Agronomic and environmental soil testing for phosphorus and threshold levels in soils

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Agronomic and environmental soil testing for phosphorus and threshold levels in soils

Abstract
Greater knowledge of soil phosphorus (P) is needed to develop application recommendations for Iowa farmers. This project provides more data on the topic by addressing both agronomic and water quality issues.

Keywords
Agronomy, Agricultural and Biosystems Engineering, Nutrient management

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences | Bioresource and Agricultural Engineering | Soil Science

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Abstract: Greater knowledge of soil phosphorus (P) is needed to develop application recommendations for Iowa farmers. This project provides more data on the topic by addressing both agronomic and water quality issues.

Question & Answer

**Q:** How can farmers apply phosphorus to greatest advantage for their operations?

**A:** Variable-rate and deep P placement are two technologies that have great promise for better nutrient management and are becoming more accessible to farmers. The results of this project showed that the main justification for their adoption is to manage P better and not necessarily to increase yield, at least in the short term. Therefore, the producer should carefully consider costs and environmental benefits before adopting these technologies. Another useful result is that farmers should trust the P index and in particular watch for factors that increase risk of P loss with surface runoff. Major efforts should be directed at reducing soil erosion and surface water flow, placing P deep into the soil, and avoiding overly high soil-test P values. High soil-test levels and practices that produce little P loss through tile drainage can have major impacts on P loss and water quality when the risk of soil erosion and surface runoff is high.

**Background**

Researchers wanted to acquire knowledge about aspects of soil testing for agronomic and environmental purposes that are required to develop environmental soil phosphorus (P) thresholds and components of a P risk index. These guidelines can be used by producers, Extension staff, and regulatory agencies.

Three primary objectives of the project were to:

1. Study the impact of fertilizer and manure applications on soil P measured with routine soil tests and new environmental soil test methods that emphasize an assessment of potential P losses to the water supply,
2. Establish relationships between values of routine and environmental P tests with P losses through water runoff or tile flow for selected manure/fertilizer management systems, and
3. Conduct an on-farm evaluation of the impact on crop yields, soil P levels, and soil P variation over a field when P fertilizer and liquid swine manure are applied using variable-rate technology.

**Approach and methods**

Several field experiments were conducted at ISU Experiment Station farms and on private farms using field-scale methods. Soil P was measured with various routine agronomic tests and recently proposed environmental P tests. Five long-term trials evaluated the effects of P application methods on crop yield and soil P for no-till and chisel-disk tillage systems. Three long-term, on-farm trials assessed the value of variable-rate application of fertilizer and liquid swine manure to achieve better P distribution over the area of the field. Three other long-term trials were employed to evaluate the impact of fertilizer and manure P applications on total and dissolved P loss through tile drainage and surface runoff.

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Agricultural and  
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**Budget:**
$24,000 for year one  
$24,000 for year two  
$24,000 for year three
Results and discussion
Research confirmed a very low probability of corn and soybean yield response at soil test P levels higher than 16 ppm. This level is the lower range (16 to 20 ppm) of the current optimum soil-test P interpretation class in Iowa State University recommendations for most Iowa soils for which maintenance fertilization is recommended. It also verified that the P placement method has little or no effect on grain yield. However, deep banding or injecting P greatly reduces the accumulation of P at or near the soil surface when compared with applications to no-tilled soils or soils managed with chisel-disk tillage.

Application of P fertilizer or P-based rates of liquid swine manure with variable-rate technology seldom results in significant yield increases when compared with the traditional uniform application rate method, however, the variable-rate method manages P application better. Less P is applied to the fields and large-scale within-field soil P variability is always reduced. Although variable-rate application is not without error, less P is applied to field areas that may already test at above optimum levels for crops. When comparing variable rate application of fertilizer to manure, there was no significant difference in reducing soil P test variability. This result was unexpected and shows that liquid swine manure can be applied as effectively as P fertilizer when care and appropriate equipment are used.

Phosphorus loss with surface runoff increases when soils are higher in P. Incorporation of P by injection into the soil drastically reduces dissolved and total P loss. The rise in P loss with increasing levels of soil-test P varied with the field and year, and sometimes was linear and other times was exponential. Recently proposed environmental P tests did not prove to be more useful than common agronomic soil tests to establish relationships between soil-test P and P concentration in surface runoff.

Phosphorus loss with tile drainage rose with increasing P application rates and the amount of soil-test P in the surface soil. However, P concentration within tile drainage was very low and unrelated to soil-test P until tested P values exceeded 80 to 100 ppm. At these high soil test levels (four to five times higher than optimum levels for crops), the annual amount of P loss to tile drainage remained very low. The environmental P soil tests were no more useful than common agronomic soil tests to establish relationships between soil-test P and P concentration in tile drainage.

Increasing soil test P to levels between two and four times the optimum level for crops increased the P loss from fields, but no clear threshold for identifying sharp increases or decreases in P loss could be established across all conditions. This result supports consideration of soil-test P effects on P loss within a comprehensive P index.

Conclusions
The placement method used to apply P fertilizer or manure P has little or no effect on grain yield. However, deep banding or injection reduces the accumulation of P at or near the soil surface compared with applications over the surface of the soil without immediate incorporation. Data from on-farm strip trials suggest that application of fertilizer or liquid manure with variable-rate technology seldom results in significant yield increases when compared with the traditional uniform application method. However, the variable rate method is more efficient at managing nutrient application because soil-test P variability was reduced. In general, the variable rate method applied less P to fields that already tested above optimum crop levels for P. Injecting swine manure into the soil drastically reduces the loss of dissolved and total P in comparison with the process of applying broadcast manure in the winter and not incorporating it until spring. There were no major differences between agronomic and environmental P tests in predicting P loss with tile drainage or surface runoff.
Impact of results
The results provided no conclusive evidence for a need to adjust current tests or equations in the Iowa P index for the soils and conditions studied. Agronomic soil tests commonly used by farmers can be employed together with factors affecting P delivery for predicting risk of P loss from fields. Overall, the study offered further information to adjust agronomic and environmental P management practices and to validate components of the Iowa P index.

Education and outreach
Information from the project has been shared with producers at 27 ISU Extension field days and winter meetings. Preliminary results were offered to the farm press in numerous interviews. The investigators made presentations to the Natural Resources Committee of the Iowa Senate, the Agriculture Committee of the Iowa House of Representatives, the Iowa Department of Natural Resources and the Iowa Farm Bureau Federation.

Partial results from the project have been published in *Agronomy Abstracts* and in several ISU Extension publications. Manuscripts are being prepared for *Agronomy Journal* and *Soil Science of America Journal*.

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