SITE- SPECIFIC RESEARCH IN NORTH DAKOTA

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ABSTRACT

Site-specific fertilizer application is currently being practiced in the Red River Valley of North Dakota/Minnesota. A study has been initiated to determine sampling practices suitable for North Dakota producers using site-specific farming both within and west of the valley. Two forty acre fields were sampled in 1994 in a 110 ft. grid, separating each sample into 0-6" and 6-24" subsamples. Smaller grid sizes were also obtained at 10 and 2 ft. grid distances in selected areas of each field. Nitrates, sulfate, chloride, zinc, P,K and pH were analyzed on the 110 ft. samples. All nutrients were spacially variable, with sulfate having the greatest range in values. Relationships were detected between the surface layer and subsurface nitrate within each field. Further investigation of 249 grid sampled fields in an eastern North Dakota data base found that correlation was high between surface and subsurface nitrate levels in the data base. Research is continuing and expanding in order to determine the soil sampling methods needed to determine site- specific fertilizer recommendations in different areas of the state.

INTRODUCTION

From the fall of 1993 to 1995, the number of variable-rate applicators in the Red River Valley of North Dakota/Minnesota has climbed from 0 to over 15 units. The driving force behind the rapid increase in grid sampling and variable-rate application has been the sugarbeet industry. Research from Crookston, MN has shown benefits of over $70/acre between using site-specific nitrogen fertilization and single rate fertilization. Commercial grid soil sampling is currently performed on about a 4 acre grid, with 6-8 cores representing each sample. Each soil core is extracted from either a 2 ft. or 4 ft. depth depending on the crop. The grid density being used was determined as only a first guess concerning the actual field variability, but it is a leap from the generally recommended method of 20 random cores composited to represent an entire field. North Dakota has little experience in grid sampling and very little data concerning field variability. A previous study has shown that variable rate application based on a dense grid increased small grain yields, but was not more profitable than single-rate fertilizer application practices. This study was initiated to provide producers across the state with information regarding field variability. It was also designed to determine what sampling density is needed, whether grid sampling is appropriate, or whether landscape would be a better indicator of fertility differences.

METHODS

Two forty acre fields were sampled in a 110 ft. grid. The first field is located near Gardner, ND in a heavy, relatively level valley soil. The second field is located about 3 miles southeast of Valley City, ND in a more rolling field with variable landscapes and soil textural differences typical of the soils of the central till plain of North Dakota. Each

sample was divided into 0-6 in. and 6-24 in. depths. The two depths were analyzed for nitrate-N, chloride (Cl) and sulfate-S. Olsen Phosphorus (P), potassium (K), zinc (Zn) and soil pH were analyzed on the surface 0-6 in. cores. Within each field, a subgrid was taken in a 60 ft. square area at 10 ft. intervals to 24 in. in depth. Nitrate-N and P was analyzed on each subgrid sample. Within each subgrid, an 8 ft. area was sampled at 0-6 in. and analyzed for P.

Locations were identified in the 110 ft. grid that would correspond to locations representing a 220 ft, 330 ft, and 5 acre grid pattern. Less dense grid location values were used to generate maps using inverse distance squared estimates between the sampled locations. Maps were made using Surfer (Golden Software Co., Golden, CO. 1993-4).

The grid evaluation procedure includes a comparison of membership of nitrate-N estimates from less dense grids in the same soil test category as the measured values from the 110 ft. sampling. In this procedure, the variability of values from the field and from the subgrids were considered before determining the category ranges for each field. At Gardner, the soil test categories were nitrate-N levels 20 lb/a apart (i.e. 0-20, 20-40, 40-60), and at Valley City, the categories were 30 lbs/a apart (i.e. 0-30, 30-60, 60-90). Nitrate levels higher than 120 lb/a were all considered in the same high category. From each less dense grid map, the estimate of nitrate-N at the location of each 110 ft. grid sampling was compared to the measured value in the dense grid. For example, at a location at Gardner a measured value was 20 lb/a nitrate-N. The estimate at that point was 15 lb/a nitrate-N. At that location, the estimate of 15 lb/a was between 0-20 lb/a, so the estimate was within the soil test category as the measured value. An estimate of 35 lb/a at the same location would not be in the same category. Measured values from the original data set that represented the locations of a less dense grid measured point were not considered in any correlation or membership procedure because of autocorrelation concerns.

RESULTS

The Gardner field, despite the uniform topography, ranged in nitrate-N levels from 4 lb/a in the top 2 ft. to 123 lb/a in the top 2 ft.(Figure 1). Variability within distances less than 60 ft., however, were much less. Most samples within the 10 ft. subgrids were between 10 lb/a nitrate-N of the average level (Figure 2). P levels within the 2 ft. grid showed no streaking due to a history of starter P applications (Figure 3). The level of variability in the subgrids at Gardner and Valley City suggest that 3-5 cores would be sufficient to represent a sample location, as compared to the 6-8 cores presently being used.

Figure 1. Nitrate-N levels at Gardner, ND, 110 ft. grid.

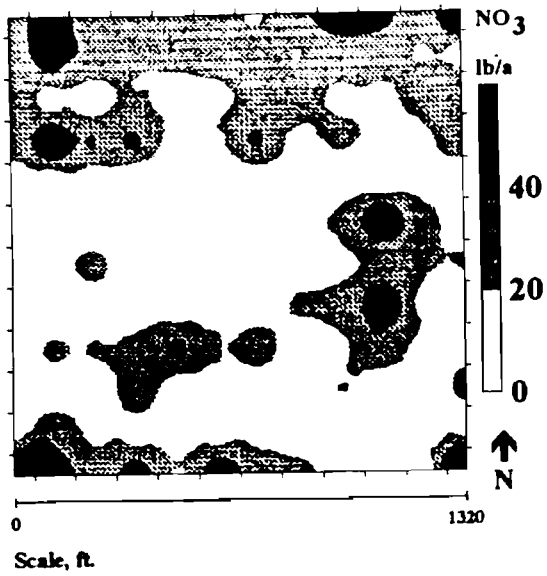


Figure 2. Gardner nitrate-N levels, 10 ft. grid.

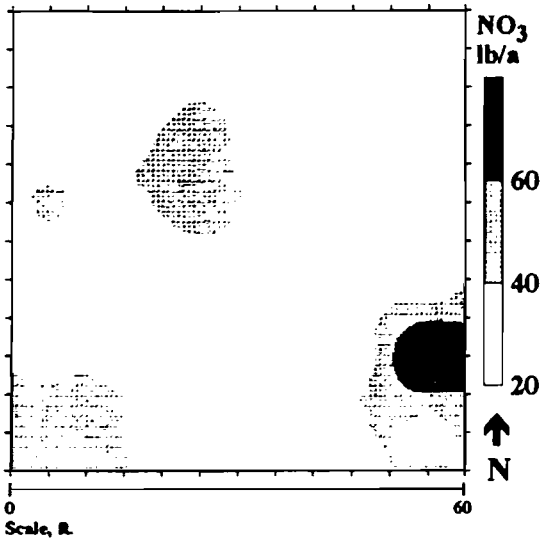
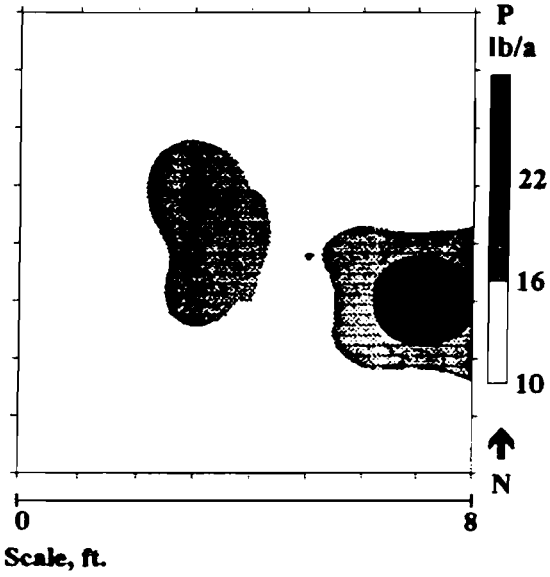


Figure 3. Valley City P levels, 2 ft. grid.



The Valley City field was more variable than the Gardner field in all of the soil nutrient levels. Nitrate-N to 2 ft. varied from 4 to 554 lb/a. Variability at the 10 ft. and 2 ft. grids was much lower than field scale variability, suggesting that 3-5 cores would be sufficient to represent a sample location. Sulfate-S levels ranges from 4-564 lb/a 2 ft. (Figure 4). The 110 ft. grid was compared to different grid patterns of 220 ft., 330 ft., and a 5 acre grid (Figure 5). As the density of sampling decreased, the location of relatively high and low nitrate-N boundaries determined from the 110 ft. grid map changed and fewer fertility features were kept at lower density sampling. At the 5 acre grid, little definition remained compared to the original nitrate-N mapping of Valley City.

Figure 4. Sulfate-S levels, Valley City, 110 ft. grid.

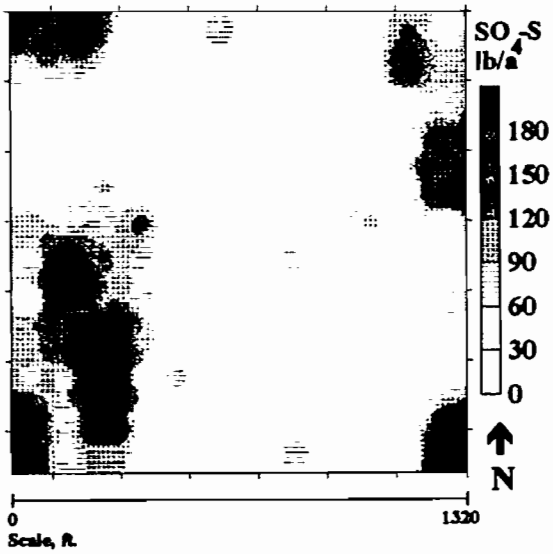
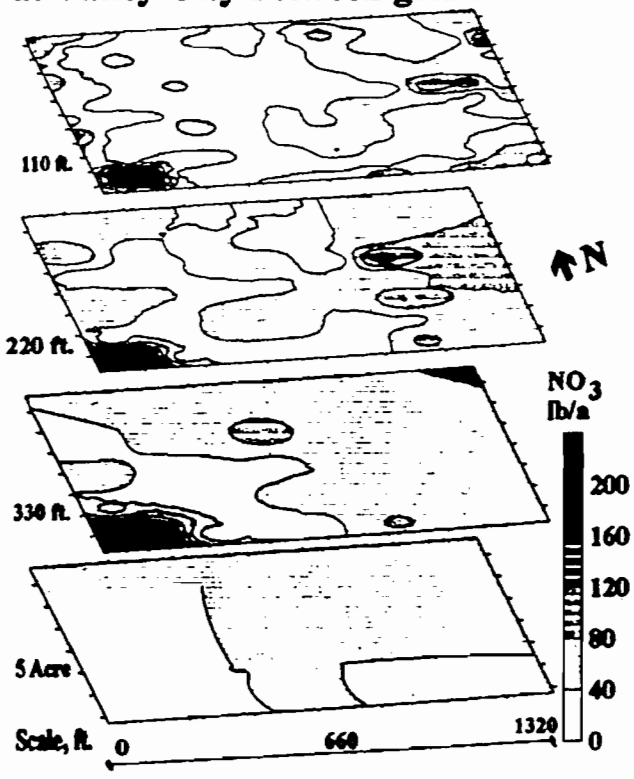


Figure 5. Comparison of nitrate-N at Valley City between grid sizes.



Correlations were made between each sampled 110 ft. location compared to the estimate made with each of the less dense grids (Table 1). Correlations of nitrate-N levels at Valley City were generally very low. Correlations at Gardner were higher, with the 5 acre Gardner grid nearly equivalent to the 220 ft. grid at Valley City.

Table 1. Correlation of 0-24 inch nitrate-N in a 110 ft. grid with estimates from less dense grid patterns.

Grid size	r	
	Valley City	Gardner
220 ft.	0.175	0.513
330 ft.	0.065	0.351
5 acre	0.073	0.158

Membership in the same soil test category is shown in Table 2. As the density decreased, so did the membership in the same soil test category. At Valley City, there was not a difference between the 330 ft. and 5 acre grid, however, all grid sizes contained greater membership than the mean. At Gardner, all grid sizes were higher in membership than the mean, but the mean value was in the same soil test category as over half the sample location values.

Table 2. Membership in the same soil test category of estimates of sampling grids compared to category described by 110 ft. grid.

Grid size	% of mapping in the same category	
(ft.)	Valley City	Gardner
110	100.0	100.0
220	72.9	77.1
330	55.6	61.8
5 acre	57.6	56.9
Mean	34.0	50.7

An observation during the study was the similarity of features from surface nitrate-N levels compared to deep cores (Figure 6). Correlation was done at Gardner to determine the relationship of nitrate-N with depth.

The high correlation obtained prompted a search into grid sampling data from work by Dahnke at three locations from 1987-1991. Grid samples taken during these studies were separated by depth, but the depth values had not been previously correlated. Correlation of surface to whole core nitrate-N is shown in Table 3.

Figure 6. Nitrate-N levels Gardner, surface compared to whole core depth.

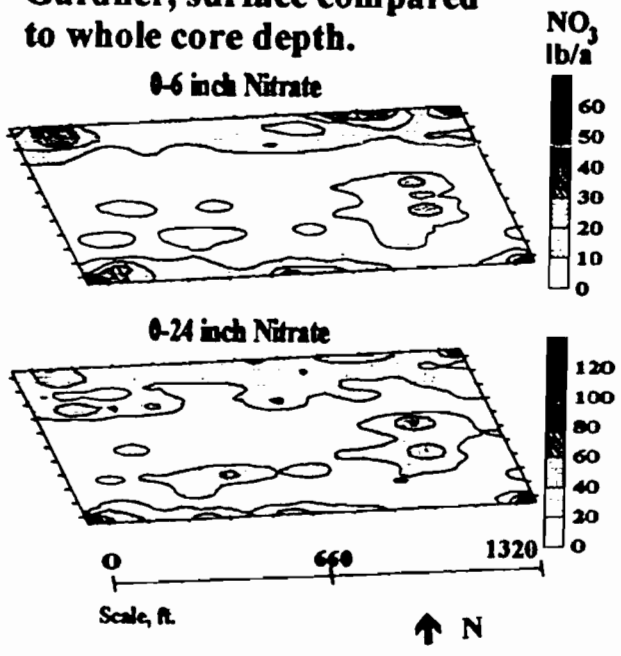


Table 3. Correlation of surface nitrate levels in NDSU research grid fields with deep nitrate.

Location	Comparison	r
Gardner 1994	0-6" w/0-24"	0.858
	0-6" w/ 0-48"	0.755
Oriska 1990	0-6" w/ 0-24"	0.579
	0-6" w/ 0-48"	0.973
Buffalo 1991	0-6" w/ 0-24"	0.701
Marion 1987	0-6" w/ 0-24"	0.785

Table 4. Correlation of surface nitrate levels in 249 fields analyzed by Agvise Laboratory, Northwood, ND, 1994.

Comparison	n	r
0-6" w/ 0-24"	249	0.737
0-6" w/ 0-48"	80	0.608
0-24" w/ 0-48"	80	0.899

A database of 249 grid sampled fields from eastern North Dakota/western Minnesota was obtained from Agvise Laboratories of Northwood, ND and surface to whole core correlation was calculated within each individual field (Table 4). The correlations show that there is a high level of correlation between surface values and whole core values of nitrate-N in these fields.

SUMMARY

A study was initiated to determine the sampling density needed to direct variable-rate fertilizer application in North Dakota. The current practice of sampling in a 4 acre grid is probably justifiable in the valley for the present until more information is obtained concerning field variability between years and locations. A 4 acre grid would not be as descriptive of a field west of the valley in more variable landscapes. Denser grids may be impractical using the present methods of 6-8 cores per sample and sampling from 2 to 4 ft. in depth. However, research suggests that variability in a small sampling area is much less than whole field variability. Samplers may be able to take 3-5 cores per sample, reducing sampling cost with little effect on sample values. Another possible cost reduction may be possible if future research indicates a consistent relationship between surface and subsurface nitrate levels as was found this year. A composite sample of 8-12 cores separated by depth would give a field ratio of surface to whole core nitrate. The field would be sampled in a grid of surface samples and the ratio would be applied to all sample results to give a map of total nitrate. If future research verifies a consistent relationship between surface and deeper nitrate, sampling costs would be reduced, allowing denser grids to be more practical than present. The effect of landscape position and soil productivity on soil fertility and crop yield has been cited in some studies and will be investigated in the future in North Dakota.

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