Potential for Use of Electrical Conductivity Measurements for Refinement of Soil Survey Information

T.E. Fenton, professor
Department of Agronomy

Introduction

Precision agriculture (PA) is concerned with understanding and managing variability. PA is made possible by the merging of several technologies--GPS-Global Positioning Systems, GIS-Geographic Information Systems, yield monitors, remote sensing, digital soil maps and databases, and variable rate applicators. Operators may be involved in only one or all these technologies and still be considered involved in PA. The ultimate goal is to improve the management of agricultural land. To achieve this goal data on soils, crops, pests, weather, etc., that will help in determining the best management practices for a field are needed. However, these technologies are only tools to aid our understanding, analyses, and conservation of sustainable agricultural ecosystems.

Scale is a problem in understanding variability. Soil maps made at a scale of four inches per mile (1:15840) or 5.28 inches per mile (1:12,000) generally will not explain all the variability of the data gathered by a yield monitor collecting data on a second by second basis even after the problems associated with interpreting yield monitor data have been resolved. Therefore, more detailed soil observations or remote sensing methods, such as electrical conductivity, may contribute to our understanding of the causes of variability.

Electromagnetic Induction

We have examined a number of remote sensing techniques for studying soils but the one that seems to have the most potential in recognizing and quantifying soil variability in the Midwest is the use of electromagnetic induction (EM) data. We investigated ground-penetrating radar (GPR), but it did not work well for Iowa soils. Primary factors influencing electrical conductivity of soils include the content of salt, kind and amount of clay, water, mineralogy, soil temperature, etc. The EM measurements may be made on a stationary basis or linked to a GPS and pulled behind a utility vehicle as was done for this study. The data discussed were generated with a Geonics Limited EM-38 and then entered into the Surfer software program to generate the spatial distribution of the EM readings as shown in Figure 1. The effective depth of the EM meter is approximately 1.5 meters, which is deeper than the observations used to make the soil map.

Field 110

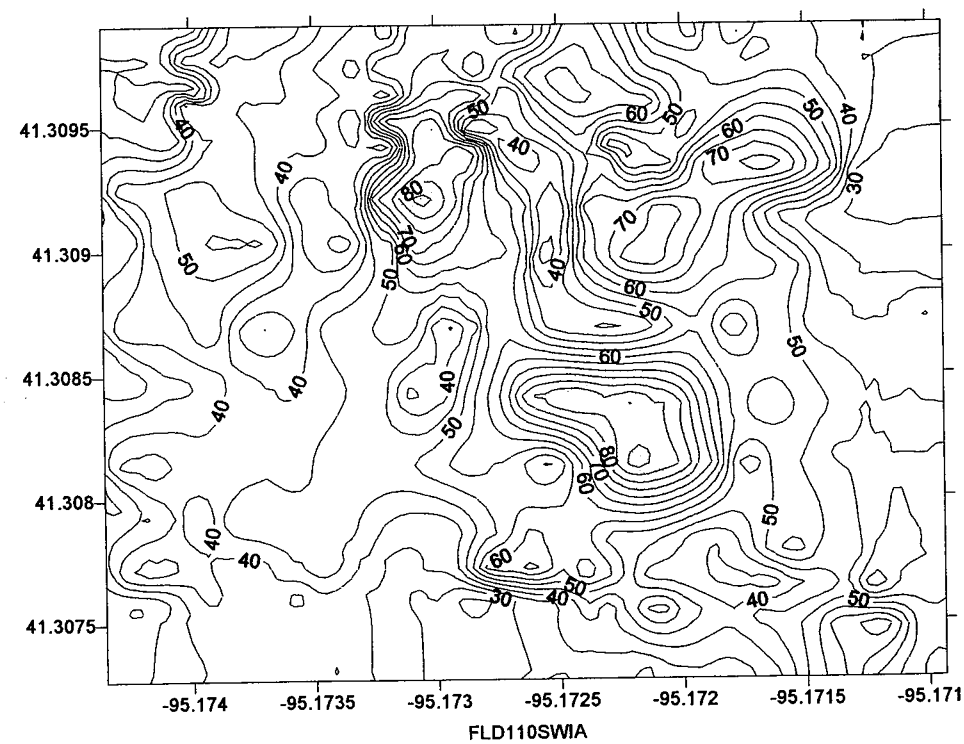
A detailed soil map of Field 110 made at a scale of 1:1200 (1 inch =100 feet) was used as ground truth to compare with the EM map shown in Figure 1. The south part of the EM map does not include the irregular southeast corner of Field 110 as shown on the soil map. Note that in the western 1/3 of the field the EM readings are more uniform and the isolines are generally not closely spaced indicating gradual changes in the EM values. This coincides with the areas of thicker loess and silty deposits that are the parent materials of the Marshall, Judson, and Ackmore soils. The EM readings in the center part of the field change rapidly as indicated by the closely spaced isolines. The higher readings are related to the presence of Clarinda soils and shallower loess deposits associated with the Exira soils. Clarinda soils are formed in clay-textured Yarmouth-Sangamon paleosols. Because of their slow permeability, they perch water above them and in the shallow loess in which the Exira soils are formed. The combination of higher clay contents and greater soil moisture result in higher EM readings.

Thus, the spatial variability of the center part of the field is greater than the western part. Geo-referenced yield data for this field are not available, but it would be expected that the more variable soil conditions in the center part of the field would result in more variable yields and in the case of these soils, lower yields compared with the western 1/3 of the field.

Summary

The use of the EM seems to have good potential as a tool in identifying sets of soil properties and in showing the spatial distribution of these properties. Studies in other areas of Iowa have shown the EM readings of soils are highly correlated with natural drainage class and the set of properties that are defined by that classification.

FIGURE 1. EM MAP OF FIELD 110



EM values are in units of millisiemens per meter (milliS/m).