SPATIAL VARIABILITY OF SOIL-TEST NITROGEN AND PHOSPHORUS ON TEXAS SOUTHERN HIGH PLAINS SANDYLAND SOILS

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Abstract

An irrigated site and a dryland site associated with the AG-CARES facility in Dawson Co., Texas were grid-sampled in 1990 and 1995, respectively. The irrigated site was sampled on a 2-acre grid and the dryland site was sampled on a 0.5-acre grid. Samples were analyzed for Soil-test nitrogen (N) and phosphorus (P), and were subjected to geostatistical analysis.

Soil-test N in the surface six inches was uniformly very low across both fields. Soil-test P was highly variable across both sites. In both cases, the variation was geographically related: low P was associated with a sloping area at the irrigated site, and P decreased from South to North at the dryland location. Conventional soil sampling procedures for N proved to be adequate at both sandyland sites, but conventional sampling would have led to under-fertilization with respect to P.

Background

The Texas Southern High Plains represents about 25 percent of the planted cotton in the U.S. About half of the acreage is farmed dryland, and the remainder receives varying amounts of irrigation. Most of the farms are large, and fields generally are 120 acres or more in size.

Most producers consider their fields to be uniform, but generally recognize that yields vary across the field. Most fields are sampled in order to make a single fertilizer rate application. From a soil series standpoint, many fields are uniform. Soil fertility levels can be quite variable on the small scale, a fact that can only be revealed through intensive soil sampling and geostatistical modeling.

Methods

The Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) in Dawson County, Texas was the site of the study. In 1990, the 160 acres (predominately irrigated) site was subdivided into a 9x9 grid, with each block representing 2 acres. Three one-inch diameter cores were collected from near the middle of each block and thoroughly mixed together. The entire site is mapped as Amarillo fine sandy loam, with a 0 to 3 percent slope.

A smaller dryland site was added in 1995. The site was subdivided into an irregular 0.5-acre grid pattern. Six one-inch diameter cores were collected within a 3 feet of the center point of the block. Samples were collected to a depth of three feet and composited based on depth increment. The dryland AG-CARES site is mapped as Amarillo fine sandy loam (0-3 percent slope), Portales fine sandy loam (1-3 percent slope), and Randall clay.

Soil samples were analyzed for soil-test N and P at the Texas Agricultural Extension Service Soil Testing Laboratory at Lubbock. The analytical data were subjected to an appropriate geostatistical model, and maps were developed using an inverse distance protocol (Davis, 1986; Rossi et al., 1992).

Results and Discussion

Original 1990 Study

Although the Extension Service recommends collecting 15-20 subsamples to represent a field, few producers collect that many samples. Table 1 shows calculated mean soil-test N and P levels as a function of sample number. There was very little difference for soil-test N, as 5 subsamples would have done as well as all 81 combined. The 5, 10, and 25 subsamples were relatively close for soil-test P; they resulted in high and medium ratings compared to the low rating when all 81 subsamples were averaged. Based on these results, the conventional random sample approach would lead to an under-application of P fertilizer. Although the field was uniform with respect to Soil-test N, Soil-test P was highly (see Fig. 1).

The AG-CARES irrigated site has a gently sloping area (3 percent) in the northeastern quadrant to a lake that is not on the site. The sloping area has been subjected to erosion and some topsoil has washed off, this can be seen by the very low phosphorus levels. The variation in soil-test P was divided evenly between very low, low, and medium levels (Table 2). The areas testing low and medium had no visible characteristics that might cause separation. Two “hot spots” were observed, but there is no apparent reason for their occurrence. Note that during the “random sampling” one of the “hot spots” was sampled, and this was partly responsible for the higher Soil-test P ratings.

New Site – 1995

The 1990 data were originally analyzed for spatial relationships to determine why cotton was showing no response to applied fertilizer P, when conventional soil-tests indicated a low-test level. The new dryland site was sampled on a 0.5-acre in 1995 to determine the optimal grid sample size. Soil-test N data were similar to those discussed earlier, and were uniform across the field with

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only five samples out of the total having a Soil-test rating greater than very low.

Table 3 shows the Soil-test P ratings distribution for various numbers of subsamples. With the exception of the 5-subsample group, the average P concentration and the distribution between ratings groups were reasonably close. Figure 2 shows the map of Soil-test P based on rating and a 0.5-acre grid. Similar to the 1990 data, there appears to be a geographical trend in the 1995 data. Soil-test P appears to decrease from the bottom to the top of the map. Unlike the 1990 data, there are fewer large contiguous areas of the same rating level. Clearly, the site is not uniform, with respect to Soil-test P. From the nature of the geographic distribution, it is easy to see how 10 and 25 random subsamples could do a reasonable job of predicting the overall Soil-test P level of the field.

From a research or environmental perspective, a 0.5-acre grid size or smaller can be useful; however, from an agricultural standpoint it appears to add a layer of complication and cost. A 2-3 acre grid size will probably be the most efficient for most agricultural producers. With that in mind, a simple test was constructed to evaluate the effect of a sample on the nature of the maps that could be generated. The analytical data from the 1995 study (0.5-acre grid) were grouped into 2-acre blocks. The data were analyzed such that: 1) a map was generated from the average of the individual components making up the 2-acre block, and 2) a 2-acre block map was generated where the Soil-test P level of each 2-acre block was represented by a random selection of one of the component 0.5-acre blocks.

Table 4 shows the distribution of number of acres within a Soil-test P rating level as a function of how the Soil-test P levels for the 2-acre block was determined. Note that the distributions shown in columns 2 and 3 of Table 4 are fixed, but the distribution in column 4 can change each time a different set of blocks is chosen. These data give some idea of the magnitude of the change in distribution that can occur, because of spurious data, and the care needed in sample collection and map generation.

References

Davis, J.C. 1986. Statistics and data analysis in geology, 2nd edition. John Wiley & Sons. New York.

Rossi, R.E., D.J. Mulla, A.G. Journel, and E.H. Franz. 1992. Geostatistical tools for modeling and interpreting ecological spatial dependence. Ecological Monographs 62:277-314.

Table 1. Comparison of soil-test N and P as a function of number of subsamples at AG-CARES 1990.

Samples	Soil-Test N	N Rating	Soil-Test P	P Rating
	ppm		ppm	
5 Taken at Random	2.2	Very Low	20	High
10 Taken at Random	2.3	Very Low	17	Medium
25 Taken at Random	2.6	Very Low	16	Medium
All 81	2.5	Very Low	6	Low

Table 2. Soil-test N and P distribution based on 2 acre grid sampling and geostatistical modeling at AG-CARES 1990.

Soil-Test Rating	Nitrogen	Phosphorus
	-------------- acres --------------	
Very Low	150	45
Low	6	53
Medium	4	61
High	<1	1

Table 3. Comparison of Soil-test P ratings as a function of number of subsamples collected over the field (AG-CARES 1995).

	Random Selections			
Rating	5	10	25	All
	----------------------- Number -----------------------			
V. Low	3	4	10	60
Low	2	3	4	20
Medium	0	0	5	32
High	0	3	6	28
	----------------------------- ppm --------------------------------			
Average	4	10	10	10
Rating	V. Low	Medium	Medium	Medium

Table 4. Comparison of Soil-test P distribution based on grid size and P variation within a grid block (AG-CARES 1995).

	Grid Size		
Rating	0.5-acre	2-acre[a]	2-acre[b]
	------------------- acres -------------------		
Very Low	30	12	17
Low	13	35	25
Medium	18	21	23
High	11	4	7

[a] P level averaged over 4, 0.5-acre blocks.
[b] a single P concentration randomly selected from one 0.5-acre block to represent the entire 2-acre block.

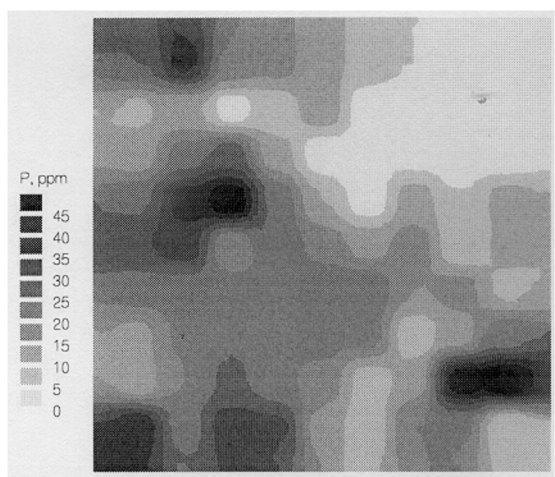

Figure 1. Map of Soil-test P distribution at AG-CARES, Dawson Co., TX, 1990 (2 acre gid).

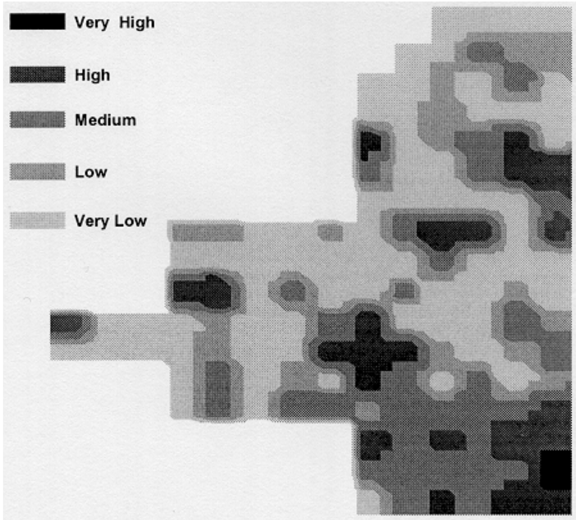

Figure 2. Map of Soil-test P ratings at AG-CARES, Dawson Co., TX, 1995, dryland site (0.5 acre grid).