Improved Soil Mapping using Electromagnetic Induction Surveys

Dan B. Jaynes

National Soil Tilth Laboratory
USDA-ARS
2150 Pammel Dr., Ames, IA

Precision farming technologies rely on accurate field maps of the soil characteristics that affect yield. These maps are best produced at a spatial resolution that is comparable to the scale of application of chemicals, seed, or other inputs (boom width or even distance between individual applicators). Unfortunately, generation of these maps is expensive and laborious since intensive soil sampling and laboratory analyses are required. What is needed is an accurate, fast, inexpensive method of producing soil maps at a level of resolution that is comparable with current and future application technology.

Soil electrical conductivity as measured by electromagnetic induction (EMI) has been used successfully to characterize soils. The electrical conductivity of a soil is determined by a combination of soil water content, dissolved salt content, clay content and mineralogy, and soil temperature (McNeill, 1980b). In many fields, a single property (e.g. salinity) is the primary factor directly controlling soil electrical conductivity. Thus, once the correlation between electrical conductivity and this property is established, an EMI survey can be used to map this soil attribute quickly and cheaply. For example, EMI meters have been successfully used to measure soil salinity (Rhoades & Corwin, 1981; Cameron et al., 1981; Lesch et al., 1992), soil water content (Kachanoski et al., 1988), to map groundwater contaminant plumes associated with elevated chloride, sulphate, and nitrate levels (Greenhouse & Slaine, 1983; Drommerhausen et al., 1995), and measure clay content (Williams & Hoey, 1987).

EMI has also been used to determine soil properties it cannot measure directly. EMI has been used to determine soil cation exchange capacity and exchangeable Ca and Mg (McBride et al., 1990), depth to claypans (Doolittle, et al., 1994), field scale leaching rates of solutes (Slavich & Yang, 1990), spatial pattern of groundwater recharge (Cook et al., 1989; Cook et al., 1992), herbicide partition coefficients (Jaynes et al., 1994) and yield (Jaynes et al., 1995). These studies were successful because the parameter of interest either influenced a soil property (e.g. water content) that affects the EMI reading directly or because the parameter is associated with pedogenic processes that create properties EMI responds to. For example, Jaynes et al. (1994) were able to estimate the herbicide partition coefficient ($K_u$) for atrazine using EMI measurements nearly as well as they could using the standard approach of estimating $K_u$ from measured organic carbon contents. This was possible not because EMI responds to $K_u$ directly but because in the soils studied, high $K_u$ values are due to high organic carbon levels and...