Corn OSAVI as Related to Soil Electrical Conductivity and Nitrogen Fertilization Rates

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***Abstract*—Soil electrical conductivity (SEC) surveys have recently become available for the characterization of soil patterns within fields. The question arises as to whether or not SEC maps can be used to drive site-specific nitrogen (N) fertilizer applications during the growing season. Corn was grown with N fertilization treatments ranging from 0 to 150 kg N/ha at topdressing. CASI airborne images were collected using a multispectral mode of operation, with 1 m spatial resolution and computed to provide an *Optimized Soil-Adjusted Vegetation Index* (OSAVI). Low SEC were related to high OSAVI. There were neither effects of N fertilization on OSAVI nor interaction with SEC properties. It is concluded that 1) N application at topdressing may not impact corn growth and 2) that variable rate N application can hardly be based on SEC patterns.**

Keywords – Topdressing; Veris®; Growth; Precision farming; Variable rate application

I. INTRODUCTION

Precision farming is about the appropriate agronomical intervention at any given location of a production unit. Nitrogen (N) fertilizer application is one of the most important factor to optimize within a field due to its unique characteristics in terms of variability in space and time, sensitivity to seasonal characteristics, impact on crop productivity, cost of product, and pollution risk. Corn is very demanding in nitrogen input. Many growers will tend to split the N application into two; a minor part at sowing, and a major part approximately a month after sowing (topdressing). Claims have been made that a measure of soil electrical conductivity (SEC) can be used as an indicator of appropriate N rates at topdressing. SEC is related to soil water status, which is in turn related to soil texture [1], a major parameter in determining the natural N supply capacity of the soil. Application of nitrogen may be varied based on individual yield goals for certain soil textures. Crop advisors may recommend a split application on lighter soils to improve effectiveness and prevent leaching [2]. Despite the errors associated with site-specific management recommendations, they are, in most cases, still vastly superior to their whole-field management counterparts [3]. Our objective was to determine the relationships between corn growth and SEC in interaction with N fertilization in order to establish the potential of SEC for driving spatially variable N applications at topdressing.

II. MATERIAL AND METHODS

A. Experimental layout

The experimental set-up was made of five fields, located on the Agriculture and Agri-Food Canada experimental farm in L'Acadie, Qc., Canada (Easting Northing coordinates: 630 366.35 m; 5 017 149.77 m). Five contiguous fields ranging between 0.66 and 1.36 ha were selected. Soil textures were generally of the loam type with some bands of clay-loam and sandy loam at the northern end (fig. 1). A fertilizer application of 14-18-26 at 300 kg/ha was made broadcast prior to sowing and incorporated to the soil top layer. The corn cultivar Pioneer 38P05 was sown between May 2th and May 7th, 2001 with a simultaneous band application of 280 kg/ha of 17-7-13 +Mg. Six N treatments (0, 30, 60, 90, 120 and 150 kg/ha) for each field (fig 4) were applied on June 8th 2001, as a liquid solution (N_{32}) in 2 or 3 replicates of 7 corn rows, depending on field width. An intensive SEC survey was conducted using the VERIS® 3100 conductivity sensor. Shallow (0-30 cm) and deep (0-100 cm) readings were recorded on November 7th, 2001, and georeferenced with a DGPS system with a spatial resolution ranging between 300 and 700 points per field.

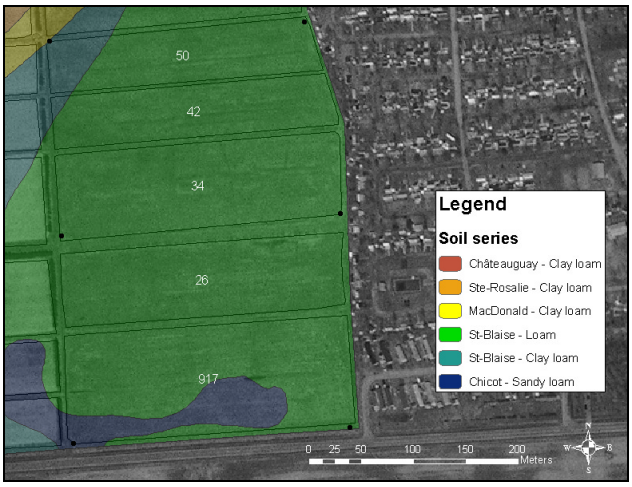

Figure 1. Soil series on the experimental site

B. *Remote estimation of OSAVI*

CASI (*Compact Airborne Spectrographic Imager*) airborne imagery was collected on July 26th 2001, using a multispectral mode of operation, with 1 m spatial resolution in 7 bands (489.5, 555.0, 624.6, 681.4, 706.1, 742.3, and 776.7 nm). The processing of CASI imagery included geo-referencing using white targets distributed on the farm and located with a GPS as ground control points, radiance calibration, atmospheric corrections and reflectance retrieval, and removal of aircraft motion. The OSAVI (*Optimized Soil-Adjusted Vegetation Index*) calculated by the equation 1, was used to map crop growth at a 1 x 1 m spatial resolution.

$$\mathrm{OSAVI} = 1.16\left(\frac{NIR - R}{NIR + R + 1.16}\right) \quad (1)$$

The geostatistical procedures (semi-variogram, kriging (2 by 2 window)) for OSAVI, $SEC_{0\text{-}30}$ and $SEC_{0\text{-}100}$ were computed with the GS+ software. Fields were rotated before interpolation to an orientation angle of 0 prior to semi-variogram calculation (omnidirectional). The GS+ files were imported and mapped in ArcView. Corn guard rows (0.75 m between treatments), were excluded from the statistical analyses. The results are presented in fig 4.

III. RESULTS

A. *Univariate and geostatistics*

Both $SEC_{0\text{-}30}$ and $SEC_{0\text{-}100}$ covered a wide range of conditions (table I) in comparison to data obtained from commercial fields in the local corn production area (data not shown). OSAVI varied from 0.45 to 0.81 (table I). The range of OSAVI in the semivariogram was in the order of 500 m, with the exception of field #42 with 53 m. The ranges for $SEC_{0\text{-}30}$ varied between 18 and 402 m, and between 21 and 76 m for $SEC_{0\text{-}100}$ depending on fields.

TABLE I. UNIVARIATE STATISTICS

Statistics	***Parameters***		
	OSAVI	***$SEC_{0\text{-}30}$***	***$SEC_{0\text{-}100}$***
Min.	0.45	4.4	7.7
Max.	0.81	22.3	23.8
Median	0.77	9.3	12.9
Mean	0.76	9.4	13.0
S.D.	0.04	1.93	2.10

B. *Effect of N fertilization on corn growth*

There was no effect of N rate at topdressing on corn growth as measured by OSAVI status (fig. 2). The crop was overall relatively uniform and normally distributed.

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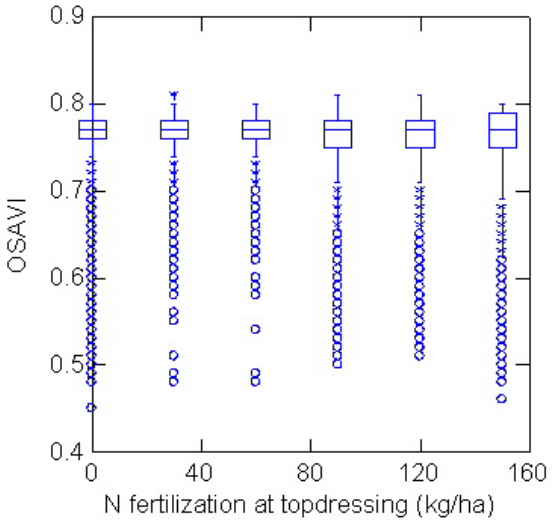

Figure 2. Box plots of *Optimized Soil-Adjusted Vegetation Index* (OSAVI) of corn at mid-season in relationship with nitrogen (N) fertilizer rate at topdressing

C. *Effect of SEC on corn growth*

$SEC_{0\text{-}30}$ and $SEC_{0\text{-}100}$ are correlated (fig. 3). Conditions of high $SEC_{0\text{-}30}$ and $SEC_{0\text{-}100}$ lead to lower OSAVI. These are mostly representative either of 1) localized depression of the landscape and 2) soil compactness. Indeed, there was not much variation in soil texture in the study area. Water accumulation and compaction are conducive to high SEC values and sub-optimal growth conditions. An example of such pattern is apparent in fig 4.

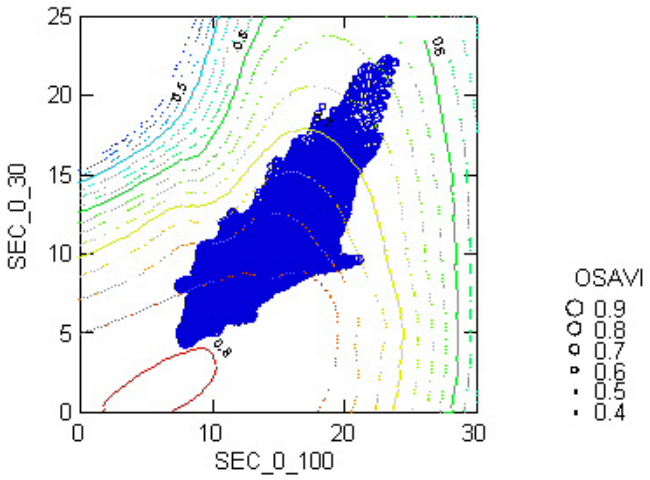

Figure 3. *Optimized Soil-Adjusted Vegetation Index* (OSAVI) of corn at mid-season in relationship with soil electrical conductivity status in the 0-30 (SEC_0_30) and 0-100 cm (SEC_0_100) horizons

D. *Interaction of SEC and N fertilization*

The Pearson correlation coefficient (R) between OSAVI and SEC_{0-30} were -0.34, -0.47, -0.46, -0.37, -0.44, -0.43 for the N treatments 0, 30, 60, 90, 120 and 150 kg N/ha, respectively. They were respectively -0.17, -0.33, -0.39, -0.22, -0.33, -0.22 between OSAVI and SEC_{0-100}. The R were therefore systematically higher with SEC_{0-30} than with SEC_{0-100} and this shows a greater importance of surface than deep soil conditions on OSAVI expression. There was no trend of a lesser correlation between OSAVI and soil conditions with an increase of N fertilisation. As well, OSAVI coefficient of variation (%) were of 4.2, 4.3, 3.8, 6.0, 5.1 and 6.1 for the N treatments 0, 30, 60, 90, 120 and 150 kg N/ha, respectively.

IV. Discussion

In order of importance, OSAVI status was impacted by 1) SEC_{0-30}; 2) SEC_{0-100} and 3) N fertilization at topdressing.

The lack of response of crop to N rate is not unusual, despite the fact that corn is considered as high N demanding crop. Obviously, the N content of the fertilizer applied at sowing (90 kg N/ha) and the microbial mineralization of organic N by the soil were sufficient to make-up for the requirements of the crop. Hence, these fields were meadows until 2000 and accumulated considerable organic matter before they were drained, leveled and plowed in fall 2000, prior to be turned to corn production.

The absence of trends according to N rates in Pearson correlation coefficients between OSAVI and SEC illustrates that high N fertilization does not tend to buffer growth variations due to soil conditions. This is confirmed by the study of OSAVI coefficients of variation according to N rates.

This study provides no support for the use of SEC in driving topdress N fertilizer application in corn but highlights the importance of achieving an adequate N recommendation according to site and seasonal characteristics.

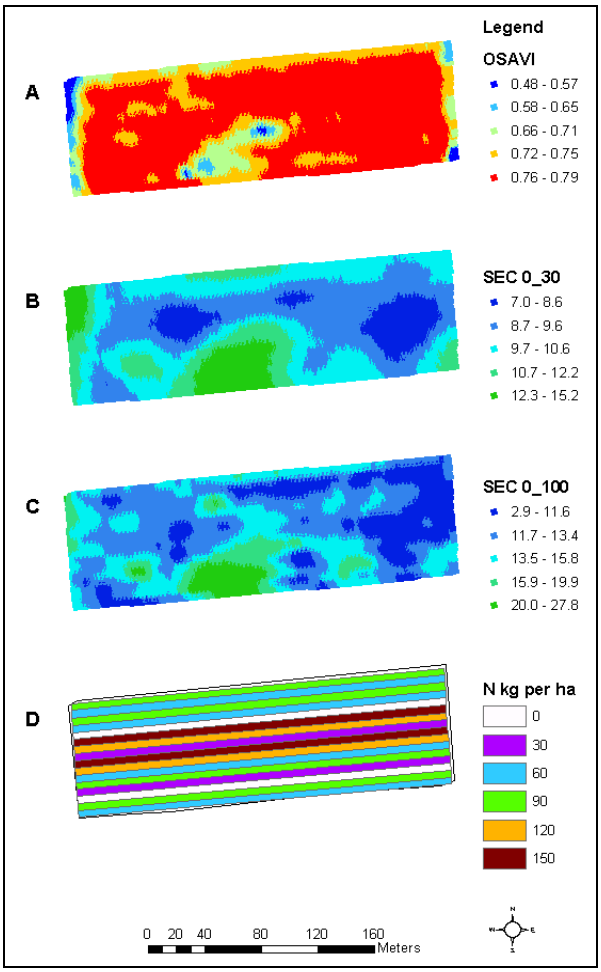

Figure 4. Example of field (#26) with krieged maps of OSAVI, soil electrical conducvitity and location of N fertilization treatments at topdressing.

Acknowledgment

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