SASKATCHEWAN

Field Mapping of Soil Nutrient Supply Rates

By Jeff Schoenau and Ken Greer

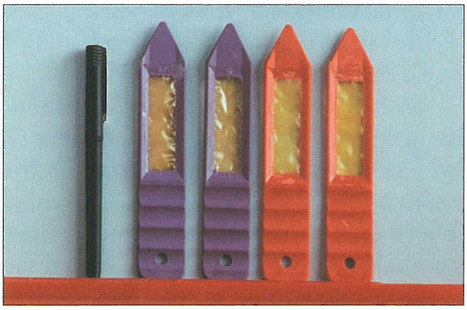
One of the limitations in the adoption of site-specific management techniques such as variable rate fertilization is the effort and resources required to obtain necessary soil information for the site. Information on soil fertility variations in landscapes can be provided by remote sensing, including aerial photographs in which soil color is related to organic matter content and soil fertility. While this approach is simple and relatively inexpensive, it may be limited by the rather indirect relationship that often exists between soil color and fertility. It is also sometimes difficult to get the degree of resolution needed when highly detailed assessments of a field area are desired.

Saskatchewan researchers have developed a simple, rapid system for estimating nutrient availability that may benefit site-specific management.

For intensive field mapping of soil fertility, some sort of direct assessment of soil fertility is usually necessary. Intensive soil sampling of an area, usually on a grid, followed by extraction of the samples with a solution such as dilute calcium chloride or sodium bicarbonate is commonly used to provide a reliable indication of how the amounts of available nutrient (e.g., nitrate and phosphate) present in the soil at the time of sampling vary across the field area. However, it provides limited information on how different locations within the field differ in their ability to supply nutrients in an available form over time under field conditions, especially with regard to mineralization of nitrogen (N) and sulfur (S). As well, the acquisition, handling and processing of many soil samples can be rather cumbersome and time consuming.

Assessing Plant Nutrient Supply Rates

As an alternative to the above approaches, we have developed a simple in-field means of assessing plant nutrient supply rates. The method involves using ion exchange membranes buried directly in the soil to act as plant root simulators to simultaneously adsorb plant available nutrient ions over the burial period. The ion exchange membranes, when chemically pre-treated,



PLANT ROOT simulator probes are used in field measurement of soil nutrient supply rates. Orange probes measure anions such as nitrate, phosphate and sulfate. Purple probes measure cations, including potassium, calcium and magnesium. (Probes by Western Ag Innovations, Saskatoon, Sask.)

exhibit surface characteristics and nutrient sorption phenomena that resemble to a certain extent a plant root surface. The exchange membrane is encapsulated in a plastic probe to create a device we have termed the plant root simulator (PRS) probe, shown in photo.

Direct insertion of the probe into the soil under field conditions allows the many factors which affect nutrient ion flux to roots, including soil texture and structure, to be accounted for in the assessment. During the burial period, nutrient ions adjacent to the probe that are already in the available form along with nutrients that are converted to the available form will be adsorbed onto the surface. The amount of nutrient ion adsorbed on the probe at the end of the burial period is used as a measurement of the potential nutrient ion supply rate to a plant and is expressed in units of micrograms of sorbed nutrient per 10 square centimeters of probe surface over the burial time. We have found that burial times of one hour are convenient for "snapshots" of nutrient ion supply rate, while longer term burials integrate and include more of the factors affecting availability, such as organic matter decomposition rates. For this purpose a burial time of two weeks works well.

Method of Use of PRS Probes

Two types of PRS probe surfaces are available for use: anion exchange and cation exchange. The anion exchange probe will simultaneously adsorb all nutrient anions, including nitrate, phosphate, and sulfate. Cation exchange probes will simultaneously adsorb nutrient cations such as potassium (K), calcium (Ca), and magnesium (Mg). Chelating ion exchange probes can also be constructed to adsorb micronutrient metals including copper (Cn), zinc (Zn), iron (Fe) and manganese (Mn).

In the field at each grid point, a small slot is first made in the soil to which water may or may not be added. If one is interested in nutrient supply rate differences which integrate differences in soil moisture content as they exist naturally in the field, then no water is added. On the other hand, to remove differences in nutrient supply rate arising from differences in soil moisture content, a small amount of water may be added to the slot which will bring the soil immediately adjacent to the probe to field capacity. The PRS probe is then inserted into the slot and allowed to remain in the soil for the prescribed period of time. The above photo shows probe placement in soil.

THE PRS probes are buried in the soil.

At the end of the burial period, the probe is removed from the soil and washed free of adhering soil in a stream of water. The probe is then placed in a dilute acid or salt solution which strips nutrients off and into solution where they can be measured for nutrient concentration. Depending on the nutrient ion of interest, most or all of these steps could be completed in the field. For our purposes, the most convenient approach has been to simply bring the washed probes from the field back to the research laboratory for analysis.

Making the Map

The PRS data obtained for each grid point in the field is entered into a computer program enabling construction of a map of nutrient supply rate. In the fall of 1995, we constructed such a field fertility map

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Colfax (**Figure 8**) shows an inverse relationship with organic matter/topography.

Topography was measured by using laser relative elevation readings at 110 ft. intervals in the field at Mandan. Fourteen NO_3-N values were selected to represent the field for the topographic/cropping estimates. The correlation coefficient between NO_3-N sampled on a 110 to 150 ft. grid and NO_3-N sampled on a 1 to 2 acre grid was 0.290. Nitrate-N sampled by topography/cropping pattern had a correlation coefficient of 0.755 with the 110 to 150 ft. grid and showed substantial superiority over grid sampling for this field.

In 1996, topographic variation will be measured at all sites and more rigorous testing of the influence of topography on fertility levels will be examined. Yield monitors will be used at crop harvest at Mandan and Colfax. The profitability of site-specific sampling and fertilizer application will be explored at two of the sites.

Summary

The initial results of these studies indicate topography may play an important part in soil sampling for variable-rate fertilizer application. More research is needed to verify the preliminary observations. BC

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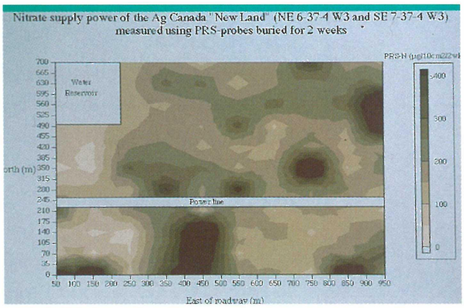

MAP shows nitrate supply rate for a 150 acre field near Saskatoon.

for a 150 acre field near Saskatoon, Sask. A grid was laid out with 104 measurement points, and the PRS burial and retrieval carried out as described previously. The nitrate, phosphate and sulfate adsorbed on anion exchange probes over a two week burial were used to calculate potential nutrient supply rate differences within the field. The values were then entered into Rockware™ on an Apple Macintosh computer.

Variations in nutrient supply rate across the field revealed the expected differences related to topography and management effects. Low-lying areas of the field, where eroded soil had accumulated and organic matter and soil moisture are higher, showed the expected higher nutrient supply rates than eroded upslope areas. The influence of past management was also evident in a portion of the field revealing high nitrate and sulfate supply rates related to the fact it was previously in grass and only recently brought under cultivation.

Because it eliminates the need to collect, handle and process many soil samples while providing a unique indication of nutrient supplying power under field conditions, we believe the PRS method is a potentially valuable tool in field fertility mapping for site-specific fertility management. BC

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