

## **Will Higher Fertilizer Prices Drive Adoption of Precision Fertilizer Management?**

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One of the most appealing concepts of site-specific agriculture is in the precise application of crop inputs—giving each part of a field exactly what is needed vs. uniformly across a field, where the soil, past treatment, drainage, or any other number of factors can vary. Especially for crop nutrients, the potential exists in precision application to not only increase crop yields but to reduce costs and reduce risks, all of which can increase returns.

Most studies have shown only modest returns, at best, to site-specific, variable rate applications of crop nutrients as compared to whole-field approaches. But with higher input costs, there is a greater chance that more efficient fertilizer use and its associated cost savings can overcome the labor, sampling, and equipment costs associated with site-specific management.

But cost savings and yield increases do not always accompany site-specific fertilizer management. A Purdue University study (Lowenberg-DeBoer and Aghib, 1999) conducted from 1993-1995 compared three scenarios—a traditional whole-field approach, a three acre grid approach, and a soil zone management approach to phosphorus (P) and potassium (K) management on several farms growing corn, soybeans, and wheat in Indiana, Michigan, and Ohio. Most of the fields tested had areas that, according to university recommendations, would require fertilization and some areas not, setting up a situation where the additional P or K could generate yield gains on low and medium testing areas and where input costs could be eliminated on the high or very high testing areas. Working with the farmer's fertilizer dealer, fertilizer amounts were based on those suggested by the Tri-State (IN, OH, MI) Fertilizer Recommendations. And since the influence of P and K fertilization extends well beyond the current crop year, fertilizer effects and costs were amortized over a multi-year period.

Comparing results for each of the approaches, yields for the grid and soil zone approaches were slightly higher when averaged across all farms, but fertilizer requirements varied, with the grid sampling approach actually calling for more fertilizer overall compared to a whole field approach, the soil zone system less. Theoretically the grid and the soil type schemes should have led to less fertilizer use, but in this real-world study that did not turn out to be the case. It is speculated that the soil zone scheme was more proficient at correctly delineating areas of nutrient deficiency vs. sufficiency.

In the end the returns for each fertilization system were similar using commodity and input prices typical of the late 1990's, but the soil zone system had slightly higher returns, the grid scheme less (Table 1). Returns on each farm each year varied less with the site-specific approaches as compared to whole field approach, reducing risk. Inputting the higher fertilizer prices of recent months provides the expected result—if fertilizer is used more efficiently, for instance with the soil zone scheme, the returns become more favorable with higher input costs. But if fertilizer use increases and yields do not, as was the case in this study with a grid approach, the returns become less favorable.



Table 1. Returns to using a grid or soil zone fertilizer sampling and application system vs. a whole field approach at two fertilizer cost levels: composite of six Midwestern farms.

Fertilizer Prices	Management Scheme		
	Whole Field Management	3 Acre Grid (Grid vs. WFM)	Soil Zone (Soil Zone vs. WFM)
	Net Return on Investment, \$/A		
\$0.22 P <sub>2</sub> O <sub>5</sub> and \$0.12 K <sub>2</sub> O	158.98	152.13 (-6.85)	161.65 (+2.67)
\$0.33 P <sub>2</sub> O <sub>5</sub> and \$0.22 K <sub>2</sub> O	154.04	146.61 (-7.43)	157.45 (+3.41)

Included in the calculations above is the cost of being precise. Field variation needs to be quantified, and the current method is to collect soil samples and have them analyzed in a lab, adding labor and lab analysis costs. Maps need to be constructed to guide applications, and then special effort or specialized application equipment is needed to modify the nutrients across the field accordingly. Personnel have to be in place that can interact with the grower and correctly integrate the testing, analysis, and implementation phases.

A more recent Purdue study (Peone, 2004) used six intensely sampled Indiana corn/soybean rotation fields to simulate various site-specific sampling and recommendation schemes. Like the other study, the fields tested had areas that would require some additional fertilization, especially for potassium, but phosphorus was generally sufficient. The scenarios were somewhat different, but included a whole-field approach and a 2.5 acre grid sampling approach. In this study the site-specific approach led to slightly lower yields and slightly less fertilizer required as compared to a whole field approach--the 2.5 acre grid was too coarse to detect some of the low-testing parts of the field. Considering all costs the whole field approach achieved slightly greater returns (Table 2). Higher fertilizer prices narrowed the difference between the approaches, but the end results were still quite similar.

Table 2. Returns to using a grid sampling scheme vs. a whole field approach at two grid sizes and at two fertilizer cost levels: composite of six Indiana fields.

Fertilizer Prices	Management Scheme	
	Whole Field Management	2.5 Acre Grid (Grid vs. WFM)
	Net Return on Investment, \$/A	
\$0.22 P <sub>2</sub> O <sub>5</sub> and \$0.13 K <sub>2</sub> O	181.76	176.93 (-4.83)
\$0.33 P <sub>2</sub> O <sub>5</sub> and \$0.20 K <sub>2</sub> O	179.41	175.24 (-4.17)

These studies demonstrate that if yields are not greatly impacted, then the force driving returns sits squarely with lowering costs. Additional analysis of the Peone study showed that about 20% of a field must contain isolated low-fertility areas to justify site-specific



management, and then only if both P and K are low and sampling density is intense enough to pick up the low fertility areas. Many crop fields that have been managed well in the past may not have areas where P and K levels are a limiting factor for yields.

Besides managing P and K, a fair amount of site-specific attention has concentrated on most farmer's biggest fertilizer expense, and a big environmental concern—nitrogen. But as unsettled as overall nitrogen response functions and recommendations currently are, and with the unpredictable nature of nitrogen in soils, site-specific nitrogen recommendations are even less settled.

More conclusive have been studies of site-specific soil pH management and liming. Lime is different in that there is an optimum range for crop response, as opposed to most crop nutrients where there is little penalty for over-application. Studies in the Eastern Corn Belt (i.e., Bongiovanni, 1998) have shown good returns to site-specific liming, where soil pH can vary significantly across a field but soils tend to be acid. And if the cost of lime rises because of higher trucking cost, variable rate lime should become even more profitable than it was when the original studies were done.

The concept of site-specific soil nutrient management caught on in a big way in some U.S. farming regions in the mid-90's, and by the late 90's over half of U.S. agricultural retailers surveyed were offering soil sampling using GPS. These same retailers reported then that about 10-15% of the acres in their areas were using some type of precision fertilizer application (Whipker and Akridge, 2005). While those numbers are somewhat higher today, they are not nearly as high as many would have predicted.

Two of the greatest limitations to profitably using site-specific technology—the cost of extra soil testing along with the difficulty in collecting enough samples to capture all of the variability—may become lesser factors in the future with technology being developed. On-the-go sensing systems for soil pH are already on the market, and research is underway to develop on-the-go sensors for other crop nutrients, as well as other related soil factors that can affect fertilization strategies, such as organic matter and soil texture. A cost-effective solution in the future could be to combine on-the-go sensing with on-board analysis and nutrient application to eliminate many of the costs associated with site-specific approaches. Combined with the possibilities for precision nutrient placement and timing that RTK autoguidance can offer, remote sensing, or other tools, innovators will continue to look for ways to increase crop yields, lower costs, and reduce risks.

### **For More Information:**

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Bongiovanni, R. 1998. Economic Evaluation of Site-Specific Lime Management. MS Thesis, Department of Ag. Economics, Purdue University.

Erickson, B. Field Experience Validates On-the-Go Soil pH Sensor. SSMC Newsletter, December, 2004. Available at <http://www.purdue.edu/ssmc/>, see Newsletters.



Lowenberg-DeBoer, J., and A. Aghib. 1999. Average returns and risk characteristics of site-specific P and K management: Eastern Corn Belt on-farm trial results. *J. Prod. Agric.* 12:276–282.

Peone, J., and J. Lowenberg-DeBoer. Managing Fields with Isolated Low Fertility Areas. *SSMC Newsletter*, February, 2004. Available at <http://www.purdue.edu/ssmc/>, see Newsletters.

Peone, J. 2004. Management strategies for corn-soybean fields with isolated low phosphorous and potassium areas. MS Thesis, Department of Ag. Economics, Purdue University.

Whipker, L., and J. Akridge, “2005 Precision Agricultural Services: Dealership Survey Results.” Staff Paper No. 05-11, Center for Food and Agricultural Business, Purdue University, West Lafayette, IN, USA, September 2005. Available at <http://www.purdue.edu/ssmc/>, see Publications.

