ONTARIO

Delta Yield: Mapping Fertilizer Nitrogen Requirement for Crops

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Significant within-field variability of soil fertility has been well documented. In an attempt to deal with field scale variability, interest has increased in site-specific crop management systems which attempt to manage different areas within a field to their optimum. The availability of on-the-go yield monitors, variable-rate fertilizer applicators and differential global positioning systems (GPS) has given producers the technological ability to carry out a site-specific fertilizer management program. However, a critical component of site-specific N management systems is the creation of the management map which indicates how to alter the rate of fertilizer applied at different locations within the field. The task is to determine what information is required to create these management maps.

Predicting the most profitable amount of nitrogen (N) to apply at any given location in a field is the key component to a site-specific N management system. We describe a novel approach developed to obtain this information and the current testing of this approach in a large, provincial on-farm demonstration project.

Are yield maps providing adequate information?

In recent years there has been a tremendous increase in the area of land for which geo-referenced crop yields have been collected. For the most part, the information collected displays yield variations within a field for which a constant management practice or crop input has been applied. Is this information useful for making management decisions, such as the most economic rate of fertilizer N (MERN) to apply to a given area in a field?

Information collected from over 300 fertilizer N response field trials with corn, conducted in southern Ontario during the period of 1962 to 1992, indicated that yield responses to fertilizer N application followed a quadratic relationship (Yield = A + BN - CN^2, where N was the amount of fertilizer N applied and A, B and C are regression coefficients). From these data sets it was observed that maximum yield and economic yield were highly correlated to each other (r>0.94). However, correlations with MERN indicated that only 0.7 to 10.3 percent and 0.1 to 15.0 percent of the variability in MERN was accounted for by maximum yield and economic yield, respectively. There was no significant relationship between the actual yield measured and the N required for an economic response.

Therefore, collection of yield data based on a single application rate does not give enough information for the producer to make a management decision in terms of variable fertilizer application. On-the-go

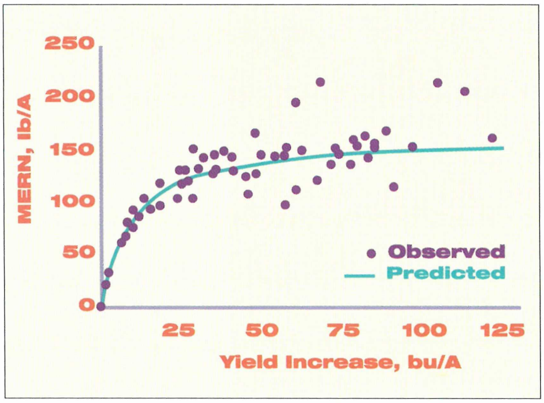

FIGURE 1. Relationship of maximum economic yield increase (ΔYield) and maximum economic N rate (MERN) for corn in southwestern Ontario. Data from side-dress fertilizer response trials conducted from 1962-1992.

yield monitor data will be of little utility in creating management maps to predict fertilizer application rates without a yield index that relates strongly to most economic fertilizer rates.

Delta Yield (ΔYield): An Index for Predicting MERN

In the context of evaluating the yield response of a crop to the application of N fertilizer, the delta yield (ΔYield) can be thought of as the increase in yield brought about by the application of N fertilizer (i.e. ΔYield = Yield with fertilizer applied - Yield without fertilizer applied). In the aforementioned Ontario studies, each field site included a zero N check treatment, and therefore a ΔYield based on either the difference between the maximum yield and the check (ΔYield-max) or the difference between economic yield and the check (ΔYield-econ) can be calculated. Correlations of MERN indicated that 50 to 77 percent and 50 to 75 percent of the variability of MERN can be accounted for by changes in ΔYield-max and ΔYield-econ, respectively. Thus, ΔYield-max and ΔYield-econ could be reasonable predictive indexes of the MERN.

Further examination of the Ontario data also indicated that the B and C coefficients in the regression equation were highly correlated to one another. The significance of this relationship (which holds across two historic data sets and three geographic locations in Ontario) is that with the ΔYield, we need only two rates of N fertilization to predict MERN where typically three or more are required.

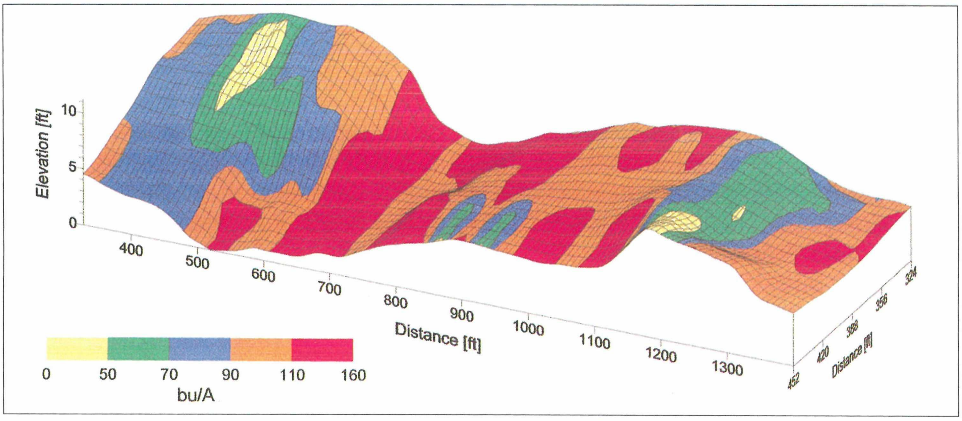

FIGURE 2. Topography and spatial distribution of yield within a 4-acre portion of a corn field fertilized at 135 lb/A of N. (Londesboro, Ontario)

Figure 1 shows the relationship between ΔYield-econ and observed or predicted (from ΔYield) MERN for sidedress N application in southwestern Ontario during 1962-1992.

Use of ΔYield in Site-Specific N Management

The usefulness of the ΔYield index in a site-specific N management system will depend on how well it can predict the spatial patterns of MERN within fields. In an initial field trial, two corn fields were divided into strips 20 ft. wide which ran the complete length of the field and received either 0 or 135 lb/A of N. Yields were estimated by both hand harvesting and combine harvesting with a yield monitor.

Landscape position had a fairly strong influence on crop yields (**Figures 2 and 3**) and on ΔYield (**Figure 4**). Note that in this field, non-responsive areas (low ΔYields) occurred both along knolls and in depressional areas, which respectively represent the lowest and highest yielding sections of the field. This further demonstrates the inability of an absolute yield map to predict the MERN. Approximately 20 percent of the field showed no response to applied fertilizer N. The most profitable response to applied fertilizer N occurred in the backslope positions. Based on the relationship given in **Figure 1** and the ΔYield map in **Figure 4**, a fertilizer recommendation map can be generated for the whole field.

Current Research

We are working on a method which may allow the producer to utilize the ΔYield approach with a minimal amount of yield loss due to the inclusion of zero N strips in the field. Ideally, one would like to be able to relate a ΔYield value to other factors which can be easily measured over the whole field. A large five-year province-wide study is underway in which 25 farm co-operators, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) personnel and researchers at the University of Guelph are developing relationships between measurable landscape and soil attributes and ΔYield. Landscape attributes will include information derived from a digital elevation model based on data collected using high-resolution (sub-inch precision) GPS. Soil attributes will include remote sensing data.

At each site, three field-length check strips (zero fertilizer N applied) are oriented

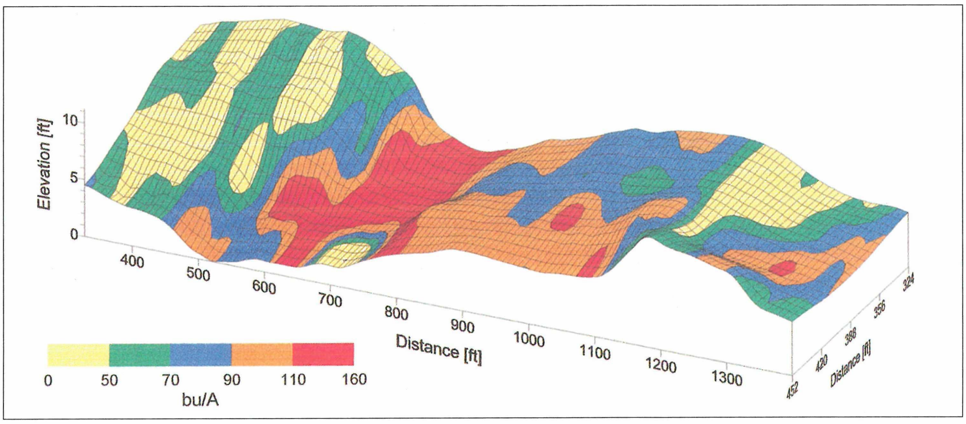

FIGURE 3. Topography and spatial distribution of yield within a 4-acre portion of a corn field fertilized at 0 lb/A of N. (Londesboro, Ontario)

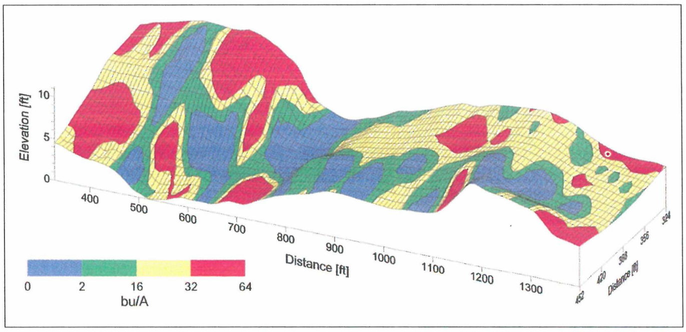

FIGURE 4. Topography and spatial distribution of ΔYield within a 4-acre portion of a corn field. (Londesboro, Ontario)

to capture the variability in topography. On-the-go yield monitors with GPS generate yield maps of both check strips and areas fertilized to current recommended levels, from which ΔYield maps are derived. Relationships among landscape/soil attributes and ΔYield maps will be used to develop site-specific management maps for fertilizer N.

The next step in the project is to evaluate the management maps by comparing yields from strips receiving variably applied N fertilizer based on the management map to yields from strips fertilized at a constant recommended rate. Economic analysis of the two systems will be conducted to evaluate the potential savings and net cost/benefit associated with the variable rate system. At selected sites, more detailed studies will be conducted to examine cumulative long-term effects of site-specific N management on soil fertility, movement of fertilizer into the groundwater, and crop N uptake. BC

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Aerial Photography...

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how much bare soil is exposed. The more soil that is removed (i.e. deeper), the wetter the soil and the darker the color. Row-to-row variation can be substantial depending on uniformity of the ridge forming process the previous year and ridge modification caused by harvesting equipment.

By waiting until after the first rain, the soil water content has a chance to stabilize and then be rather uniformly re-wetted. When soil is saturated, color differences are not as great as after a little drying.

Overall, we can use aerial photographs to help identify areas of a field that are likely to vary in certain soil properties. Caution should be employed to ensure that past management of the field or other factors have not negated the intended relationship. But if these relationships exist in other fields, it has the potential to provide a high resolution information layer at a potentially affordable price. BC

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