ALBERTA

High Soil Variability Leads to Under-Fertilization

By Doug Penney, Tom Goddard and Terry L. Roberts

Fertilizer recommendations have been developed using small plot experiments. The resulting soil test calibrations are used in conjunction with average soil test values from fields assumed to be uniform. However, yield monitors are revealing that large variations in crop yields are common, and intensive soil sampling is showing that soil tests values in fields are highly variable. These natural variations in yield and nutrient levels provide the basis for variable rate application technology. They also are causing us to re-think some of the underlying principles upon which constant rate fertilizer recommendations are made.

> Crop yield and soil test levels are two of the main factors used to predict fertilizer requirements. Yield potential or yield goal determines nutrient levels the crop needs. The soil test and an established relationship between crop response and fertilization determine how much fertilizer to apply. Other soil characteristics or climatic factors can be used to further refine the fertilizer recommendation.

Alberta Studies

Site-specific technology using a differential global positioning system (DGPS) was used to map grain yield, terrain, fertility and salinity at several locations in Alberta. The fields were distributed across diverse soils on undulating to rolling topography from central to southern Alberta. Soil nutrients were mapped using a 220 ft. x 220 ft. sampling grid.

Grid sampling showed soil nutrient levels were spatially variable, regionalized and positively skewed. When nutrient concentrations in a field are positively skewed, the mean value obtained from a composite sample over estimates the nutrient content of the majority of the field. **Figure 1** shows typical results for soil nitrate-N (NO_3-N) for an irrigated field in southern Alberta. Values ranged from 6 to 541 parts per million (ppm). The mean (42 ppm) was twice as high as the mode (20 ppm). The mode is the value, or class, that occurs most frequently in the field. In this field, areas of high NO_3-N were usually associated with high salinity and low yields.

Figure 2 shows the frequency distribution for soil test potassium (K) for a field in central Alberta. Potassium levels were variable with values ranging from 59 to 310 ppm. The mean was 135 ppm K and was 27 ppm higher than the mode. Approximately 37 percent of the gird areas sampled tested greater than 143 ppm K, and would not require K fertilization according to Alberta recommendations. Yet, 30 percent of the area was less than 101 ppm and would require K fertilization and 33 percent was between 101 and 143 ppm and may need supplemental K.

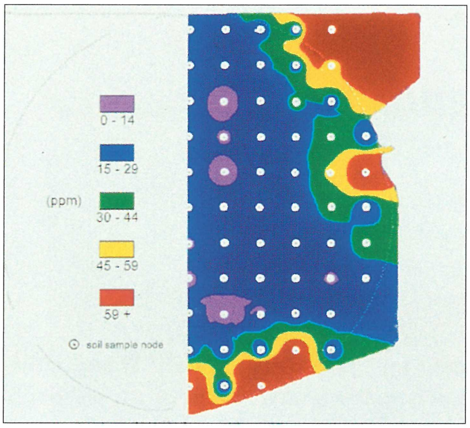

Figure 1. Spatial distribution of nitrate-N from a 220 ft. x 220 ft. sample grid irrigated field in southern Alberta (fall 1994).

Other sites in Alberta have shown similar trends of high variability and positively skewed data. **Table 1** summarizes K results from the four Alberta sites studied. In all cases, mean soil K values were substantially higher than mode values, indicating the true K status of the fields would be over-estimated by composite sampling. This same trend was observed for soil test nitrogen (N), phosphorus (P) and sulfur (S). Of the 42 data sets generated so far, the mean value has been greater than mode in all cases, except for three data sets for soil test P.

If the frequency distribution of soil test values in a field were normal, or unbiased, the mean and the mode would be equal, and both would represent the most frequent occurrence of that value in the field. However, when the mean is greater than the mode, a fertilizer recommendation based on an average value will underestimate the fertilizer required.

Positive skewness results in a systematic error when composite samples of fields are used for soil test recommendations. Small-plot experiments used for soil test calibration are usually carried out on uniform areas within the same landscape unit. The variation in soil test levels within small-plot experimental areas is unlikely to have the positive skewness shown to occur frequently in large fields. This means soil tests calibrated using small-plot trials often under estimate the optimum fertilizer rate for larger fields when the recommendations are based on composite samples of the fields. This helps explain why some fields testing high in available K, or other nutrients, still respond to fertilization.

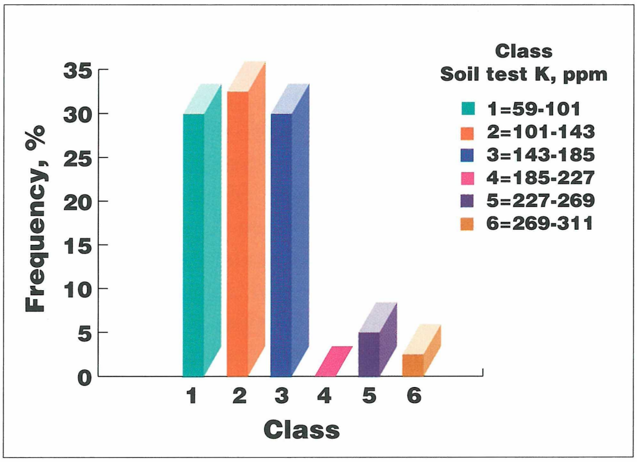

Figure 2. Frequency distribution of soil test K for a central Alberta site (fall 1993).

Summary

Spatial variability and the frequency distribution of soil nutrients have important implications for constant rate fertilizer application. Results from our work, and others, demonstrate that nutrient levels in fields are often highly variable and positively skewed. Small areas of fields with high soil test values increase the overall field average. This distorts the true fertility status of a field and can result in much of the field being under-fertilized.

Identifying the variability that occurs in fields through grid sampling and mapping specific management units are key elements of site-specific management and variable rate fertilizer application. Avoiding over fertilization in areas of high nutrient content will become an increasingly important benefit of variable rate technology. Recognition of the variability and the inherent systematic error associated with composite sampling will also allow us to better refine fertilizer recommendations for use with constant rate fertilization. BC

Mr. Penney and Mr. Goddard are Soil Specialists with Alberta Agriculture, Food and Rural Development, Edmonton. Dr. Roberts is PPI Western Canada Director, Saskatoon, Saskatchewan.

TABLE 1. Statistical characteristics of soil test K (ppm) from a 220 x 220 ft. sampling grid for Alberta sites.

Site	Year	Sample no.	Min.	Max.	Mean	Mode
1	1993	60	175	613	326	208
	1994	58	220	880	425	371
2	1993	59	162	604	323	260
	1994	60	165	839	410	247
3	1993	58	119	618	293	159
	1994	55	127	598	276	155
	1995	53	112	499	265	183
4	1993	40	59	310	135	108
	1994	40	84	418	177	137
	1995	40	69	414	162	129