KENTUCKY

New Technologies and Analytical Tools for Fertilizer Recommendations?

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Gathering information about soil fertility status and the purchase and application of fertilizers and soil amendments can result in considerable nutrient management costs. Information gathering usually consists of plant and/or soil sampling, analysis, and interpretation. Soil sample analysis is particularly important to traditional phosphorus (P), potassium (K) and pH management. Soil sampling, testing, interpretation, and recommendation development require skill and time, time that may be in short supply when crop harvest is soon to be followed by establishment of a succeeding crop. Is there a better way?

Spatially referenced yield monitoring, coupled with a measure of grain composition, can give a "nutrient removal map" that can be the basis of the next fertilizer prescription. Using tabular estimates for grain P and K composition, nutrient removal/fertilizer prescription maps could be developed directly from a field's yield map. Intuitively, nutrients would be applied where needed, as needed. If tabular estimates were thought inappropriate, one could sample the grain, either spatially or to create a random composite. Spatially referenced grain sampling requires time and skill comparable to that for grid soil sampling. However, there is no reason to believe that grain composition is constant across the field or that it will exhibit a spatial pattern similar to that for grain yield or the soil test nutrients.

> Developing fertilizer recommendations can be one of the more important and costly tasks undertaken as part of a site-specific management plan. New technologies can help, but also complicate, fertilizer recommendation development. The traditional soil test approach can be intensified with site-specific analysis. A crop nutrient removal approach might be based on spatially referenced yield monitoring, but requires some information on grain composition. Among the spectrum of alternatives, which is the "best"?

Limiting factors other than nutrient stress often drive yield differences within the field. For example, should this year's weed competition pattern, which has a negative effect on yield, drive fertilizer application for the next crop? If yield was low in part of the field because of low soil test P, should the fertilizer P rate for that area be based on the yield and P removal? New technologies such as the yield monitor and spatial analysis may help to improve fertilizer recommendations, but how do they compare with the existing options?

The objective of our study was to compare five alternative approaches for generating fertilizer rate prescriptions for P and K. These approaches were: a) our "expensive standard", based on grid soil sampling and spatial soil analysis; b) based on a single composite soil sample, created from the average of the grid soil samples in a field; c) based on a yield map, single values for grain P and K taken from a published table, and spatial analysis of nutrient removal; d) based on a yield map, single values for grain P and K from a single composite sample created from the average of the grid grain samples taken in a field, and spatial analysis of nutrient removal; and e) based on a yield map, grid grain samples taken in the field, and spatial analysis of both grain composition and nutrient removal.

Methodology

Two fields, designated 112 (51.4 acres) and 950 (43.4 acres), were chosen. Both fields were planted to corn, without prior tillage, in April 1999. In both fields the dominant soil is well drained, but both also contain significant areas of only moderately well drained soil. Field 112 had a history of mineral fertilizer applications and 950 had a history of swine manure and fertilizer nitrogen (N) applications. Corn yield was determined with a calibrated yield monitor on a combine equipped with Global Positioning System (GPS) technology. Grain and soil samples were taken at the same point, on a 180 x 200 ft. grid, prior to and after harvest, respectively. A digital elevation map was generated for each field. Soil samples were analyzed for extractable P and K (Mehlich 3), water pH, soil organic matter, and texture. Grain tissue was analyzed for total P and K.

Geostatistics were used to characterize the spatial variation in crop yield, nutrient composition, and soil properties within a field. The grain yield at the soil/grain sampling points was determined by averaging the yields at the four points nearest each grid sampling point. The tabular values used to calculate nutrient removal and fertilizer prescription maps were 0.326 percent P = 0.353 lb P_2O_5/bu and 0.221 percent K = 0.267 lb K_2O/bu (assuming 15.5 percent field moisture corn). **Table 1** shows the fertilizer rate recommendation as related to nutrient removal or soil test nutrient values.

Maps for each fertilizer rate prescription alternative were constructed. The nutrient removal/prescription maps were developed by: a) multiplying the yield by grain P and K at each grid sampling point and using an interpolation method (kriging) to predict values at all unsampled points in the field; b) same as a), above, but using the tabular grain P and K concentration information; and c)

TABLE 1. Fertilizer recommendations as related to removal

Fertilizer recommendation, lb/A	Removal, lb/A		Soil test, lb/A	
P_2O_5 or K_2O	P_2O_5	K_2O	P	K
0	0-15	0-15	> 56	> 300
30	15-45	15-45	42-56	225-300
60	45-75	45-75	28-42	175-225
90	75-105	75-105	14-28	100-175
120	105-135	105-135	0-14	< 100

TABLE 2. Soil test, yield, and grain composition information.

Property	Field 112	Field 950
P (M3)	53.9 ± 30.9	147 ± 64
K (M3)	429 ± 158	392 ± 121
OM	2.57 ± 0.44	3.26 ± 0.56
pH	6.32 ± 0.60	6.41 ± 0.27
Clay	19.5 ± 3.9	17.7 ± 2.8
Silt	71.2 ± 4.3	72.8 ± 3.3
Sand	9.2 ± 9.1	9.5 ± 1.8
Yield, bu/A	130.4 ± 46.9	137.6 ± 22.4
Grain P, %	0.29 ± 0.04	0.35 ± 0.03
Grain K, %	0.33 ± 0.03	0.41 ± 0.03

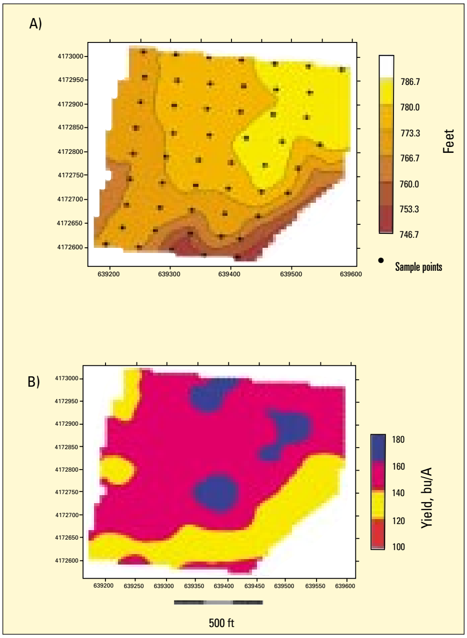

Figure 1. Field 950 A) elevation and sampling points; B) map of yield (interpolated).

same as a), above, but using the average grain P and K concentration found for the grid grain samples. The same interpolation method was used on the grid soil test P and K data in order to develop soil test based fertilizer prescription maps. Average P and K soil tests, using all the grid soil samples, were considered in arriving at a single prescription rate for the field.

TABLE 3A. Portion of field 950 (%) receiving each fertilizer P rate,

Fertilizer recom-mendation, P_2O_5 lb/A	Grid soil test P	Composite soil test P	Removal tabular grain P	Removal grid grain P	Removal composite grain P
	....	....	%	....	....
0	100	100	0	0	0
30	0	0	38.4	30.5	23.3
60	0	0	61.7	69.5	76.7
90	0	0	0	0	0
120	0	0	0	0	0

TABLE 3B. Portion of field 950 (%) receiving each fertilizer K rate,

Fertilizer recom-mendation, K_2O lb/A	Grid soil test K	Composite soil test K	Removal tabular grain K	Removal grid grain K	Removal composite grain K
	....	....	%	....	....
0	78.6	100	0	0	0
30	21.2	0	99.0	100	0
60	0.2	0	1.0	0	67.0
90	0	0	0	0	33.0
120	0	0	0	0	0

Observation

"Composite" soil test, grain yield, and grain tissue P and K information for the two fields are given in **Table 2**. On average, Field 112 is lower than 950 in soil test P and organic matter, but higher in soil test K. Texture and pH were more similar. Grain yield was lower and more variable in 112 than 950. For both fields, grain P was close to the tabular value; however, grain K was well above the tabular value.

Topography, soil properties, and yield were variable, but were spatially related, in each field. In general, lower elevation and decreased drainage capacity were related to lower corn yields. **Figure 1 (A and B)** shows sampling point locations, elevations, and yield (interpolated) in field 950. Grain P and K were spatially autocorrelated, but were not well related to yield or other soil properties (data not shown). Considerable variation in soil test P in field 950 is shown in **Figure 2A**, but no fertilizer P would be recommended because there were no areas with a soil test P value below 56 lb P/A. The removal fertilizer prescription map, using the yield map and the tabular grain P concentration (**Figure 2B**), delimits two areas with rate prescription differences due to large yield differences. The removal fertilizer prescription maps obtained using the grid or the "composite" of grain P

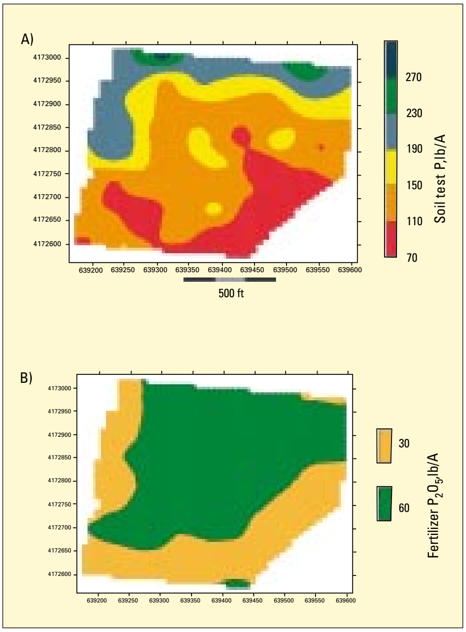

Figure 2. Field 950 A) map of soil test P; B) fertilizer P prescription from P removal using tabulated grain P concentration.

and K values actually measured in field 950 were similar to prescription maps based on the tabular grain P value. Comparing the five methods of arriving at a P recommendation for field 950, removal fertilizer prescriptions always called for more fertilizer than the soil test prescriptions on this manured field (**Table 3A**). Areas in the removal maps calling for the greatest fertilizer P recommendation were often those areas with higher soil test P (**Figure 2 A** and **B**). "Composite" soil analysis called for no fertilizer P or K for 950.

Using the same five methods to arrive at a K recommendation for field 950 (**Table 3B**), a similar pattern of bias error, resulting in greater fertilizer recommendations with removal prescriptions, was observed. However, there were some differences between soil test and removal approaches. Grid soil sampling identified some areas needing K, relative to the composite soil sample. The composite grain sample resulted in a greater K prescription relative to the other two removal approaches (**Table 3B**).

The soil test K map for field 112 (**Figure 3A**) also showed considerable variation. Lower soil test K was associated with the moderately well drained soil and resulted in a fertilizer K prescription that was not called for on the rest of the field (**Figure 3B**). Comparing recommendation approaches for this field, more fertilizer P and K were prescribed, relative to that recommended by grid soil sampling, by the three removal approaches (**Tables 4A** and **4B**). The "composite" soil analysis recommended no K fertilizer and a uniform rate of 30 lb P_2O_5/A for this field. Relative to grid soil sampling, this P

TABLE 4A. Portion of field 112 (%) receiving each fertilizer P rate,

Fertilizer recommendation, P_2O_5 lb/A	Grid soil test P	Composite soil test P	Removal tabular grain P	Removal grid grain P	Removal composite grain P
	………	………	%	………	………
0	30.5	0	0	0	0
30	36.0	100	43.1	94.5	74.1
60	31.7	0	56.5	5.5	25.9
90	1.7	0	0.5	0	0
120	0	0	0	0	0

TABLE 4B. Portion of field 112 (%) receiving each fertilizer K rate,

Fertilizer recommendation, K_2O lb/A	Grid soil test K	Composite soil test K	Removal tabular grain K	Removal grid grain K	Removal composite grain K
	………	………	%	………	………
0	79.2	100	0	25.2	0
30	15.9	0	92.4	68.8	22.4
60	4.3	0	7.6	5.9	74.9
90	0.6	0	0	0	2.7
120	0	0	0	0	0

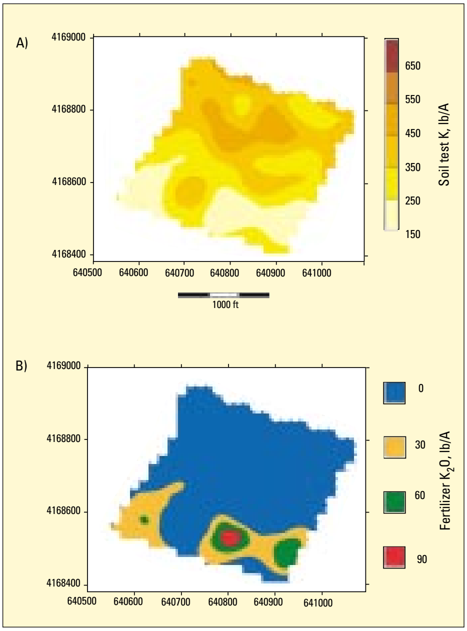

Figure 3. Field 112 A) map of soil test K; B) fertilizer K prescription from soil test K.

recommendation appears appropriate for a third of the field, over-fertilizes a third of the field, and...most seriously...under-fertilizes a third of the field. However, these seemingly equal divisions among the recommended P fertilizer rates were not so uniformly distributed across field 112 (map not shown).

Conclusion

In this study, it appeared that composite soil sampling was not necessarily inferior to grid soil sampling in terms of the resulting fertilizer P or K recommendations. In general, the nutrient removal-based prescription maps resulted in greater recommendations than either soil test approach. We also observed that our chosen tabular grain P and K concentrations resulted in prescription maps that were sometimes very different from those developed using P and/or K concentrations taken from a field's grain samples. Our results suggest that using spatially referenced yield information and tabular grain concentration information to develop fertilizer P and K rate prescription maps rests on possibly invalid assumptions. Problematic assumptions include: a) that the field's grain composition is generally uniform and close to that given in the chosen table, and b) that the demand of the past crop, rather than the current supplying power of the soil, is well related to the need for fertilizer for the next crop. We speculate that the yield map might be used to stratify a field into more uniform "management zones", which would then be randomly soil sampled for optimal nutrient management information. We are evaluating this option at present. BC

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