based on their NIR spectra. The system can sort single seeds at a rate of about 1 kernel/2 s (about 1 kg/day) according to quality attributes such as scab damage, protein content, hardness, waxy character, moisture content, internal insects, vitreousness, and color class.

A calibration to sort scab-damaged seeds was developed by using either kernels that had been manually sorted based on their visible scab damage, or kernels where we measured their actual vomitoxin levels. Partial least squares (PLS) regression was used for all calibrations. These calibrations were then used to sort samples for various breeding programs. Previous work to measure scab damage and vomitoxin levels with this technology is presented by Dowell et al. (1999).

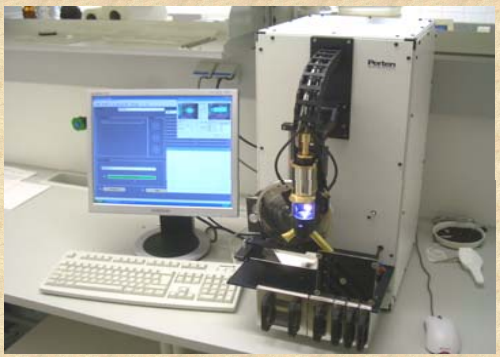

Figure 1. Automated Single Kernel Near Infrared (SKNIR) Sorting System

Results and Discussion

Sorting for DON and NIV. One hundred kernels from each of three replicates of 192 samples were sorted into scabby and healthy fractions (Figure 2). Figure 3 shows a plot of the regression equation which shows important wavelengths used in the classification model. Our calibration for this classification resulted in kernels in test sets classified with 90% accuracy when compared to visual classifications. More importantly, the toxin concentrations were 0.25 ppm NIV and 0.73 ppm DON in the healthy fractions, and 25.71 ppm NIV and 61.30 ppm DON in the scabby fractions (Horevaj et al., 2007). Thus, our system effectively separated seeds into healthy and scabby fractions which was important for researchers studying the resistance of soft red winter wheat lines to DON and NIV chemotypes of *Fusarium graminearum.*

Figure 2. Samples after separating healthy kernels from scab-damaged kernels using a single-kernel near-infrared sorting system

Evaluating samples for scab damage. Four replicates of 21 samples were sorted into scab-damaged and healthy portions by the SKNIR system, and the results were compared to visual sorting and correlated to quality factors (Wegulo et al., 2008). FDK ranged from about 1% to 71%. The FDK determined by the SKNIR system were well correlated to the results obtained by visual sorting. This automated means of sorting should provide breeders with a fast and more consistent means of evaluating breeding lines.

Sorting hard from soft kernels in segregating lines. A low protein soft wheat line with scab resistance was crossed with a high protein hard wheat. The resulting cross was then sorted with the SKNIR sorter to return high-protein hard wheat and low-protein soft wheat to the respective breeding programs. These samples were planted and the resulting seed sorted into healthy and FDK portions. The healthy portions were then inoculated to determine if lines are being enriched for scab resistance. These samples are currently being grown in field studies.

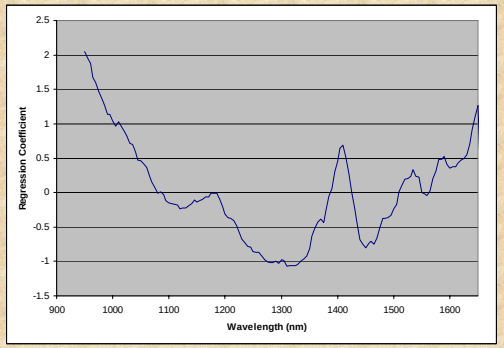

Figure 3. Regression coefficients used for sorting Fusarium damaged kernels. The absolute value of the regression coefficients indicates the wavelengths important in classifications.

Conclusions

This SKNIR system provides a means to rapidly detect FDK in breeder samples. The sample can then be sorted into healthy and FDK portions for subsequent evaluation or breeding purposes. The system can also be used to sort samples by other quality factors such as hardness or protein content to help breeders develop high-quality lines with improved resistance to FHB.

References

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