Arizona Grain Research and Promotion Council

Field Distribution of Soil and Plant Variables Affecting Wheat Grain Protein Content and Yield: A Field-scale Study to Improve Farm Management

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Summary
This project consisted of two phases of field work and a final effort in data analysis. The two phases of field work included: a) using sensor technology to measure the spatial distribution of soil electrical conductivity (EC_a) and canopy reflectance in the early stages of development durum wheat grown under conventional irrigation and fertility management in Central Arizona; and b) record the spatial variability of yield, in terms of quality (i.e. protein content) and quantity in nominal units as bushels per acre. Soil salinity was measured using a real-time acquisition EC_a sensor and reflectance of light from the crop was measured using a tractor-mounted spectral sensor. These measurements on soil salinity and reflectance of light from the crop canopy (ie. crop biomass and color) were conducted in Sacaton AZ on two 17.5 acre fields and recorded at late tillering. The grain was harvested using a combine equipped with a yield monitor, allowing in-field variability of grain yield and protein to be correlated with soil salinity and crop reflectance. Analysis of information was performed on these data sets to explore the level of association between the soil/plant characteristics at the early phases of development and the resulting yield components. Results in this study showed some correlation between high soil salinity and low protein and yield. However, the correlation between crop reflectance and grain yield and protein was weak possibly because the crop reflectance measurements were taken too early in the life cycle of the crop. Maps of soil salinity and crop reflectance that were correlated with grain yield and protein could perhaps be used to manage parts of fields differently, to predict yield, or to avoid dockage from low protein grain.

I. Field Methods

This project was carried with the support of Mr. Karl Button, a grower cooperator in the Sacaton area. Mr. Button provided access to two fields to carry out early season EC (electroconductivity, a measure of variables affecting water retention such as salt content and textural differences) and spectral sensor measurements, and allowed the use of the instrumented yield monitor during harvest time. The two fields selected were each planted with 17.5 acres of wheat, these fields are located in the following coordinates: Field 1 (33.111375 deg N, -111.731075 deg W); and Field 2 (33.153505 deg N, -111.821255 deg W). Mr. Button recognizes Fields 1 and 2 with the names Wahapta and Wilsons respectively. These fields were conventionally managed by Mr. Button according to normal practices for water, weed and insect control, and fertilization. All of the expenses incurred in growing wheat were covered by Mr. Button.

1.1 Sensor deployment

Electrical conductivity and canopy spectral surveys were carried out on January 14 (Wahapta) and February 6, 2010 (Wilsons) when the crop was in the late part of the tillering stage, before jointing. Data acquisition was completed in a single pass with the use of combined systems instrumented for the particular purposes of this project. Figure 1 shows the Veris 3000 EC sensor

(Salinas, KS) and a pair of Holland Scientific ACS-470 spectral sensors (Lincoln, NE). The sensor was equipped with six filters including 450, 550, 650, 720, 770, and 820 nm. Data acquisition was done in continuous mode with the sensor combo pulled with a tractor. EC_a sensor output included shallow (top foot) and deep (0-3 ft) apparent electrical conductivity, and spectral sensing allowed the computation of vegetation index (NDVI) to assess crop biomass and greenness. These sensor signals were geo-referenced with the use of a Trimble AgGPS 232 receiver (Sunnyvale, CA). Sensor deployment lasted for about an hour inside each field. Data sets were processed in GIS software for spatial analysis of these soil (EC_a) and crop canopy (spectral) variables.

1.2 Instrumentation of yield monitor

A grain combine, property of the University of Arizona, was instrumented with an array of sensors and a monitor screen in the cab. The main components of the yield monitor included grain elevator impact plate (for mass flow measurements), GPS for position information, grain moisture, and speed sensor to calculate area. The main computer installed in the cab was an Ag Leader Insight with the harvest function unlocked. A GPS receiver was mounted on the combine to feed positioning information to the on-board screen, as well as providing a signal to the navigation light-bar (Trimble 21-A) for swath control of straight passes of the combine. In addition to yield monitoring components, this grain combine was retrofitted with a GPS display, data-logger, and controller to record the location of samples taken for protein analysis. Figure 2 presents the main components of the instrumentation of this unit. The complete yield monitoring system was tested and calibrated in barley fields at the Maricopa Agricultural Center.

1.3 Harvest operations

The fields were harvested in mid-June time frame, which is normal for this area. The crop in both fields suffered significant lodging due to the heavy weight of the grain. This crop condition slowed down significantly the harvest operation. In each field, 66 samples were collected, geo-referenced electronically, and sent to the laboratory for protein content determination. Figure 3 shows the instrumented grain combine in operation at the time of harvesting. The yield monitoring system worked flawlessly and yield (lbs/acre) and protein content (%) data were collected in the two fields under study.

II. Data analysis

All the layers of information were processed using Manifold v.8 software (Carson City, NV). The data analysis included interpolation of all the variables to produce raster files for correlation analysis. Visual inspection of the field distribution of variables was confirmed by statistical analysis to indicate that soil EC had a strong association with the field distribution of protein content across the fields (see maps in Figure 4). Vegetation index derived from spectral data showed a moderate to weak association with yield and protein content. Follow up discussions within the group of researchers and our grower collaborator Mr. Karl Button lead us to conclude that soil properties have a predominant role in determining the nutritional value of the crop and some of the complex dynamics of soil water/fertility interaction with the crop were captured by the soil ECa sensor with interesting trends. Our discussions extended to what adjustments can be made to the research methods in order to improve the results of future experimental work. A second year of study will monitor more closely the dynamics of N in the soil and it is expected that the results will bring us closer to the overall objective determine management solutions to optimize durum wheat protein content.

III. Outreach.

Farm Press reporter Cary Blake wrote a report on this project, which appeared in the August 21, 2010 issue of this nation-wide distribution magazine under the title: “Technology improved yield and protein in irrigated wheat”. A second piece on this research appeared on October 13, 2010 in the Trivalley Dispatch, a newspaper of local publication under the title: “UA ag specialist in Maricopa seeks better wheat via technology”. More extension products will be generated to be presented at growers meetings across the state.

Figure 1. Field deployment of EC and spectral sensors in Sacaton AZ. January 2010

Figure 2. Grain mass flow sensor (left) and moisture sensor (right) installed in grain combine for yield monitoring operations. Maricopa Agricultural Center – May 2010

Figure 3. Harvest operations in two selected fields in Sacaton AZ. June 2010

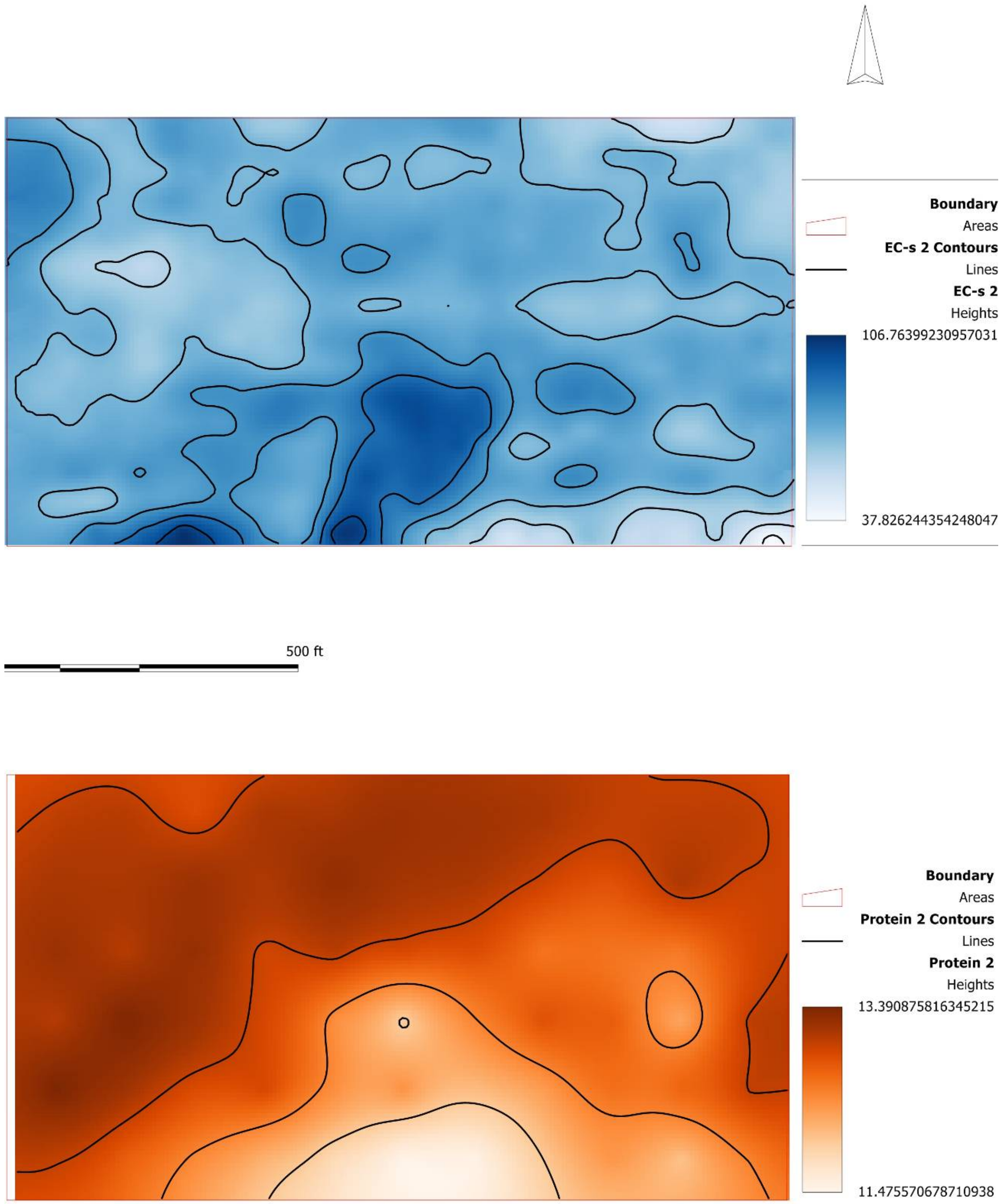

Figure 4. Maps showing the field distribution of early season soil EC (top) and final protein content (bottom) for a field in Sacaton AZ. June 2010