GRID SAMPLING OR TOPOGRAPHY SAMPLING FOR SOIL NUTRIENTS

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ABSTRACT

Site-specific application of fertilizers uses field soil sampling for its information basis. Many fields are currently sampled using a grid approach. In North Dakota, examination of grid sampling showed nitrate-N to follow topographic patterns in a field, allowing the possibility of less intensive sampling for N. Reviewing previous grid sampling work in Illinois, some soil properties may be associated with landscape features, including nitrate-N in the surface 6 inches and soil pH. However, Illinois soil pH relationships with topography were weakened when lime applications were made. P and K were more related to grid sampling than to topography in Illinois and North Dakota. P was more related to topography in North Dakota in fields with a history of low P application. Chloride was more related to landscape when soil levels were low. In fields with relatively high levels, grid sampling was better correlated. This suggests that in areas with substantial fertilization of non-mobile nutrients, grid sampling may be the preferred initial choice of sampling methods. In fields with a history of low fertilizer rates and with mobile nutrients, topography may be more appropriate in directing variable-rate fertilization.

INTRODUCTION

Grid sampling is often used to represent soil fertility variability in fields prior to variable-rate fertilizer application. Franzen and Peck (1993) rejected topography sampling when compared to grid sampling for P and K. Grid sample spacing of about one sample per acre has been proposed as a basis variable-rate application by Wollenhaupt, et al. (1994) and Franzen and Peck (1995).

However, recently, Franzen, et al. (1996) reported that work in North Dakota suggested that topography was more descriptive of soil nitrate-N patterns than a one sample per acre grid. Topography sampling for nitrate-N also reflected field levels better in a field investigated by Hollands, 1996. Previous research of Carr, et al., (1991) and Fiez, et al. (1994) also supports using landscape as a sampling tool. Should both grid and topographic sampling approaches be used, and if so, when may one be more appropriate than the other?

MATERIALS AND METHODS

The Illinois sites are two forty-acre fields that have been described in detail by Peck (1992). The Mansfield site has been sampled periodically in an 82.5 ft. grid since 1961. The Thomasboro site has been sampled in the same grid since 1982. Lime was applied to parts of the Mansfield site within the sampling period, but none from 1986 until 1993. Topographic relationships are based on soil series maps in Figure 1. In 1992, the fields were also sampled in a 220 ft. grid, as well as the 82.5 ft. grid.

The North Dakota sites are located near Gardner, Colfax, Valley City and Mandan. The Gardner site is 40 acres in a relatively level, Red River Valley field of heavy texture. The Colfax site is a 40 acres in a more sandy area of the valley with subtly rolling topography. The Valley City site is 40 acres of rolling landscape with surface textures varying from clay loam to sandy loam. The Mandan site is an 80 acre field with rolling topography typical of many areas of dryland farming in western North Dakota. Topography of each site was determined using a laser leveler survey device and a GPS receiver for elevation and positional information, except the Colfax site, where topography is suggested by organic matter content of the surface samples.

At Valley City, Gardner and Colfax, samples were obtained from soil cores taken in a grid 110 ft. apart and separated into a 0-6 inch depth, and a 6-24 inch depth. At Mandan, the field is divided into an east field, center field and west field. The east field was sampled in a 110 ft. grid, and the other two fields were sampled in a 150 ft. grid. Nitrate-N and chloride was analyzed on the 0-6 inch and 6-24 inch depths. P was analyzed using on the 0-6 inch core using the Olsen procedure. Sample locations were selected from the data sets based on location to represent 220 ft., 330 ft. and 5 acre grids. The 5 acre grid was 330 ft. by 660 ft. in dimension for Gardner, Valley City, Colfax, and the east field at Mandan, and 440 ft. by 450 ft. in the west and central fields at Mandan. Mapping was performed using Surfer for windows, (Golden Software Co., Golden, CO) using inverse distance squared estimates and contouring.

RESULTS AND DISCUSSION

The Illinois fields were fertilized with P and K until 1987. From 1988 through 1992, no fertilizer or limestone was applied. Table 1 shows that a 220 ft. grid was better at representing the Thomasboro field in 1992 than soil type (topographic) sampling for both P and K. Figure 2 shows that Mansfield soil pH levels in 1991 were similar to the soil type map. However, soil pH levels in 1982 (Figure 3) showed more variability within a soil type area and were probably influenced by a lime application of about 4 tons/A to the north half of the field in 1981. These data and figures suggest that in fields with a history of heavy fertilization of soil non-mobile nutrients or liming, grid sampling may better represent field variability.

Nitrate-N in the surface 0-6 inch depth at Mansfield and Thomasboro are shown in Figure 4. Nitrate-N patterns are similar to soil type patterns at each site. Some variation within the Drummer soil type at Thomasboro may also be related to drainage differences observed within that soil type. Low nitrate areas at this site tend to be located in areas where water stands periodically during high rainfall periods. This may be due to subsurface drainage tile patterns or from drainage disruption from the growth of a shelterbelt tree line running north-south about 500 ft. from the west border of the field. Although nitrate-N has not been correlated to yield in Illinois, nitrate-N

Table 1. Grid sampling and soil type comparison of P and K levels at Thomasboro, 1992.

Sampling procedure and nutrient	% of estimates ± 5 lb/A P or 15 lb/A K.	% of estimates ± 10 lb/A P or 30 lb/A K.
220 ft. grid P	36.0	77.5
soil type P	29.6	72.3
220 ft. grid K	60.5	88.5
soil type K	54.9	83.4

patterns within the two fields nonetheless illustrate that mobile nutrient levels may be related to landscape/drainage.

In North Dakota, sampling by topography at Mandan, represented by 14 sample points, was better correlated with nitrate-N levels than by 220 ft. grid sampling (Table 2). Grid sampling with 220 ft. spacing at Valley City was better correlated with nitrate-N than topography, but topography was better than 330 ft. or the 5 acre grid. Topography sampling at Valley City was based on 5 point samples. At Colfax, where topography sampling was also based on 5 point samples, grid sampling at a 220 ft. and 330 ft. spacing was better than topography sampling for nitrate-N. However, topography sampling was better than a 5 acre grid at Colfax. At Gardner, where topography sampling was based on 6 sample points, grid sampling at a 220 ft. spacing was better than topographic sampling. However, topographic sampling was better than 330 ft. and 5 A grid spacing for nitrate-N.

Although correlation of nitrate-N estimates with topography was often, but not always superior to grid sampling, the representation of fertility level variability within the fields was superior to any level of grid sampling (Figure 5). At Valley City, for example, nitrate level patterns are represented better by topography based sampling than by any grid sampling comparison.

With respect to P, 220 ft. grid sampling was equal to or better than topography sampling at all four sites. At Mandan and Gardner, topography was superior only to the 330 ft. grid. At Valley City, topography was better than only the 5 acre grid, while at Colfax, grid sampling of all spacings was better than topography.

Although topography was sometimes better than the 330 ft. and 5 acre grid, some sort of grid sampling was usually more appropriate. Because applications of P fertilizer are relatively immobile in the soil, previous application of P from fertilizers and manures may cut across soil types, increasing P variability within soil types and reducing representative patterns from

Table 2. North Dakota sites correlation (r) of nitrate-N, P and chloride with topography and grid sampling estimates of original grid sampled locations, 1995.

Nutrient	Site	Topography	220 ft. grid	330 ft. grid	5 Acre grid
Nitrate-N	Mandan	0.76	0.29*	0.44**	0.23
	Valley City	0.35	0.50	0.21	0.21
	Colfax	0.32	0.62	0.45	0.06
	Gardner	0.31	0.39	0.23	0.04
P	Mandan	0.58	0.58	0.22	0.58
	Valley City	0.33	0.75	0.68	0.09
	Colfax	0.16	0.62	0.37	0.17
	Gardner	0.40	0.44	0.34	0.56
Chloride	Mandan	0.22	0.56	0.17	0.14
	Valley City	0.33	0.04	0.13	0.04
	Colfax	0.09	0.56	0.14	0.33
	Gardner	0.20	0.13	0.26	0.07

*Mandan comparison 220-300 ft. grid. **Mandan comparison 300-450 ft. grid.

native landscape contributions.

An example of the effect of previous application is shown in Figure 6 at Colfax, where an application of zinc at some time in the past cuts across the landscape, which is suggested by soil organic matter levels. Compare the patterns of zinc in the field to patterns of nitrate-N the same year. Mapping zinc levels from the same topographic patterns as influence nitrate-N levels would portray a different pattern than that generated by grid sampling.

With respect to chloride, topography was superior to all grids at Valley City, but the 220 ft. grid was superior to topography at Mandan and Colfax. At Gardner, topography was better than the 220 ft. grid, but correlation was lower than the 330 ft. grid. All grids were superior to topography at Colfax.

SUMMARY

Sampling by topography appears to be most useful when describing fertility patterns of mobile nutrients. Topographic sampling may also be useful when levels of non-mobile nutrients are relatively low, or when fertilizer use has been low during the recent past. However, when sampling for non-mobile nutrients in cases where these nutrients have been applied in unknown or relatively high amounts, grid sampling may be a more appropriate means of gathering fertility information. If a field has a pattern revealed by grid sampling that is related to topography, then topographic sampling may help to reduce future sampling and analysis costs.

REFERENCES

Carr, P.M., G.R. Carlson, J.S. Jacobsen, G.W. Nielsen and E.O. Skogley. 1991. Farming soils, not fields:A strategy for increasing farm profitability. J.Prod. Agric. 4:57-61.

Fiez, T.E., B.C. Miller and W.L. Pan. 1994. Winter wheat yield and grain protein across varied landscape positions. Agron. J. 86:1026-1032.

Franzen, D.W. and T.R. Peck. 1993. Soil sampling for variable rate fertilization.pp. 81-90. IN:1993 Illinois Fertilizer Conference Proceedings. Jan. 25-27, 1993, Springfield, IL. R.G. Hoeft, ed. Univ. of IL. Coop. Ext. Serv., Urbana, IL.

Franzen, D.W. and T.R. Peck. 1995. Field soil sampling density for variable rate fertilization. J. Prod. Agric. 8:578-574.

Franzen, D.W., A.D. Halvorson, V.L. Hofman and L.C. Cihacek. 1996. Initial comments on site-specific management in North Dakota. pp. 115-125. IN:1996 Great Plains Soil Fertility Conference Proceedings. Denver, CO, March 5-6, 1996. J. Havlin, ed. KS St. Univ., Manhattan, KS.

Hollands, K., 1996. Relationship of nitrogen and topography. pp. 123-128. IN:1995 Sugarbeet Research and Extension Reports. Vol.26. Jan. 1996. N. Dak. St. Univ. Ext. Serv., Fargo, ND.

Peck, T.R. 1991. Spatial variability of soil pH, P and K in two Illinois fields. IN:1991 Illinois Fertilizer Conference Proceedings. Jan. 1991. R.G. Hoeft, ed. Univ. of IL. Coop. Ext. Serv., Urbana, IL.

Wollenhaupt, N.C., R.P. Wolkowski and M.K. Clayton. 1994. Mapping soil test phosphorus and potassium for variable-rate fertilizer application. J. Prod. Agric. 7:442-448.

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Figure 1. Soil series, Illinois sites Mansfield and Thomasboro.

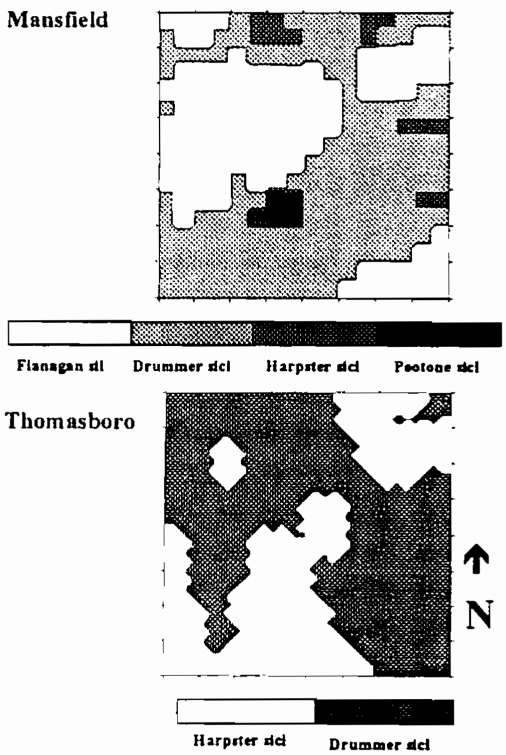


Figure 2. Mansfield pH, 1991.

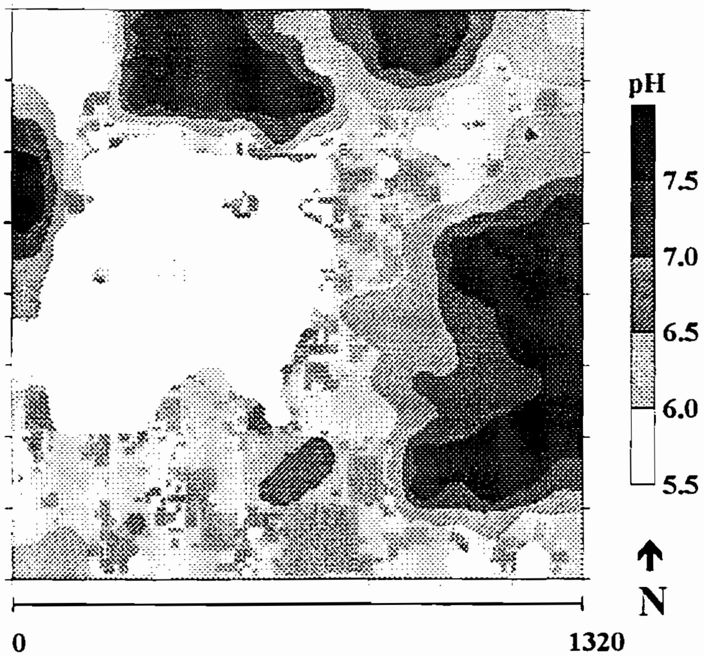


Figure 3. Mansfield pH levels, 1982, following a 4 ton/A limestone application to the north half of the field in 1981.

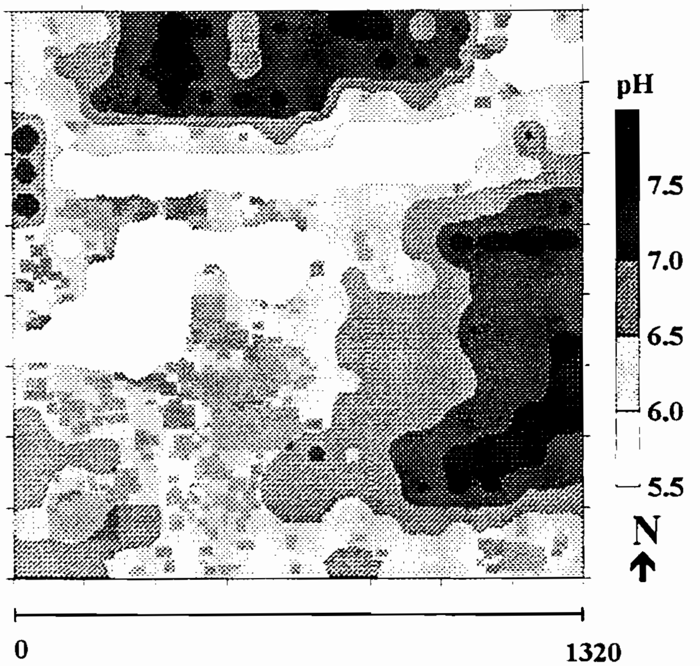


Figure 4. Soil nitrate-N levels, 0-6 inch depth, Mansfield and Thomasboro, IL, 1991.

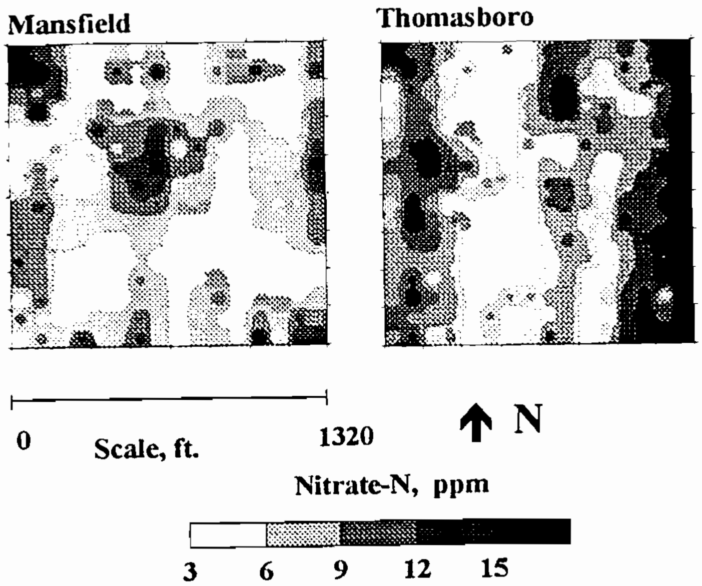


Figure 5. Comparison at Valley City, 1995 of nitrate-N mapping using topography and several grid sizes.

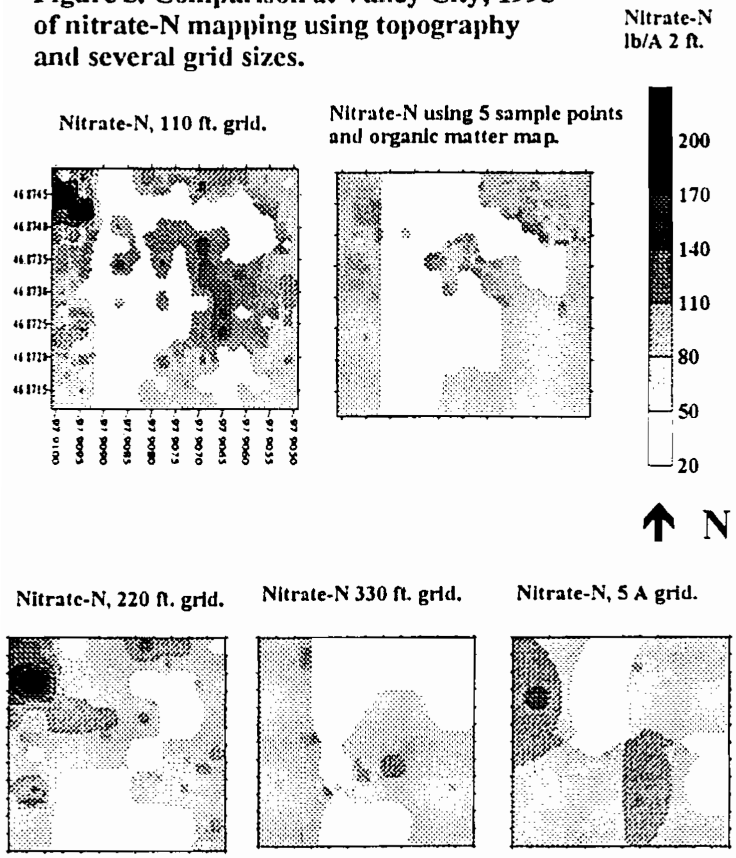
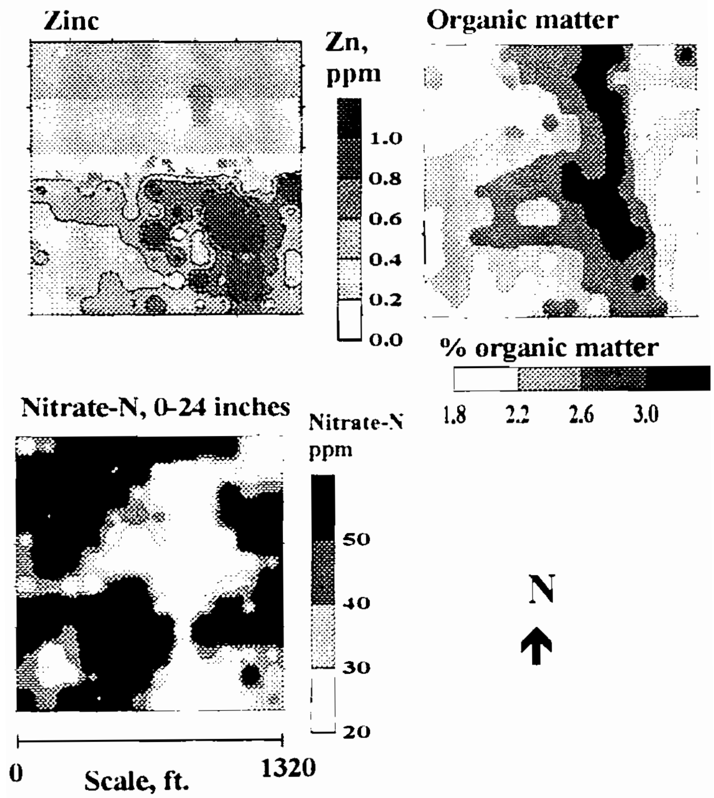


Figure 6. Colfax DTPA extracted zinc levels, 1995, compared to organic matter levels and soil nitrate-N.



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