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In-field variability of terrain and soils in southeast Kansas: Challenges for effective conservation

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Abstract. *A particular challenge for crop production in southeast Kansas is the shallow topsoil, underlain with a dense, unproductive clay layer. Concerns for topsoil loss have shifted production systems to reduced tillage or conservation management practices. However, historical erosion events and continued nutrient and sediment loss still limit the productive capacity of fields. To improve crop production and further adoption of conservation practices, identification of vulnerable areas of fields was performed using publicly available high imagery products and terrain maps. The information can be used to develop protocols for alternative management to protect vulnerable areas and reduce topsoil loss. Yield and plant growth information were collected at harvest from production fields. Additional measurements of soil electrical conductivity further delineate soil variability. Although fields commonly have only a moderate slope (1–3%), calculation of surface curvature indicates areas of fields at higher elevations that often coincide with areas of thin vegetation, indicating high erosion losses. DEM analysis revealed areas within fields that held water and areas of high potential runoff where soil loss was likely. Transitioning to conservation management practices such as reduced tillage and use of cover crops may improve the soil microenvironment and enhance the long-term sustainability of the agronomic production system. Implementing precision management practices could also improve net return by reducing inputs on regions with low productive capacity.*

Keywords. *soil erosion; claypan; electrical conductivity; terrain analysis*

Introduction

Crop production in southeast Kansas is challenging because of the limited productive capacity of the soil. The potentially productive silt loam topsoil is underlain with an unproductive claypan. High rainfall levels and historical conventional production practices have contributed to significant soil erosion in many crop fields. The conventional production systems could benefit from spatial management, which could also be useful in controlling soil and nutrient losses.

Materials and Methods

Crop production fields were selected in collaboration with farmer-cooperators. The conventional crop rotation is corn (planted from mid-March to mid-April and harvested in August), winter wheat (planted in October and harvested in June of the following year), and double-cropped soybeans (planted after wheat harvest in June and harvested in October-November), producing three crops in two years. Conventional tillage operations are typically performed prior to planting corn in the spring, while soybeans are commonly no-tilled planted or drilled into wheat stubble. Most crop production in rainfed. The area has high annual rainfall amounts in excess of 100 cm, with most rain received in the spring (April – June). Common nutrient management includes addition of N:P:K at the following rates: corn (150:40:20), wheat (100:30:20), soybeans (none). Yields were recorded with commercial yield monitors on combines, and mapped in SMS Advanced (AgLeader, Ames, IA). A Veris Soil Electrically Conductivity system (Veris Technologies, Salina, KS) was used to measure soil electrical conductivity after crops were harvested. Yield and soil EC measurements were converted to shape files and exported to ArcGIS for further analysis.

High-resolution imagery was collected through the USDA National Agricultural Imagery Program (NAIP). Elevation data and orthoimagery for production fields were downloaded from the U.S. Geological Survey (USGS) (http://nationalmap.gov) and analyzed using ArcGIS with Spatial Analyst (ESRI, Redlands, CA). Historical images were downloaded from Google Earth.

Digital elevation maps (DEMs) were downloaded from the Kansas Data Access and Support Center (http://www.kansasgis.org/resources/lidar.cfm), and were used to perform terrain analysis of the production fields using ArcGIS 10.1 (Esri, Redlands, CA). The Watershed Delineation Tool in ArcGIS was used to delineate subwatersheds within each field, and paths of water flow out of the fields (http://www.arcgis.com/home/item.html?id=8e48f6209d5c4be98ebbf90502f41077).

Results and Discussion

Historical imagery highlights management of the field and potential problem areas (Figure 1). Terraces were implemented in the field to control gully erosion (Fig. 1b), along with a grassed waterway (Fig 1a). Areas of the field that have experienced potentially high rates of erosion are evident as lighter-colored areas of the field.

Fig 1. Imagery of crop production field in southeast Kansas. (a) Grassed waterway. (b) Terraces. (c) Erosion prone area.

The grassed waterway serves as a major drainage path out of the field to the south (Figure 2). Note that runoff from the field to the west enters this field and also drains through the waterway. The northeast portion of the field is also a major drainage way.

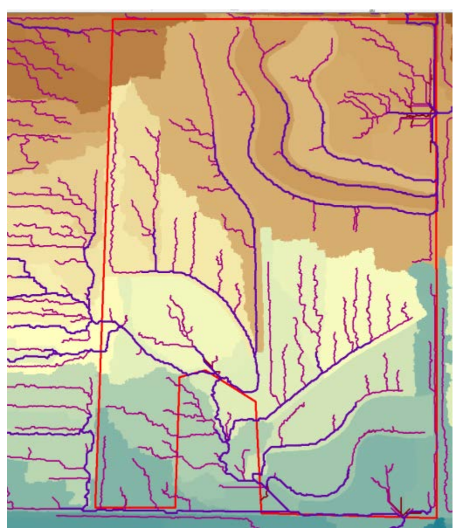

Figure 2. Subwatershed delineation and major flow paths through the field. Field outline is in red.

Comparison of yield maps provides an interesting comparison between the summer crops (corn and soybeans) and the winter crop (wheat; Figure 3). The summer crops show a very strong yield depression in two major areas of the field that correspond to areas of high soil electrical conductivity (Figure 4). Other studies have shown that high soil EC may indicate high clay content (Kitchen et al., 2003). Our preliminary results have shown the negative impacts on yield with higher clay content in the soil (Sassenrath et al., 2015).

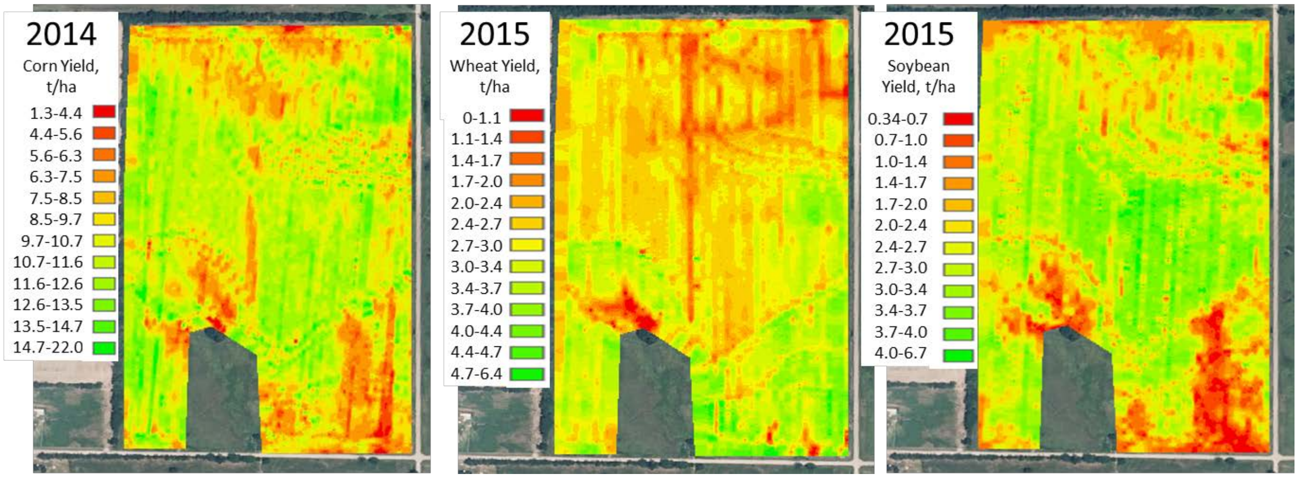

Figure 3. Crop yields from one complete rotation for corn (2014), winter wheat (2015) and double-cropped soybeans (2015).

Interestingly, the wheat yield showed an opposite response to these areas. However, this may be in response to differences in soil water and nutrients, rather than clay content. Wheat yields in southeast Kansas are commonly reduced because of high rainfall amounts in the spring, just prior to wheat harvest (Sassenrath et al., 2014). This may be due in part to fungal damage. The spring 2015 growing season was particularly wet, with substantial yield loss due to Fusarium Head Blight (Boswell, 2015). The northeast portion of the field had much lower wheat yields. This area coincided with the lowest elevation in the field (data not shown), and had substantial drainage (Figure 2). Although the southeast area of the field was also lower in elevation, it did not have many drainage paths, and appears to be drier.

Soil nutrient levels may also account for the differences in wheat yield. Because this field was managed conventionally (consistent inputs throughout the field), the areas with very low corn yields would have higher levels of residual nitrogen. This extra nitrogen may have provided an additional boost to the following wheat crop.

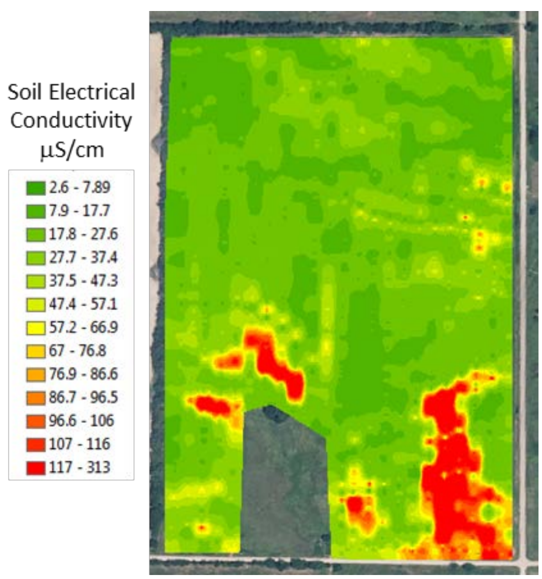

Figure 4. Soil electrical conductivity measured with a Veris 3100 system.

Conclusion or Summary

These results indicate the potential power that prescription management could have to improve conventional production systems. While the excess nitrogen not captured in the corn harvest may have contributed to improved wheat yields, this wasteful application of nitrogen on a poorly producing area of the field cost the farmer. Note that an approximate "break-even" yield for corn in southeast Kansas is about 6.3 t/ha; a significant portion of the corn field was grown at a loss. Better matching inputs to productive capacity could improve the overall net return on the field. Moreover, better nutrient management could reduce the potential for nutrient runoff.

Additionally, conversion to conservation practices may improve the soil, particularly by reducing tillage to reduce erosion. More aggressive conservation management, such as implementing cover crops, will be needed to correct the areas of the field that have been highly eroded.

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