Relationship of Crop Yield and Protein Content to Soil Properties in an Undulating Landscape in South Central Saskatchewan

Elliott Hildebrand[1], Jeff J. Schoenau[1]

[1]Dept. of Soil Science, 51 Campus Drive, University of Saskatchewan, Saskatoon, SK S7N 5A8

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Introduction

Fertilizer application decisions for crops grown on the prairies are traditionally based on measuring the nutrient status of the soil. Typically, this involves analyzing a soil sample taken prior to sowing the next crop. Variable rate application seeks to improve the efficiency of applied fertilizers by identifying areas in a given field with different yield potentials based on topography, texture and moisture. This data is uploaded to a seeding drill capable of applying fertilizer at varied rates based on GPS location. However, there is a cost in money and time to identify and sample separate management zones, and predicting the crop response to added fertilizers requires the identification of limitations on yield in each of the zones. Thus, the challenge is to identify efficient and reliable mechanisms that can form the basis of the variable rate prescription map. Both yield and protein harvest data may be useful along with soil data to delineate management zones.

The significance of this project is to asses if a variable rate fertilizer prescription map can be improved with both yield and protein data. The protein content of a crop such as wheat reflects the balance between available nitrogen and other limitations on plant growth. For example, a protein content greater than 15% would indicate high N availability relative to other limitations such as water and salinity, while a protein content less than 13% would indicate that not enough N was applied to maximize yield (Engel et al., 1999).

Materials and Methods

This study is located at SW31- 20- 03- W3 near Central Butte, SK, Canada. The soil is a Haverhill association Brown Chernozem with localized saline solonetz areas of the Ardill-Kettlehut association. Approximately 40 acres each of Waskeda wheat, Invigor 5770 canola and Meadow peas were seeded on May 9, May 2, and April 27 respectively in the spring of 2012 (Figure 1). Please see Figure 2 for a representation of the transect layout for wheat. Pre-seed glyphosate was applied to the wheat and canola, but not to the peas. Seeding rates were 70, 4.5, and 160 kg/ha respectively for wheat, canola and peas. Fertilizer application was 50kg N/ha and 20kg P/ha for wheat and 60kg N/ha and 30kg P/ha for canola. Peas were inoculated with Tag-Team inoculant, but received no fertilizer. Herbicide application included fenoxaprop-p-ethyl

(Puma®) and fluroxypyr and 2,4-D (Attain XC®) for wheat, gluphosinate ammonium (Liberty®) for canola and ethalfluralin (Edge®) and imazamox (Solo®) for peas.

Two transects were laid out east to west in each field. Each transect included eight geo-referenced points for a total of sixteen points per crop. These were marked by burying a magnetic ball at approximately 30cm depth , allowing unhindered operation of equipment, and easily located using a metal detector. Measurements taken in fall of 2012 included yield and protein data. Soil was sampled for available N and P, organic carbon to depths of 0-30cm and 0-60cm. Salinity was measured by EM38 and conducted by Dr. Evan Morris and associates of Ecotech, Regina SK. EM38 readings were taken to four depths of 0.6, 1.2, 1.5 and 3.0m. Precipitation was 318mm between April to October which is considerably greater than the 190mm received in the 2011 growing season.

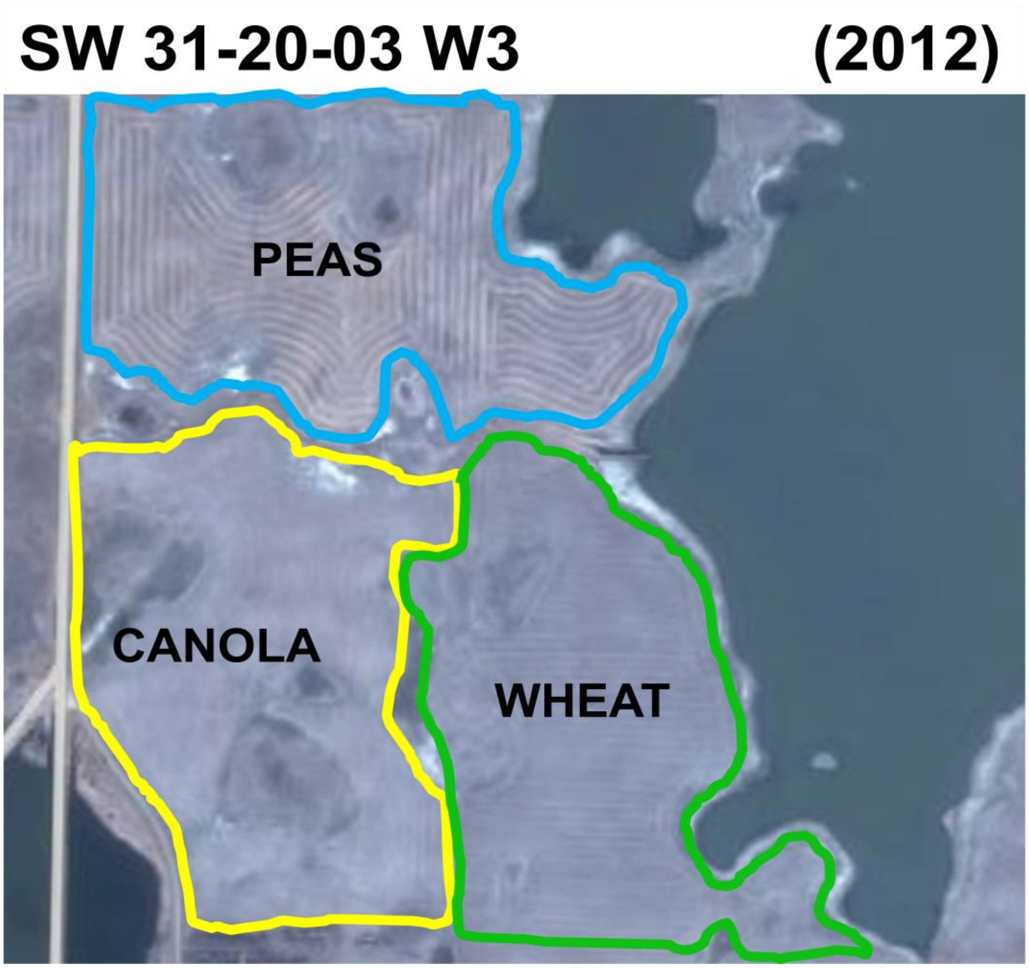

Figure 1: Plot layout map (2012).

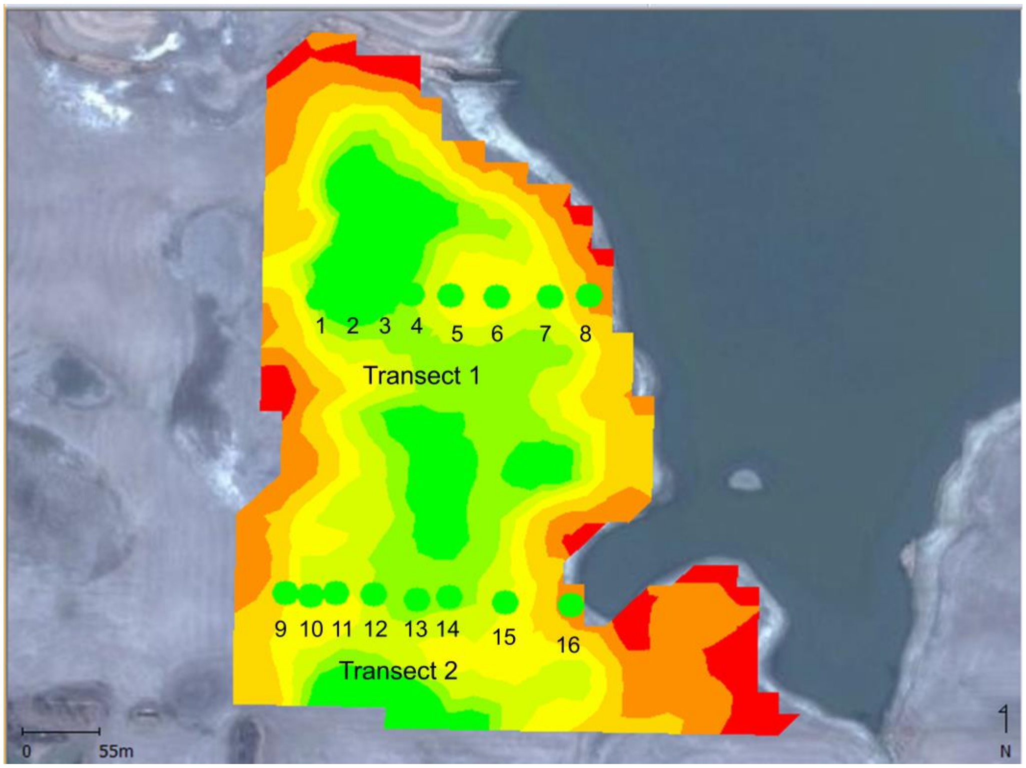

Figure 2: Wheat field showing georeferenced transect points.

Results and Discussion

At the time of presenting at Soils and Crops Workshop 2013, certain results were available. These included grain yield, EM38 readings to four depths (0.6, 1.2, 1.5 and 3.0m), elevation and organic carbon to 0-30cm and 30-60cm. Other data such as soil, plant and seed nutrient concentrations as well as protein content will soon be processed. Stepwise regression was performed to determine if some soil factors influence yield more than others. This revealed three factors: elevation, salinity to 0.6m, and organic carbon in the 0-30cm depth as having the greatest effect on yield. However, correlation analysis revealed that only organic carbon in the 0-30cm depth had a significant effect on wheat yield ($r=0.55$ $p<0.05$) and that only salinity in the 0.6m depth had a significant effect on pea yield ($r=0.52$ $p<0.05$). Assessment of the relationships between yield, protein and soil properties will be performed when the remaining data is available.

The relationship between yield, elevation, salinity (EM38 reading) to 0.6m depth and organic carbon to 30cm depth for the wheat plot is shown by individual transect in Figures 3 and 4. Yield and elevation are plotted on the y-axes and the x-axis shows transect position. Organic carbon and EM38 values are plotted alongside the elevation curve to show in order to visualize yield vs three soil properties simultaneously. Figure 3 reveals that as elevation increases, organic carbon and EM38 values decrease along with a corresponding decrease in yield. This is expected as greater soil moisture will be present at lower slope positions. This trend is observed in points one through seven but is interrupted at point eight. Transect point eight is characterized by an extremely high EM38 value and low organic carbon. Thus, despite a low elevation and good moisture, this high salinity will be severely detrimental to crop growth. Transect 1 is characterized by an undulating topography with a total range in elevation of ten feet over a length of 620 feet and range in yield of 26 bushels per acre making it clear that there should be potential to create management zones based on yield potential in different parts of this field.

The relationships between yield and soil properties for wheat in transect 2 are shown in Figure 4. Transect 2 is characterized by an undulating topography with total elevation range of thirteen feet over a length of 656 feet and range in yield of fifteen bushels per acre. This transect had less variation in organic carbon content than transect 1. Transect point sixteen exhibits that same characteristics as point eight in that there is a low elevation and high salinity. These points are characterized by a 'bathtub ring' of salinity. The relationship between yield and soil factors in the other points of transect 2 are less pronounced than in Figure 1 as there is no clear trend from points nine to twelve. There is a general decrease in yield from points thirteen to sixteen corresponding with a decrease in elevation. The 2012 growing season received more moisture than normal, so there may be some disease pressure on the transect points that slope toward the slough.

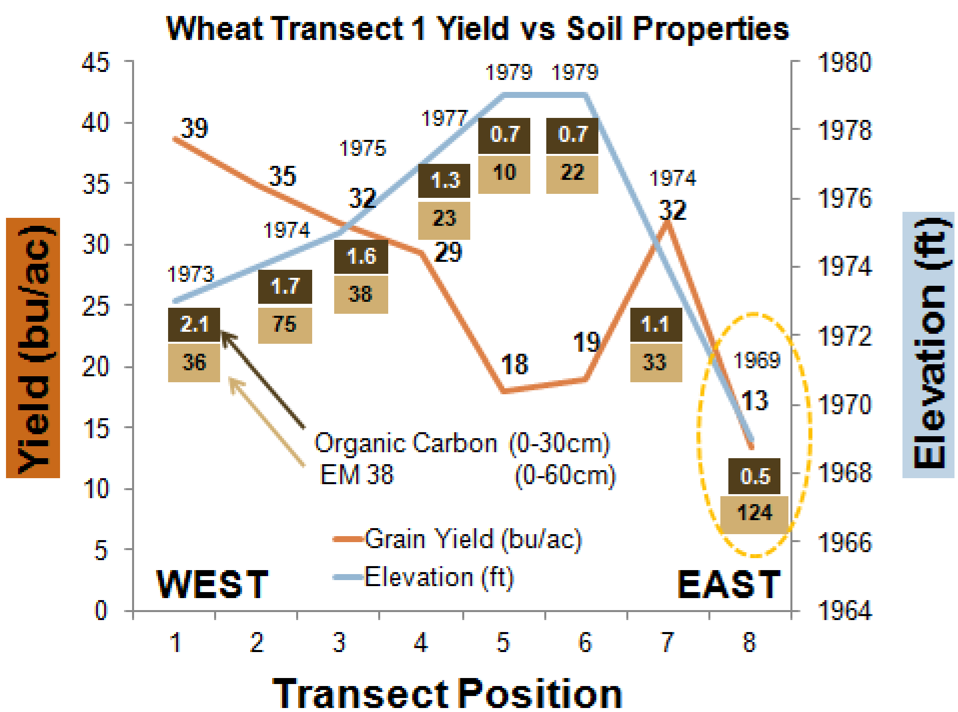

Figure 3: Wheat transect 1 yield vs soil properties.

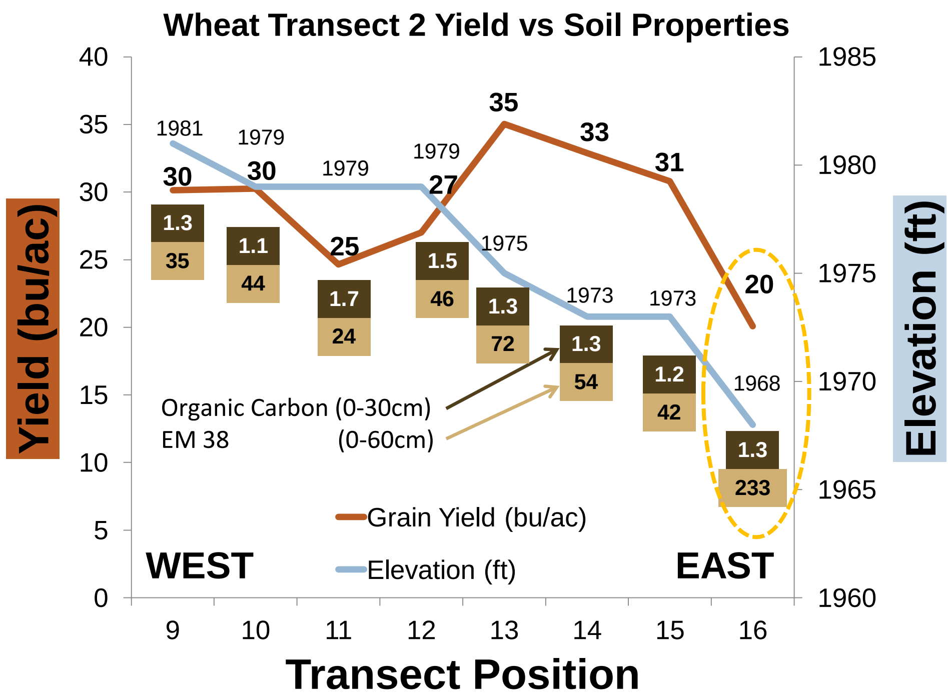

Figure 4: Wheat transect 2 yield vs soil properties

Conclusions

Preliminary results from this study indicate that there is considerable variability in wheat yield and soil properties such as elevation, organic carbon and salinity. This is encouraging as it shows that different areas of the field have different yield potentials ranging from 13 to 39 bu/ac in transect 1 and 20 to 35 bu/ac in transect 2. Data on soil nutrients, plant nutrient components and protein will be available soon, and will enable further elucidation of the nature of these relationships. Once these have been established the transects will be split in half with one half receiving the uniform N rate in 2013. The individual points on the other half of the transect will receive a variable N rate determined by analysis of these relationships.

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References

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