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Effective use of precision agriculture for improved management of phosphorus, potassium, and lime

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Abstract
This article summarizes results of ongoing research on soil sampling methods and variable-rate technology (VRT), and on the use of precision agriculture technologies for on-farm strip trials. The research emphasizes the management of phosphorus (P), potassium (K), lime, and starters.

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INTEGRATED CROP MANAGEMENT

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Sampling by soil type or grid sampling?

Results of intensive sampling of many fields show that nutrient variability is complex, that it differs markedly among nutrients and fields, and that there is both a large-scale (several acres) and small-scale (a few feet) variation. The variations of P and K have a major small-scale component and often do not follow commonly used soil-type maps. Soil organic matter and pH tend to follow soil types more closely, but small areas with unmapped soil types often introduce variation and uncertainty. The different combinations of large- and small-scale variability together with differences in nutrient levels in relation to crop needs determine that no sampling scheme is optimum across all fields. Figure 1 shows how different maps of soil test P and K are dependent on the sampling method used. Cells of about 4 acres often do not represent nutrient variation appropriately, either because the variation within the cells is very large or because cell borders do not follow soil types or the landscape. This method often overestimates nutrient and pH levels. A more intensive sampling describes nutrient supplies better but is more expensive. Two alternatives seem reasonable. One is to improve the traditional "by soil type" method by defining the sampling areas better on the basis of yield maps, landscape, and high-resolution aerial photographs. The other alternative is to invest in an intensive grid sampling spaced over time (2-acre cells or smaller every 4 or 6 years) and to test a few contrasting points in between those dates to check for changes in nutrients such as P and K that are highly affected by fertilization and removal. These alternatives are being tested in ongoing projects.

Variable-rate fertilization and liming

This research is in various stages of development, and includes lime, P, and K trials. Results of variable versus fixed P comparisons in six corn or soybean fields based on a 4.4-acre grid-point sampling showed little or no yield advantage from VRT compared with fixed fertilization even though soil-test P varied from low to very high in all fields. Possible reasons for this result are that responsive areas at each field were small, soil sampling was not reliable, or both. This method may show low-testing areas that actually do not represent the large area of the cells. The lime trial showed little response to lime (0.6 bu/acre) and no difference between fixed or variable applications even though soil pH varied from 5.5 to 8.2. In the P trials, use of VRT resulted in slightly lower amounts of P applied. In the lime trial, use of VRT saved substantial amounts of lime because less than half of the field received lime compared with the fixed rate treatment. To obtain better answers, additional VRT trials based on a 0.2- to 0.5-acre soil sampling were recently established for P, lime, and K at the Iowa State University's Sorenson demonstration field and at producers' fields.

On-farm comparisons of management practices

Precision agriculture technologies can be successfully adapted to on-farm evaluations of management practices. Use of differential global positioning system (DGPS), yield monitors, and computer software allows for a detailed evaluation of treatment effects for different parts of a field. For example, one project focuses on studying the variation in corn response to pop-up (in the furrow) N-P-K starter fertilization within fields. Figure 2 shows the much more complete information that can be obtained in comparison with a conventional weigh-wagon strip trial. The results for that field show no response to the starter in some areas but more than 20 bu/acre in others. Much of this research can be done by producers when a minimum set of quality control procedures is followed. Potential errors arise from incorrect calibration of the yield monitor, inaccurate geo-references, effects of field borders and waterways, changes in the harvest swath width, and unaccounted for yield variability.

A look ahead

Precision agriculture technologies have great potential to improve soil fertility and crop management. The impact of VRT on soil fertility management and farm profitability depends on factors such as nutrient levels in relation to crop needs, nutrient variability, crop response, fertilizer recommendations, and additional costs. The main uncertainty with VRT is not rooted in the technology itself but in the reliability and cost of the soil sampling on which it is based. Ongoing research should provide better answers about how to achieve the full potential of this and other new technologies.

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Figure 1. **Distribution of soil-test P values in three fields assessed by four soil sampling methods.**

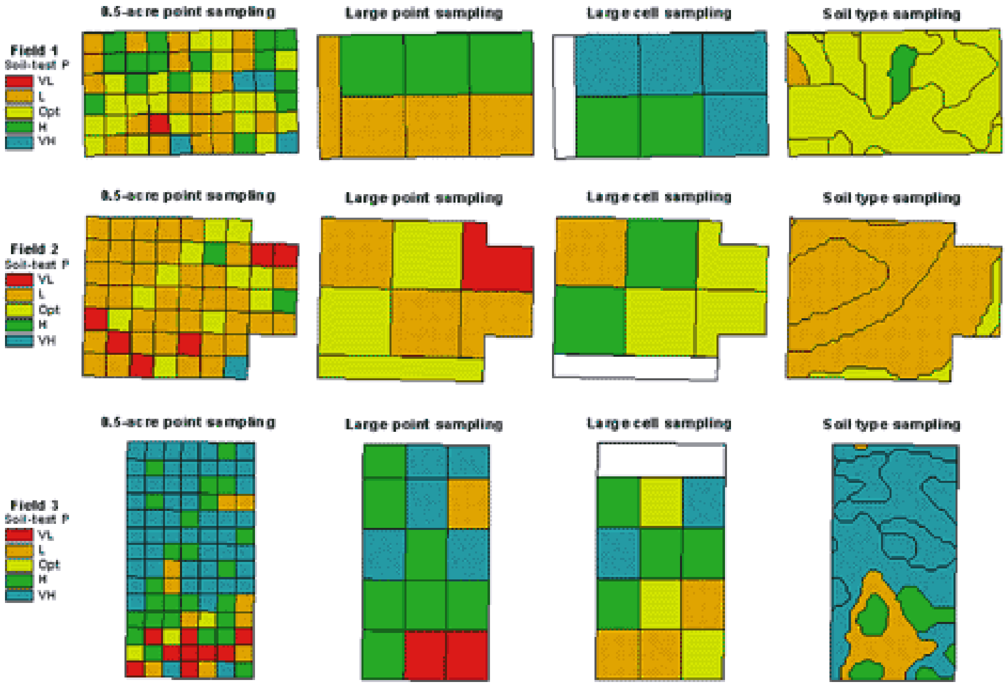
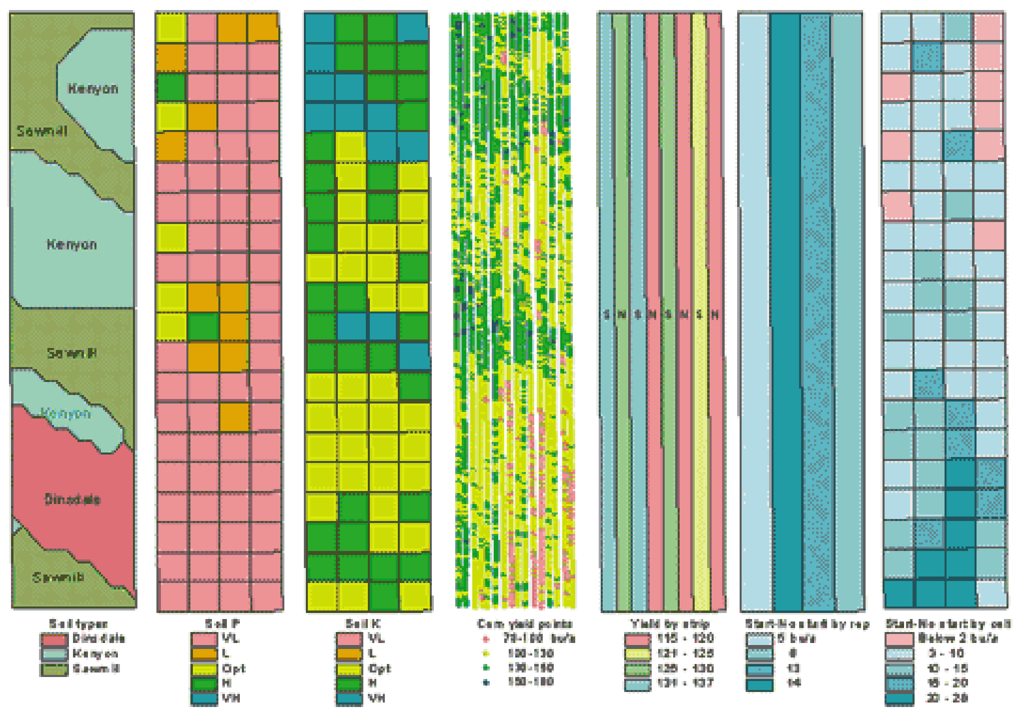


Figure 2, below. **Within-field variation in soil types, soil tests, corn yield, and corn response to starter pop-up N-P-K fertilization.**



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