COMPARISON OF NITROGEN MANAGEMENT ZONE DELINEATION METHODS

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Introduction

An alternative to dense grid soil sampling for delineating residual soil N levels or N availability is a zone sampling approach. The zone approach assumes that soil N patterns are logically linked to some inherent causal effect, either natural or man-made. A number of delineation methods have been examined, including apparent soil EC (Kitchen et al., 1999), yield mapping (Taylor and Whitney, 2001; Diker et al., 2002), topography (Franzen et al., 1998), aerial imagery (Williams et al., 2002; Sripada et al., 2002), satellite imagery (Shanahan et al., 2000), use of soil survey (Franzen et al., 2001), organic matter (Fleming and Buchleiter, 2002) and grain protein (Long et al., 1998).

In the Northern Plains, some of these methods have been tested individually, but have not been generally compared as others have begun to do (Whelan et al., 2002; Kitchen et al., 2002; Chang et al., 2002). The purpose of this study was to compare several methods of N management zone delineation against relatively densely soil sampled grid points to determine whether one method is superior to others, or whether a combination of methods would better delineate soil N patterns in a North Dakota field.

Methods

The square, forty-acre field used in this study is located three miles southeast of Valley City, North Dakota and has been sampled and examined since 1994. The rotation is spring wheat, barley and sunflowers, although the sequence of the rotation varies depending on the year and cooperator preference. The field is sampled for residual nitrate in the fall to a depth of 4 feet, with increments of 0-2 feet and 2-4 feet. Only the 0-2 feet depth will be examined in this paper, since it is this depth that defines N recommendations to the subsequent crop. Soil samples are taken in a systematic 110 feet grid pattern, with grid points consisting of three 0-2 feet cores combined, dried and ground together to make the composite sample. Data from 2001 and 2002 were used to make the comparisons between zone delineation methods and soil nitrate sampling data. The 2001 crop was barley and the 2002 crop was spring wheat.

Topography was determined by using elevation readings from similar grid points as for soil sampling, using a laser emitting source and light sensing survey pole. Apparent soil EC measurements were collected using a Veris® electrical conductivity (EC) sensor, driving through the field in passes approximately 50 feet apart. Aerial photography was conducted while the crop was in the vegetative stage of growth just prior to flowering or heading. The airplane flew at about 5,000 feet in altitude and took the photos nadir using Ektochrome color film. Satellite imagery was received for the wheat crop prior to heading.

An Order-1 soil survey was conducted by a certified soil survey person and member of the NDSU Department of Soil Science. Yield mapping was accomplished with a John Deere Greenstar® system operated by the field cooperator.

Topography, aerial photography, satellite imagery, EC and yield were sorted into five classifications. Topography was based on IDRISI's terrain analysis using five landscape features and the other data sorting was based mathematically on frequency quintals.

The five zones produced from each method were given an average nitrate value based on eight random interior sampled nitrate values within each zone, if that many values were available. If the zone was too small to include eight sample grids, as many as were available were averaged to give the zone a value. The zone nitrate map thus produced was divided into 144 square grids represented by the 144 nitrate sampling points and regression was conducted between the estimated nitrate levels within the zone map compared with the original point sampled grid nitrate data.

Multiple combinations of data were compared first by normalizing the data, then by assigning a weight to each data layer based on the correlation of the individual data layer with nitrate. At each grid point, the normalized, weighted value of the one layer is multiplied by the other normalized, weighted layer or layers of data to create a new zone map. The average nitrate values within each of the five zones produced were determined as explained above and regression analysis was conducted against the point sampled nitrate data set.

Results

All comparisons of zone delineation methods were significantly correlated with the base nitrate sampling grid at the 5% probability level or less. Methods with r values less than 0.3 were 2001 EC, 2002, EC, 2001 Order 1 soil survey and 2002 Aerial photograph (Table 1). The 2002 aerial photograph may have been lower than 2001 because the photograph taken was an infrared digital photograph, compared to the Ektochrome color photograph taken in 2001. A problem with the EC information is in this field, low EC values are common in both low nitrate areas and areas with apparent lateral water flow over a sloping argillic horizon, which results in an area lower in total salts, but higher in nitrate. Higher r values were obtained with topography, yield, 2001 Order 1 soil survey, 2001 aerial photography and satellite imagery in both years.

Consistency of correlation between years would probably be important for any delineation method, since most commercial applications would not have as robust a data set to compare and evaluate their zone strategy choice. Topography, yield and satellite image had the most consistent r values in a higher range than other comparisons between years. The r value of EC comparisons across years was consistent, but with a lower r value than other methods.

Although additional comparisons will emerge from these data sets, Table 2 shows comparisons of topography and EC, topography, EC and satellite image, topography, EC and yield, and topography, yield and satellite imagery. A combination of topography, yield and satellite imagery had the highest correlation values compared to other combinations. although all combinations were consistent between years and generally had higher values than their individual parts. Although one might expect EC to pull the correlations down compared to the better individual correlation of topography, yield and satellite image, it did not. Generally r values were somewhat higher with combinations of zone delineation methods than topography alone. Perhaps one of the reasons that a combination of topography with EC did not hurt the correlation was that EC received about half the weight as topography and yield. Previous investigations with unweighted comparisons resulted in reduced correlations of multiple comparisons.

The exception to higher correlation using multiple comparisons appears to be using all methods, which perhaps illustrates a danger in adopting a "shotgun" type of approach to delineation methods.

Table 1. Correlation of zone delineation method with base nitrate results from a 110 ft. systematic grid sampling, Valley City, ND, 2001 and 2002.

Comparison – Method vs nitrate sampling data	Correlation (r)
2001 topography	0.39
2002 topography	0.41
2001 yield	0.47
2002 yield	0.36
2001 EC	0.28
2002 EC	0.24
2001 Order 1 survey	0.24
2002 Order 1 survey	0.46
2001 Satellite image	0.41
2002 Satellite image	0.35
2001 Aerial photo	0.38
2002 Aerial photo	0.16

Table 2. Comparison of zone delineation method combination on correlation with sampling base nitrate data, Valley City, ND, 2001 and 2002.

Comparison	Correlation (r)
2001 Topography + EC	0.44
2002 Topography + EC	0.39
2001 Topo + EC + Satellite	0.49
2002 Topo + EC + Satellite	0.45
2001 Topo + EC + Yield	0.49
2002 Topo + EC + Yield	0.46
2001 Topo + Yield + Satellite	0.52
2002 Topo + Yield + Satellite	0.48
2001 All methods	0.54
2002 All methods	0.37

Summary

Six nitrogen zone delineation methods, topography, yield, Order 1 soil survey, aerial photography, satellite imagery and apparent soil EC, were compared with a sampling base of soil nitrate. Zones for each delineation method were produced using a classified data approach. All methods were significantly correlated with the base nitrate patterns. The highest, most consistent correlations were achieved with topography, satellite imagery and yield mapping. Preliminary combinations of methods using weights based on relative correlation of each method individually resulted in generally higher correlations than any method used alone. However, use of all methods together did not provide the highest correlation. Work will continue to evaluate combinations of delineation methods, and to make the classified, weighted algorithm available to others.

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