Site-Specific Management Guidelines

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# Identifying Good Candidates for Precision Phosphorus Management


## Summary

1. Findings from this study are applicable to fields with phosphorus (P) frequency distributions similar to that shown in **Figure 1**. In fields with high soil test P variability, precision management of P produced the greatest level of profitability when the composite soil test P level was in the high to very high soil test P categories.
2. Average soil P test level and prior field histories can be used as a decision aid to reduce economic risks associated with adopting precision farming techniques.
3. Appropriate P response models and yield goals must be used to accurately assess potential profitability associated with precision P management.


A headline for the *Precision Farming Gazette* reads **"Precision Phosphorus Management Increases Mr. Jones' profits by $100/acre."** Do you believe this? Are you willing to invest $20 to $25/acre to find out?

Investing in variable rate P management is profitable in some fields and not in others. The important question is, where is precision P management profitable and where it is not? To develop an answer to this question we must agree on what is generally accepted. A list of precision farming principals could include the following statements.

1. Holding all other variables constant, profits decrease as production costs increase and precision farming initially increases production costs.
2. Net returns increase as yields increase, and precision farming should increase yields.
3. Field variability of soil test values may increase the need for site-specific management, and different areas respond differently to added inputs.
4. Converting information into knowledge, which will improve the decision making process, is difficult.

The goal of this Guideline is to demonstrate an approach for converting information into a form that will improve decision-making (statement 4). This goal can be reached by balancing costs (statement 1), benefits (statement 2), field variability, and scientific studies (statement 3).

An understanding of the third statement is critical because it indicates that as soil test variability increases, the benefits associated with variable rate applications increase. For example, a consultant collects a field composite sample (made up of 15 cores) which is analyzed and used to develop a conventional single P rate application. If each of the 15 cores contained identical P concentrations, then the field can be correctly fertilized with a conventional one-rate application. However, if the 15 soil cores have P concentrations ranging from 2 to 40 parts per million (ppm), a field average of 13 ppm, and a median (point where half of the values are above and below the average) of 11 ppm, then the application of a single fertilizer rate, based on 13 ppm, will under-fertilize over half of the field while the remaining portions will be over-fertilized (**Figure 1**). The contour map shown in **Figure 2** demonstrates this principle.

Statement 4 is not trivial, and to convert information into improved decisions requires an understanding of expected costs and returns as well as basic agronomics. Partial budgeting provides an effective means of evaluating agronomic questions in terms of dollars and cents. In partial budgeting, only costs and returns directly associated with the proposed management change are considered. Factors that must be considered in developing precision P management partial budgets include: soil sampling costs, P variability, and expected profit associated with precision P management and climatic conditions.

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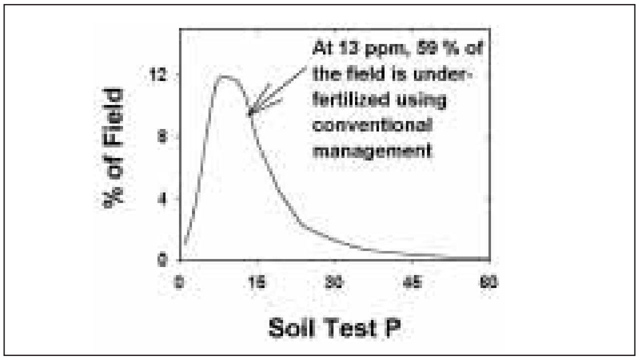


**Figure 1.** **A hypothetical P frequency distribution. This distribution is based on the results of many grid sampled fields.**

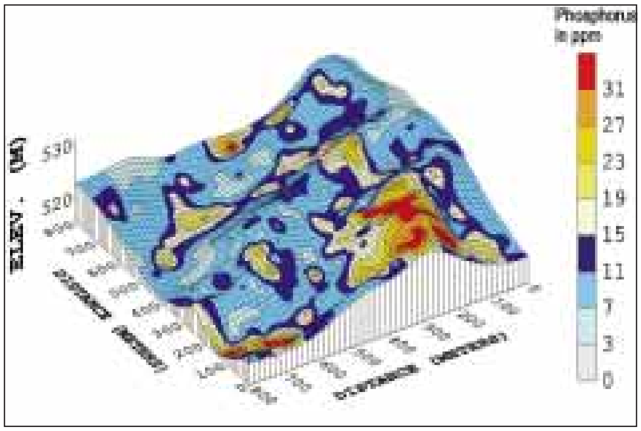


**Figure 2.** **A P contour map of a 160 acre field ( ½ mile by ½ mile) located in eastern South Dakota. All areas with P concentrations less than 13 ppm will be under-fertilized if a conventional fertilizer rate is applied.**

An experiment using yield goals from eastern South Dakota, South Dakota fertilizer P recommendations, and several P response models demonstrates a method for developing partial budgets for precision management. For the soil and climatic conditions tested, several criteria for identifying "good" candidates for precision farming were outlined as listed below.

**Criteria 1:** The soil test P level in a composite soil sample for the field from the last several years varied greatly and all of the samples were not characterized in the high or very high soil P categories. For example, this year the soil test P was 18 ppm. In previous years, soil test P values were 9 and 14 ppm.

**Criteria 2:** If the soil test P level is in the high to very high index ranges, precision P management may improve profitability.

**Criteria 3:** The crop must respond to additional P fertilizer, and the greater the P response, the greater the profit associated with precision P management. It is important to point out that the expected response from P fertilizer is different for different areas of the country and in order to estimate the impact of precision P on potential profitability, realistic P response models must be used. Phosphorus response influences the second and fourth criteria.

**Criteria 4:** If the field composite has a soil test P in the low and medium index ranges, then a relatively high fertilizer P rate uniformly applied over the field may be the most profitable. Remember when determining the P rate, it is likely that over half the field has less P than the field average.

Based on this approach, a similar analysis can be conducted for other sites. A brief example on how to use partial budgeting as a decision tool is provided below.

## Partial Budgeting Example

A partial budgeting experiment was conducted to evaluate several P response models and soil test P level on expected returns. Assumptions associated with this analysis are listed below.

**Crop responses from P:** Three different P response models were evaluated (**Figure 3**). In the first model, the maximum yield increase for soil testing in the very low soil P category was 15 percent (small). In the second model, the maximum yield increase was 25 percent for soil testing in the very low P category (medium), and in the third model the maximum increase was 35 percent (high). In all models, the first increment of P added increased yield the most. The last increment increased yield the least. It must be pointed out that different soils and crops have different fertilizer responses. When possible, use local calibration results. If calibration results are not available, Murrell (1999) has tabulated results from several studies. Nitrogen and P fertilizer recommendations were calculated using South Dakota State University Extension Service Fertilizer Guidelines (Gerwing and Gelderman, 1996).

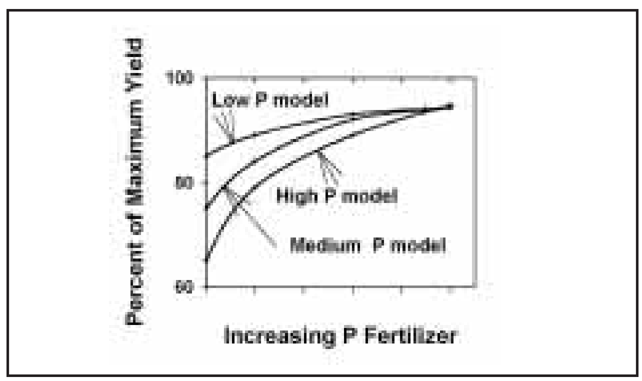


**Figure 3.** **Phosphorus response models evaluated in the simulation experiment.**

**Prior field management**: Corn and soybean yield goals were 160 and 40 bu/A, respectively, no manure had been applied, N fertilizer was required for corn, and a corn/soybean rotation was used.

**Economic considerations:** Corn and soybeans prices received were $2.50 and $5.50/bu, respectively. Yield monitor and other information management equipment were not purchased; variable and conventional fertilizer application costs were $7.50/A and $5.00/A, respectively, grid and soil sampling analysis cost were $1,280/160 acre field; and N and $P_2O_5$ costs were $0.25 and 0.28/lb, respectively.

**Soil test values:** Different soil test P values were simulated by adding -4, 0, +3, and +5 ppm P to each sampling points. A contour map of the actual results is shown in **Figure 2**.

## Findings

Economic analysis showed that if the crop had a minimal fertilizer P response, precision fertilizer P management might not increase corn and soybean yields enough to warrant grid sampling and the use of variable rate equipment (**Table 1**). This was especially true for soils testing in the very low (0-3 ppm), low (4-7 ppm), and medium (8-11 ppm) soil test P categories. For these soils, the most profitable practice would be to apply a relatively high rate of fertilizer P to the entire field. For soil testing in the high range (12-15 ppm) economic benefits were predicted regardless of P model.

Increasing the crop response to P from a maximum of 15 percent to 25 or 35 percent yield gain increased calculated profitability. Increasing the yield goal produced the same results as selecting a higher fertilizer P response model. This analysis showed that in order to obtain realistic profitability estimates, an appropriate fertilizer P response model and yield goal must be selected.

Potential profitability increased with increasing the average soil test value from 9 ppm to the 13 ppm. As soil test P level increased from 13 to 18 ppm, profitability decreased. It should be noted that different fields have different soil test P frequency distribution, which will influence the results. These findings were modeled after a field with the P contour map shown in **Figure 2** and the P frequency distribution shown in **Figure 1**. Interactions among average soil P level, P model, and profitability were the direct response of several factors.

**First**, when an appropriate rate of fertilizer is uniformly applied to a field having a soil test P level in the medium category, only areas that have soil test P levels in the low or very low soil test P levels are under-fertilized. In under-fertilized areas, 50 to 60 percent of the fertilizer needed by the crop might be applied by a conventional treatment. Therefore, yield losses may be minimal due to the differential crop response to fertilizer (**Figure 3**).

However, if the field soil test P level is high or very high, fertilizer recommendation will be minimal. Under these conditions, significant yield losses can occur in areas where soil test P levels are in the low to medium ranges (**Figure 3**).

**Second**, net returns are directly related to the expected crop response to additional fertilizer P. If the expected response is large, precision management will increase profitability. However, if the expected response is minimal, it is likely that profits will be minimal or a loss may be realized. For example, if you invest money in the bank at -1 percent interest, the more you invest the more you lose.

**The third factor** concerns fields that possess nutrient “hot spots” such as old manure piles or feedlots. In this situation, if soil samples taken from P hot spots are included in the composite sample, the resulting soil test P value will not represent the actual amount of P in the field. Under these conditions, the reported soil test P will lead one to believe that the overall soil test P of the field is greater than it actually is. In reality, only small areas of the field will have elevated P levels, while the rest of the field may lack sufficient P to produce an optimum crop yield. Basing a P rate on this soil test would result in a substantial portion of the field being under-fertilized. ■

**Table 1. The potential impact of different fertilizer response curves, average soil test value, and grid sampling on profitability.**

| | Average soil P and soil P category | | | |
|---|---|---|---|---|
| Yield increase[1], % | 9 (medium) | 13 (high) | 16 (v. high) | 18 (v. high) |
| | - - - - - - - - Profit ($/A 2 years) - - - - - - - - | | | |
| 15 (small) | -6.42 | 1.31 | -4.65 | -8.25 |
| 25 (medium) | -0.02 | 12.43 | 5.12 | -1.74 |
| 35 (high) | 6.34 | 22.72 | 11.72 | 0.43 |

[1] Maximum yield increases for soil testing in the very low P category.

## References

Gerwing, J. and R. Gelderman. 1996. Fertilizer Recommendation Guide. Cooperative Extension Service. South Dakota State University. Brookings, SD.

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