Using Sensors for Phenotyping and Assisting in Selection in Spring Wheat

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Research Questions

A continuous pipeline of new, higher yielding hard red spring wheat (HRSW) varieties with tolerance to biotic and abiotic stresses is needed to sustain viable spring wheat production in the region. Developing new spring wheat cultivars is a costly endeavor and requires the evaluation of thousands of lines for every variety that is released. Not only is the process of selection time consuming and expensive, it is also not an exact science and the possibility of discarding genotypes that could become highly successful varieties is quite high. Our research question is; can the use of canopy spectral reflectance, and other indices obtained from vehicle-mounted sensors help breeders to select genotypes with beneficial characteristics, such as superior yield and stress tolerance.

Results

Prior to and shortly after flowering, data from the sensor suite described below were collected from the four most advanced yield trials planted by the NDSU spring wheat breeder at two locations in North Dakota. We have not yet completed the analysis of the data, as it requires multiple steps, and we are still learning the geographic information system (GIS) procedures that are essential to the research in software such as ArcMap and Quantum GIS. The primary result that we can report at this stage is that the platform designed for gathering the data seems to be working, that the system of data collection is also functional, and that researchers are now trained in how to best implement this type of research from several national training meetings and conferences.

Application and Use

The primary application of this research will be to assist breeders in identifying genotypes that may have desirable traits: such as high yield, maturity, stalk strength, and stress tolerant. Once we completely analyze the data, we will have a better idea on how well some of the measurements predict the performance of advanced lines and will work towards integrating some of these sensor-based phenotyping measurements into earlier stages of the HRSW breeding program with the intent of improving selection efficiencies.

Materials and Methods

A suite of sensors developed by Holland Scientific (Lincoln, NE, USA) and used by other breeding programs in the USA, was chosen for use in this project. The system is a combination of active and passive sensors consisting of a three-band active optical sensor, a multi-parameter data acquisition sensor and geospatial data logger. The active optical sensor will provide measurements for red, red-edge and near infrared reflectance, red and red-edge normalized difference vegetation indices (NDVI and NDRE) and estimation models for leaf area index (LAI), plant canopy chlorophyll content (CCC) and optical sensor-to-plant distance (plant height). The multi-parameter sensor will provide measurements for passive upwelling and down-welling photosynthetic active radiation (PAR), passive temperature for both canopy and ambient air, humidity and atmospheric pressure. These sensors were mounted on a four-wheeler and connected to a Trimble RTK system so that all measurements were georeferenced. Data were collected from four advanced yield trials, replicated at Casselton and Prosper, North Dakota. Data from the sensors will be correlated to yield and protein data from these trials.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

At this stage, this research will have no direct economic benefit at the farm level. If this system of phenotyping advanced lines proves to be helpful to breeders, the number of lines that are identified, released, and used by producers, will determine the value of this research.

Related Research

This is a topic of intense interest in the breeding and genetics research circles. There are a number of programs using this type of methodology.

Recommended Future Research

We need an additional year to gain the expertise and experience to effectively evaluate the current platform as to its future usefulness. No significant changes in our research approach is proposed for the next year. Once this first year's data analysis is completed, we will be able to move through data analysis much faster, allowing for practical applications to the HRSW breeder in-season.