Characterization of spatial variation in wheat yield and protein using soil and plant sensors - 2012

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Summary
The goal of this project is to improve our understanding of the effect of soil fertility on grain yield and quality by looking at field-scale distributions. In 2012 one field in Sacaton AZ was selected for this study. A soil apparent electrical conductivity survey at time of tillering showed variations in a NW-SE diagonal transect, which was used to accommodate a smart sampling scheme for in-season soil/plant-stem Nitrogen monitoring. Sensor-based canopy spectral and plant height measurements using a mobile platform complemented the dataset. Observations were organized in three field zones, consistent with Low (L), Medium (L) and High (H) EC values. Sensor readings showed that zone H contained plants with more vigor, also associated with soil/plant Nitrogen values 2.4 times higher on average than zone L. Yield and grain protein differences ranged from 5,265 to 8,091 lb/acre and 12.96 to 14.33% for zones L and H respectively. In this study EC values were highly associated with textural changes in the field. EC surveys and yield monitoring data can be used to delineate management zones to change the in-field distribution of Nitrogen through variable-rate application technology already available commercially. Sensor-based management of N fertilizer will optimize durum wheat yield and quality

Introduction
Research funded by the AGRPC since 2010 has yielded meaningful results in the spatial analysis of yield variability, in terms of both quantity and quality. A particular strength of this research has been the emphasis on field-level analysis in fields under conventional management by a grower cooperator in the Sacaton AZ area. The results have shown the strong influence of soil properties associated with soil water-holding capacity, as characterized with bulk EC measurements, on the final protein levels in the field. Canopy reflectance data characterized the amount of plant biomass at tillering but showed weak association with yield components at the end of the season. Our work in 2010 and 2011 has provided meaningful information because never before had been generated information on the spatial distribution of key soil/plant variables at the field scale in wheat production in Arizona. This type and quality of information is crucial to develop recommendations with a solid basis for improved fertility management under a site-specific, variable-rate approach. Other areas of management that can be improved with this line of work include irrigation management and seeding operations. Our work in 2012 continued to be oriented towards developing recommendations on how to improve yield and grain quality through site-specific management, and timely application of production inputs. As we will see in the methods section, we followed a smart-sampling scheme to keep track of plant and soil Nitrates. The analysis of timing and amounts is expected to yield important information to help the fertility management of durum wheat.

Experimental Work

In 2012 we continued to use the approach of working with a grower collaborator to monitor actual field conditions created with his conventional management scheme as well as by the natural variability of soil in the field. In agreement with Mr. Karl Button, manager of Ramona Farms in Sacaton AZ, we selected one field in Sacaton AZ (111.731302 deg W, 33.111317deg N). This field had 15 acres of Westmorland durum wheat dry planted on December 23.

An improved scheme of smart sampling was followed during the growing season with the specific objective of capturing the dynamics of soil/plant Nitrogen with a reduced number of samples. Field zones were defined based on an on-the-go soil electrical conductivity survey using the Soil EC 3100 sensor manufactured by Veris Technologies (Salina, KS) performed on January 31, 2012 when the crop was at tillering stage. Figure 1 shows the geographical distribution of the ten sampling points selected with the smart-sampling procedure.

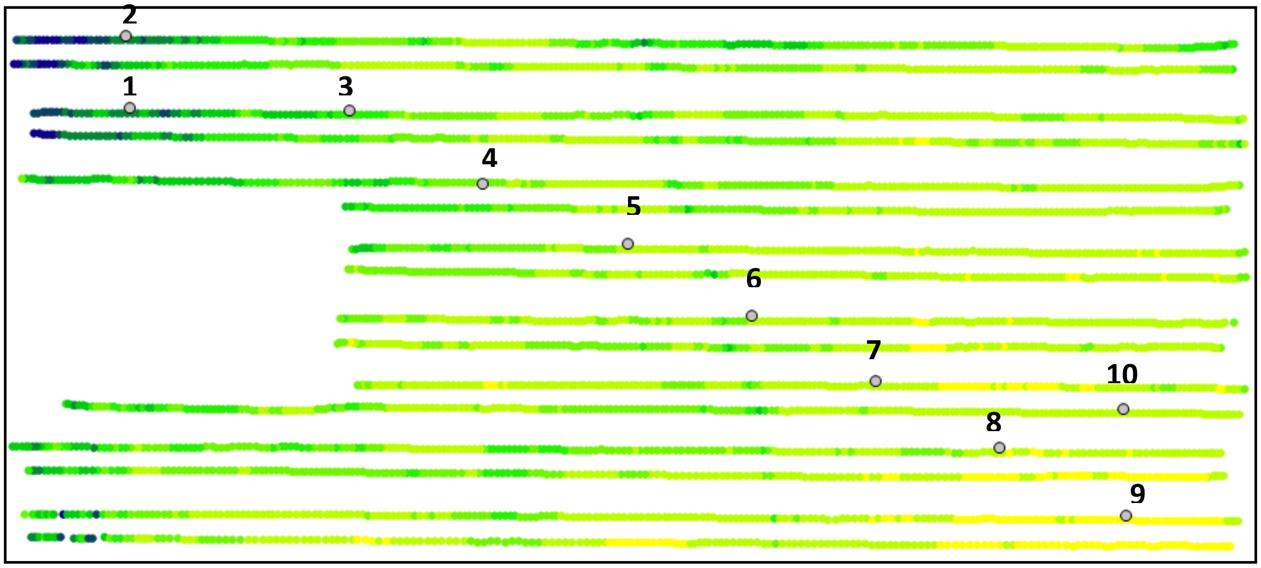


Figure 1. Top soil bulk EC survey showing zones of high, medium and low relative EC. NW-SE diagonal distribution of sampling points 1-10.

Selected soil and plant samples for laboratory determination of N status were taken at tillering, jointing-booting, and flowering; along with spectral measurements of the crop using a mobile platform. We chose to use the CropCircle ACS-470 3-band active spectral sensors (Holland Scientific; Lincoln, NE) that provided information on the canopy reflectance at 670, 720, and 820 nm. These quantities were combined to compute the normalized difference vegetation index (NDVI) which is an indicator of vegetation status. In order to geo-reference all the data generated in this project we used a differential correction GPS model AgGPS232 manufactured by Trimble (Sunnyvale, CA). All electronic signals from soil/plant and yield sensors were collected with the use of a data logger model CR-3000 manufactured by Campbell Scientific (Logan, UT).

Soil and plant samples were collected following the guidelines recommended by Ottman M, "Fertilizing Small Grains in Arizona", 2006 (Extension bulletin AZ1346) and were sent to a commercial laboratory for Nitrate Nitrogen quantification. These point samples were collected just hours before the timing of fertilizer applications on February 2, March 26, and April 11, 2012. In addition to soil-plant sampling, on those same dates we deployed optical sensors to measure canopy light reflectance of the crop. Figure 2 shows the mobile platform used for the purpose of collecting continuous plant sensor data.

Figure 2. Field deployment of sensors in mobile platform. System set up in boom to continuously collect canopy spectral data.

Harvest of the experimental site was carried out in early June with a Case-IH combine instrumented with a yield monitor system sponsored by the AGRPC in 2010. At the time of harvesting, we collected geo-referenced grain samples for quality determination in the laboratory.

Results

The analysis of soil and plant dynamics showed a strong spatial distribution, which was well characterized with the soil EC survey. Figure three presents these values in columns for the three dates when samples were collected. Moreover, the values of soil and plant Nitrates when aggregated by zones showed a strong association with yield (lb/ac) and protein content. Yield report generated with SMS software is attached as Appendix 1 at the end of this document.

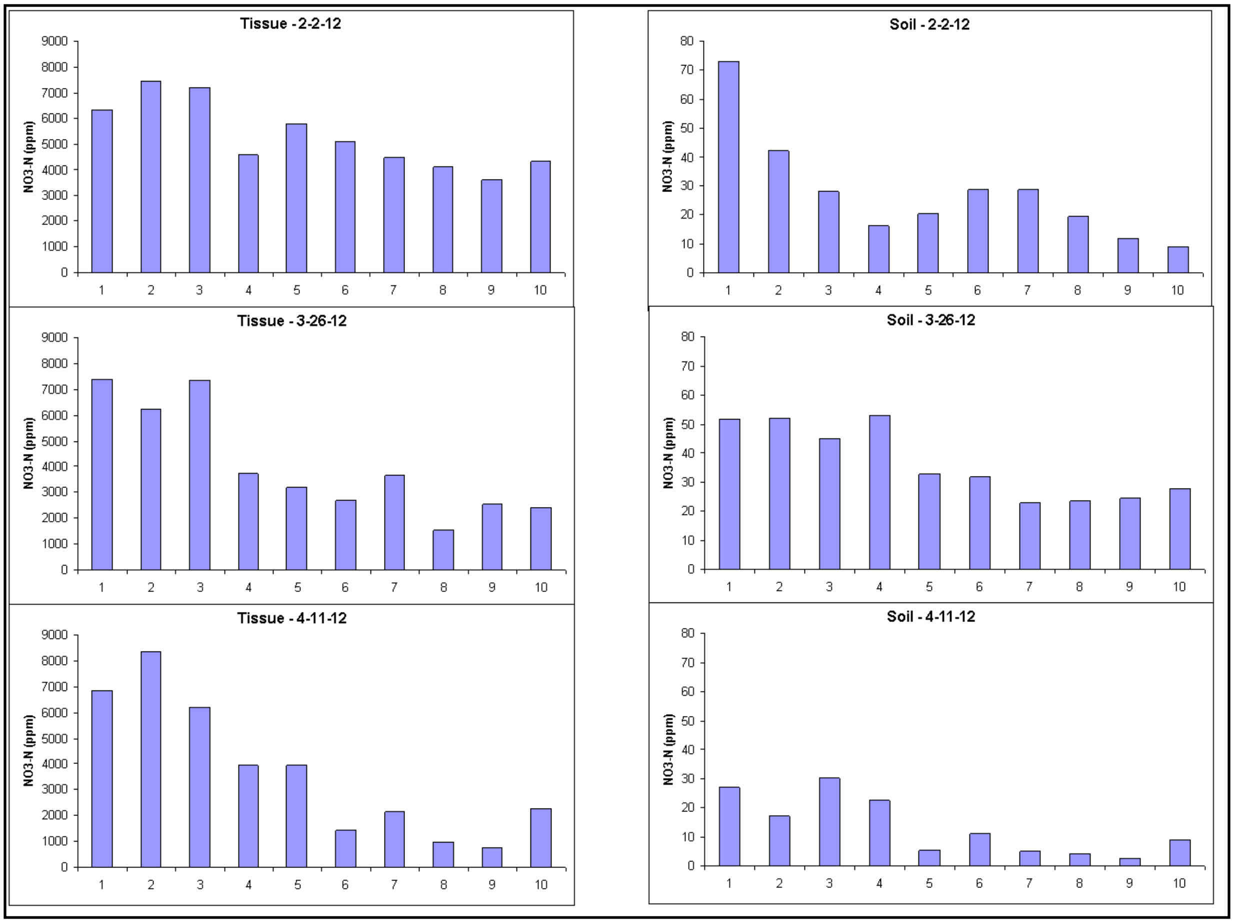


Figure 3. Values of soil and lower-stem Nitrates-N on three dates during the growing season. Columns arranged by sample number according to the field ID number seen in Figure 1.

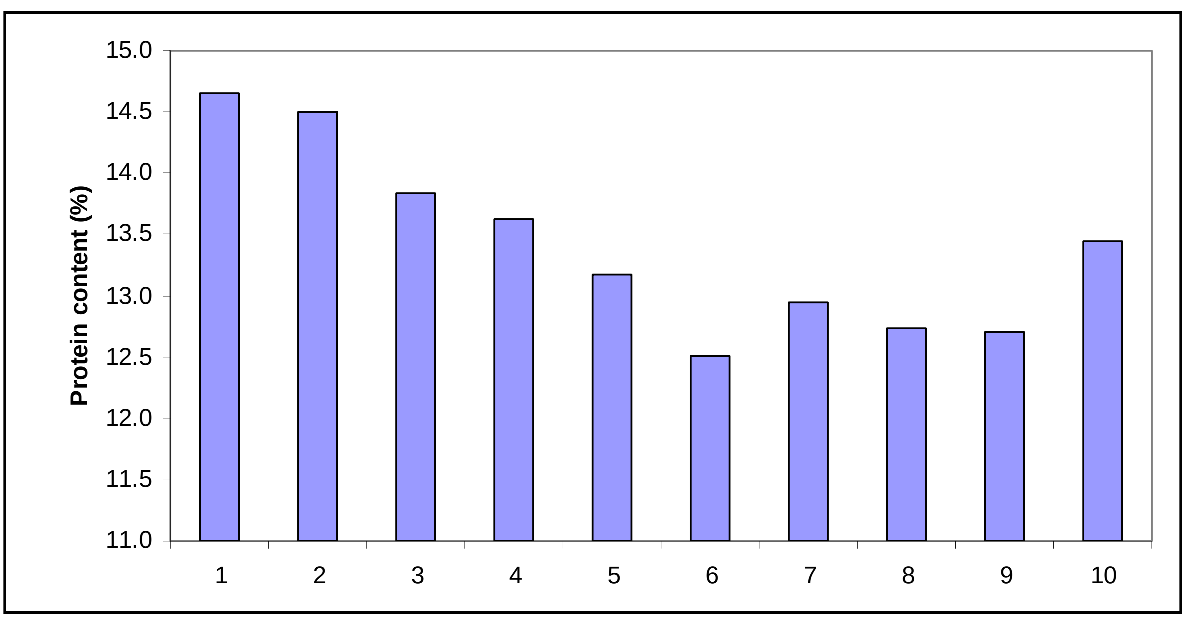


Figure 4. Values of grain protein content according to 12% moisture standard.

Discussion

This year's experiment clearly showed the extent of field distribution in the values of Nitrates and the resulting grain yield and protein content, in spite of the uniform management of Nitrogen fertilizer carried out by the grower cooperator. The distribution of these values was highly correlated with the soil physical/chemical condition as characterized by the soil electrical conductivity survey performed early in the season. These results suggests that there is good potential for the implementation of variable-rate N application technology with zone definition based on a combination of soil EC and yield monitoring data. Appendix 2 shows the maps and software procedures used to generate prescription files for automatic variable-rate application of Nitrogen fertilizer in this field. As a case-study, we defined a prescription that would use the same total amount of fertilizer of the average field condition (mid-EC zone), but the rates for the high and low EC zones were below and above this value respectively. The variable-rate strategy is expected to yield meaningful benefits to durum wheat production in the semi-desert in the event of increased costs of fertilizer and/or any event that limits the availability of this production input.

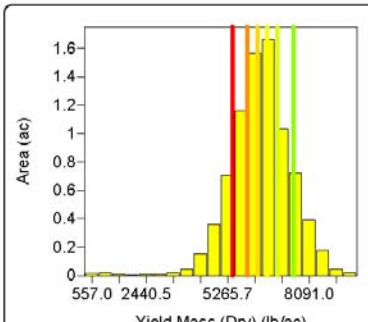
Appendix 1. Yield report generated with AgLeader SMS software in pdf format.

Grain Harvest 2012 - Wet Camp(WHEAT)

Grower : K. Button
Farm : Bapchule
Field : Wet Camp
Year : 2012
Operation : Grain Harvest
Crop / Product : WHEAT
Op. Instance : Harvest - 1
Area : 8.138 ac
Avg. Yield : 105.63 bu/ac
Avg. Moisture : 6.659 %

Yield Mass (Dry)
(lb/ac)

7,535.39	-	11,804.10(1.103 ac)
6,981.17	-	7,535.39(1.141 ac)
6,626.35	-	6,981.17(1.158 ac)
6,289.37	-	6,626.35(1.169 ac)
5,942.26	-	6,289.37(1.175 ac)
5,431.93	-	5,942.26(1.190 ac)
321.54	-	5,431.93(1.201 ac)



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Appendix 2. Procedures for creating prescription files using AgLeader SMS software. Material presented to growers during the field day at the Maricopa Agricultural Center on 10-17-12

Using Yield Monitor Data for Management Decisions

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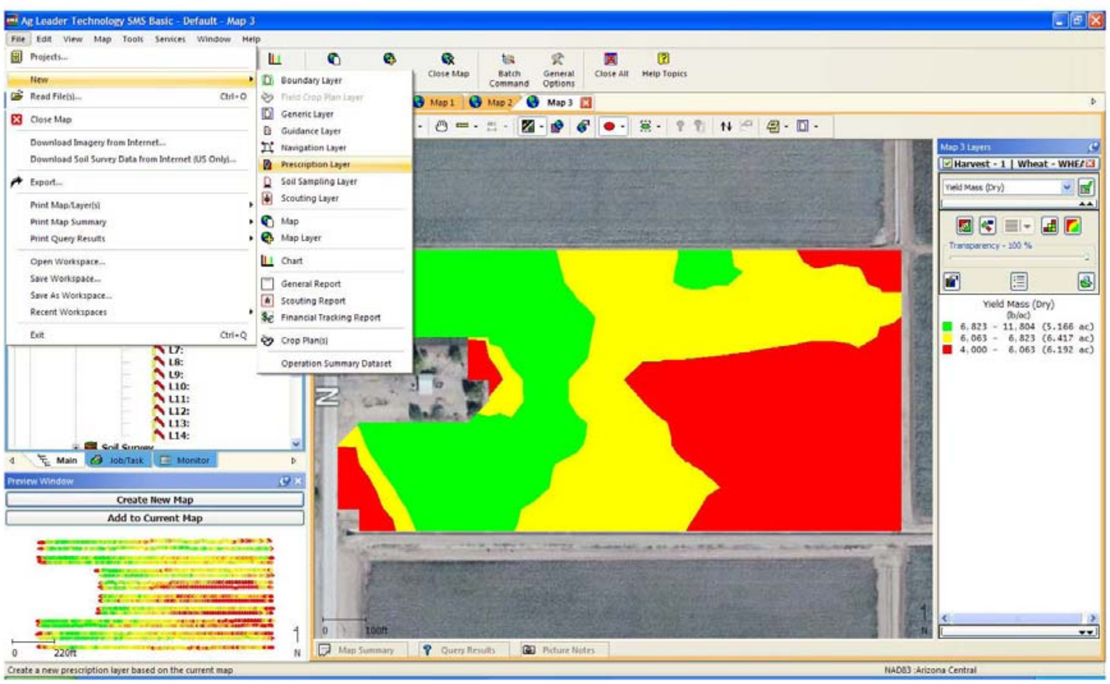

Appendix 2. Continuation