Department of Agronomy

# Soil Science News & Views

Vol. 19, No. 5, 1998

## Precision Agriculture: A Field Study of Soil Test Variability And Its Effect on Accuracy of Fertilizer Recommendations

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Use of precision agriculture techniques in Kentucky during the past several years has generated interest in how to soil sample a field for use in programming computer-driven, on-the-go, variable rate fertilizer spreaders (VRS). The advantage achieved by VRS is related directly to variability of soil test (ST) values within a specific field and the accuracy of how they represent the field. Since variability of ST values commonly exists on a small scale, a very intensive sampling procedure (grids of one acre or less in size) would be required to accurately describe the nature and extent of such variability within a field. The cost of sampling and analysis on such a scale would be prohibitive to most commercial producers. For this reason, many fertilizer dealers offering VRS to customers recommend sampling on a 2.5 acre grid (330x330 ft), and use this 2.5 acre unit as the basis for VRS within a field. Use of this procedure to vary fertilizer rates within a field is based on the assumption that variability of ST values within each 2.5 acre block is less than that for the field as a whole. And further, this assumes that ST values are fairly uniform across the swath width of the spreader (about 60 ft) and along the 330 ft pathway of the spreader as it is driven through each 2.5 acre block. Both these assumptions are questionable. Wells (1) reported variation in ST phosphorus (STP) of nearly two-fold across and along 40 ft wide spreader swaths in a 3.4 acre field which was intensively sampled in Shelby Co., KY. Recommendations for phosphate fertilizer



rates among the 162, 8 x 20 ft blocks sampled in that study varied from 0 to 110 lbs/A. If the entire 3.4 acre area had been fertilized with a uniform rate based on results from one composite sample taken randomly from within the 3.4 acres, the entire area would have received 80 lbs $P_2O_5$/A. Application of the uniform 80 lb rate to the 3.4 acres as compared to the rate which would have been required for each of the 162 areas sampled within the 3.4 acres, would have resulted in only 31% of the area receiving the correct rate. Additionally, 39% would have been underfertilized and 30% would have been overfertilized. Such variability within a 3.4 acre block would not likely be overcome by use of a VRS programmed with the capability to vary rates every 2.5 acres.

We conducted a similar study in Hardin Co., Kentucky, during 1997, in a 90 acre field which had been sampled in 35, 2.5 acre blocks for use in programming a VRS to change fertilizer rates on each 2.5 acre block. The study was designed to determine how well a central composite soil sample of 2.5 acre grids represents that grid, and if such a sampling method improves accuracy of fertilizer recommendations.

## Description of the Study

Soils in the field were mostly Crider silt loam, selected because of their importance in cash grain production in Kentucky. Each of the 35, 2.5 acre blocks had been sampled on a central composite grid basis, whereby a composite sample, comprised of 8 cores (0-4 inch deep), was taken around a 60-80 ft radius from the center of each block. The soil test value of this one composite sample was used to represent the entire 2.5 acre block for programming a VRS to vary rates on a block-by-block basis. We selected three of the 35 blocks (A, B, and C) for sampling on a more detailed basis in order to measure soil test variability within each of the three 2.5 acre blocks studied. In blocks B and C, we soil sampled along a linear transect through the center of each block. This resulted in 24 samples taken across the 240 ft width of each block. Additionally, we sampled a 300 x 300 ft area within block B, on a 60 x 60 ft grid basis, resulting in 25 samples taken from the grid intersects. In block A, we conducted a small plot fertility study which resulted in 44, 10 x 40 ft plots within a 110 x 160 ft area. Each of the 44 plots was soil sampled, providing a very detailed sampling within this small 110 x 160 ft area. All samples, taken from the 0-4 inch depth, were analyzed at UK's Soil Test Laboratory in Lexington, using the Mehlich-III soil test extractant. All soil samples were taken before fertilizer was applied for the 1997 corn crop.

## Results

### Scale of Sampling and Soil Test Variability

Table 1 summarizes ST variability on 4 scales: (1) a 90 acre field sampled in 2.5 acre blocks, (2) two, 2.5 acre blocks, B and C, each sampled 24 times along a 240 ft linear transect through the center of the block, (3) a 2.5 acre block, B, sampled on a 60 x 60 ft grid, and (4) a 110 x 160 ft area within block A divided into 44, 10 x 40 ft blocks for individual sampling. Ranges in ST values and % coefficient of variation (% CV; the higher the CV, the greater the variability). As shown, there was much less variability for pH than for STP and STK, regardless of sampling scale. Range of STP was very wide, and was only narrowed down to a two-fold difference by the very intensive sampling in block A. There was little difference in % CV for STP among the 35 blocks within the 90 acre field and the % CV of the more intensive sampling used in blocks B and C. Variability of STK was much less than for STP, regardless of sampling scale, although the very intensive sampling of block A reduced % CV for both STP and STK measurably, as compared to the 35, 2.5 acre blocks.

Table 2 summarizes the effect of sampling method on the average ST values for the 3 blocks studied. As shown, each method gave different answers, differing more so for STP than for STK or pH.

### Variability Across 60 Ft Wide Spreader Swaths

Table 3 summarizes ST values measured within four, 60 ft wide swaths across blocks B and C. As shown, there was much variability across each swath width, more so for STP than for STK or pH. The STP values varied about two-fold across the swath.

### Accuracy of VRS Fertilizer Rates As Compared to a Uniform Rate

The question of concern in use of VRS fertilizer application is whether it is more effective in matching rate of recommended fertilizer applications to variations of ST levels within a field as compared to a single recommended rate for the entire field. Table 4 summarizes the accuracy of one uniform recommendation, as related to ST variability measured among the 35, 2.5 acre blocks for the 90 acre field and within 3 of the 2.5 acre blocks studied. Recommended rates of phosphate and potash are those made by UK, on a crop sufficiency basis. As shown in table 4, all average levels of STP and STK, regardless of sampling scale, exceeded those needed to increase yields, and the UK recommendation was that no phosphate or potash was needed. On the basis of the zero fertilizer recommendation, accuracy of the recommendation is summarized in table 4 in terms of amount of area which would have been correctly or incorrectly treated. For treating the whole 90 acre field uniformly, based on the average soil test values of the 35 central composite samples, the recommended rate of no fertilizer would have been correct for phosphorus on 66% of the field, and on 74% of the field for potassium.

### Conclusions

Results of intensive soil sampling studies conducted on 3, 2.5 acre blocks in a 90 acre field indicated that the 2.5 acre sampling units were too large to account for the variability in STP and STK found within the 3, 2.5 acre blocks studied. The UK soil test recommendation based on a central composite sample would have resulted in substantial under-fertilization of two of the 3 blocks for phosphorus, but was considerably more accurate for potassium.

### References

1. Wells, K.L. 1996. Variation in Soil Test Phosphorus and Corn Yields within a 3.4 Acre Field. In, Proc. 1996 Sou. Soil Fert. Conf. Memphis, TN. Oct. 15-16, 1996. Samuel Roberts Noble Foundation, Ardmore, OK

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# Table 1. Variability In Soil Test Values

| | Range in S.T. Values | | | %Coefficient of Variation | | |
|---|---|---|---|---|---|---|
| | pH | P[1/] | K[1/] | pH | P | K |
| Block A (44 small plots) | 5.4-5.9 | 37-77 | 281-507 | 2.7 | 17.0 | 13.5 |
| Block B 60x60 grid (25 sites) | 5.5-6.3 | 42-221 | 267-725 | 0.6 | 60.2 | 25.4 |
| Block B traverse (24 sites) | 5.3-5.9 | 41-140 | 261-501 | 2.8 | 27.2 | 19.3 |
| Block C traverse (24 sites) | 5.5-6.5 | 29-212 | 272-533 | 4.1 | 62.3 | 17.3 |
| 90 Acre Field (35 blocks, 2.5 ac. ea.) | 5.4-6.7 | 15-138 | 153-478 | 5.1 | 57.0 | 28.0 |

[1/] lbs/A

**Table 3. Variability of Soil Test Values Across Four Separate 60-Ft Wide Spreader Swaths [1/]**

| | Swath No. 1 | | Swath No. 2 | | Swath No. 3 | | Swath No. 4 | |
|---|---|---|---|---|---|---|---|---|
| Block | range | Av. | range | Av. | range | Av. | range | Av. |
| | | | - - - - pH - - - - - | | | | | |
| B | 5.8-5.9 | 5.9 | 5.7-5.8 | 5.8 | 5.4-5.9 | 5.7 | 5.3-5.8 | 5.6 |
| C | 5.8-6.6 | 6.2 | 5.8-6.1 | 5.9 | 5.6-5.9 | 5.8 | 5.6-5.8 | 5.7 |
| | | | - - Phosphorus[2/] - - | | | | | |
| B | 41-59 | 51 | 53-90 | 72 | 70-140 | 86 | 70-122 | 94 |
| C | 99-212 | 123 | 45-129 | 84 | 29-43 | 33 | 35-59 | 45 |
| | | | - - - Potassium[2/] - - - | | | | | |
| B | 284-375 | 320 | 261-418 | 334 | 368-476 | 427 | 388-501 | 454 |
| C | 341-533 | 420 | 319-407 | 368 | 272-316 | 292 | 309-334 | 332 |

[1/] Av. of 6 composite samples taken across each 60-ft swath

[2/] lbs/A

## Table 2. Effect of Sampling Method on Average Soil Test Values[1/] Within 2.5 Acre Blocks

| | Block A | | | Block B | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sampling Method | pH | STP | STK | pH | STP | STK | pH | STP | STK |
| Central grid composite[2/] | 5.9 | 102 | 362 | 6.2 | 168 | 463 | 5.9 | 88 | 309 |
| Linear traverse[3/] | | | | 5.75 | 76 | 384 | 5.9 | 71 | 353 |
| 60 x 60 grid[4/] | -- | -- | -- | 5.85 | 97 | 445 | -- | -- | -- |
| 10 x 40 grid[5/] | 5.7 | 54 | 385 | -- | -- | -- | | | |

[1/] STP and STK are lbs/A

[2/] one sample per 2.5 ac, comprised of 8 cores taken along a 60 ft radius from center of block.

[3/] Av of 24 samples per 2.5 ac, each sample comprised of 6 cores taken across the center of each block.

[4/] Av of 25 samples taken on a 60 x 60 ft grid (300 x 300 ft) within a 2.5 ac block, each sample comprised of 6 cores taken at each intersect.

[5/] Av of 44 samples taken from individual 10 x 40 blocks within a 110 x 400 ft area within a 2.5 ac block, each sample comprised of 6 cores taken linearly along the long axis in the center of each block.

**Table 4. Precision of Recommended Fertilizer Application: Comparison of Application Rates Based on a Single Composite Soil Sample Per Sampling Unit As Related to Soil Test Variability Measured Within the Field or 2.5 Acre Blocks.**

| Sample Unit | Phosphorus | | | | | Potassium | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | STP | Recomm. lbs $P_2O_5$ | % of Area Fertilized correct | over | under | STK | Recomm. lbs $K_2O/A$ | % of Area Fertilized correct | over | under |
| 90 acre field[1/] | 99 | 0 | 66 | 0 | 34 | 378 | 0 | 74 | 0 | 26 |
| Block A[2/] | 102 | 0 | 36 | 0 | 64 | 362 | 0 | 95 | 0 | 5 |
| Block B[2/] | 168 | 0 | 71 | 0 | 29 | 463 | 0 | 83 | 0 | 17 |
| Block C[2/] | 88 | 0 | 42 | 0 | 58 | 309 | 0 | 83 | 0 | 17 |

[1/] Composite value based on the Av of 35, 2.5 ac. blocks in the field
[2/] One central grid composite sample per block