Module 10: Economics of Nutrient Management and Environmental Issues

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The Fertilizer Institute
Nourish, Replenish, Grow

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Extension and Outreach

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Introduction

- The objective of nutrient management is to select the proper nutrient rate, placement, source, and timing for profitable and environmentally safe crop production.

- Nitrogen (N), phosphorus (P), and potassium (K) are usually the largest fertilization expenses in crop production.

- Unneeded nutrient application or poor efficiency results in increased production cost and lost potential economic return.

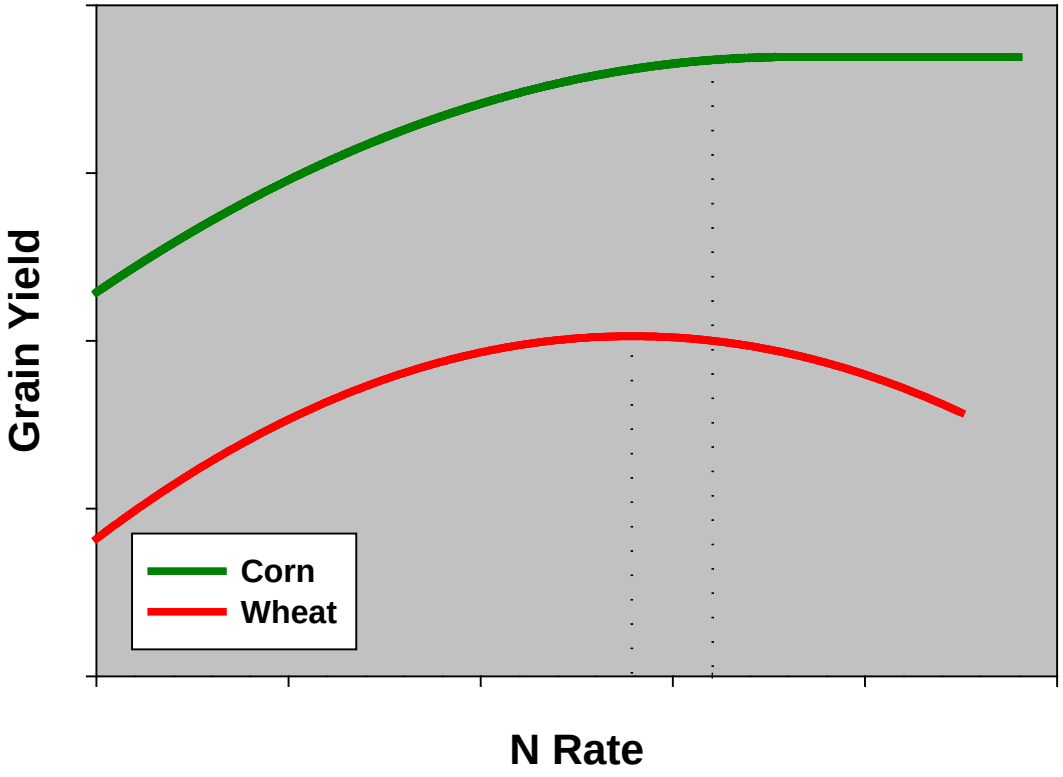
- Nitrogen and P losses from agricultural systems have been identified as likely contributors to:
  - elevated surface or groundwater nitrate (NO_3) concentrations
  - impairment of freshwater bodies
  - hypoxia of coastal waters

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

- Proper N management involves integration among adequate rate, source, timing, and placement.
- When managing N, interactions among these four factors are more important than for any other nutrient.
- Several N management options are available to help maximize profit and minimize environmental issues.
- Of in-field management practices, rate often has the greatest influence on relative losses of NO_3-N.

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Rate



Schematic representation of typical N response curves for corn and wheat. The vertical dashed lines indicate the N rate at which the maximum agronomic crop yield is reached.

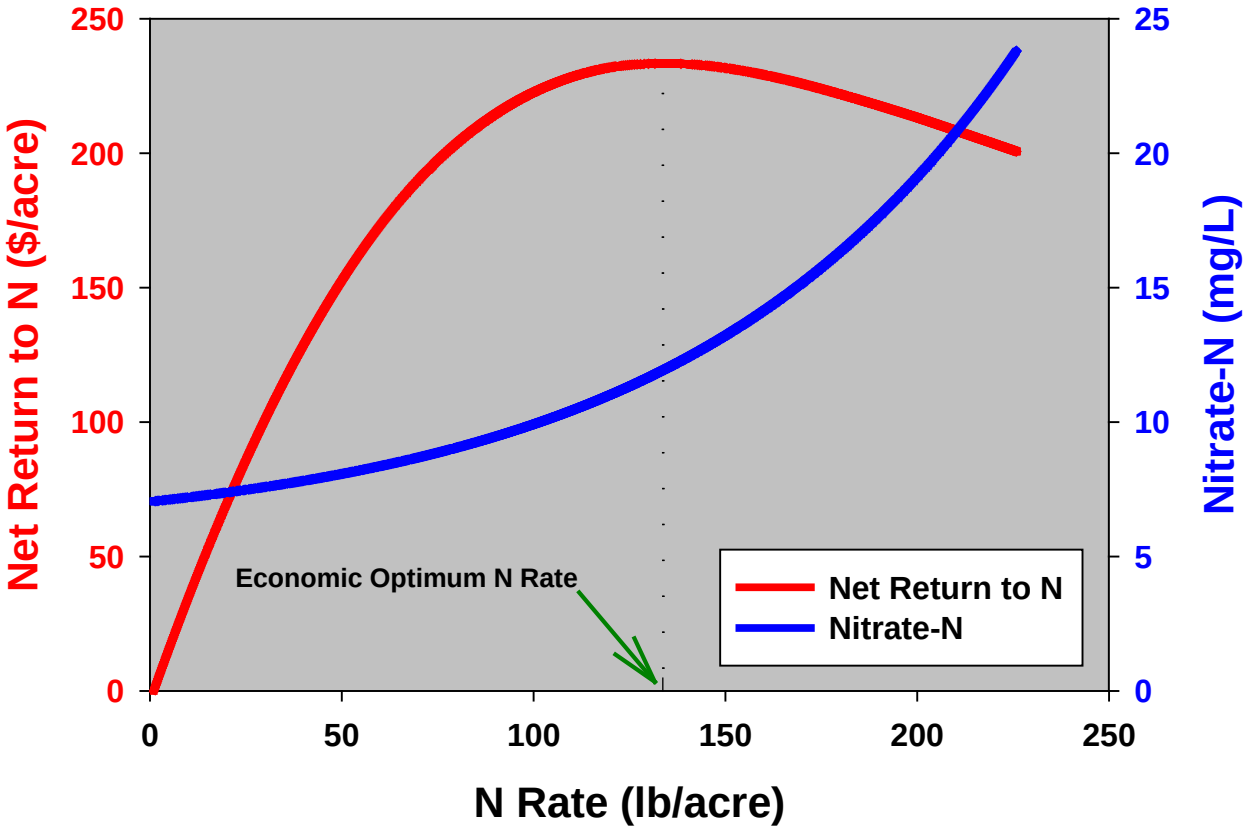
Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Rate

- Producers should apply N rates that return the most profitable yield, where the yield gain from N application will more than pay for the invested N.
- Applying N at rates that produces maximum yield always causes lower net return.
- Applying a N rate to produce maximum yield, or even greater rate, will result in greater N loss than application at the most profitable rate.
- Economic and environmental perspectives need to be considered together when making N management decisions.
- Applying more N than needed by crops to assure maximum yield is not considered an acceptable management practice.

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Rate



Importance of using economic optimum N rates for greatest profit and minimizing nitrate-N loss (via subsurface tile drainage).

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Rate

- There is potential to affect NO_3 losses through change in N rate.
- However, the success relative to water quality is not likely to be achieved solely through rate adjustment.
- If N application rates being used are above the EONR, then producers can gain economically by reducing rates to those levels.
- If producers are already applying N at the EONR, reduction below those rates will impose an economic penalty.

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Timing and Placement

- Reduction in NO_3-N concentration in tile drainage water can be observed with use of a nitrification inhibitor or moving from fall to spring applied N fertilizer or manure with high ammonium content.
- Sidedressing N in corn can sometimes increase N use efficiency and reduce losses.
- In small grain crops, split N applications often produce better results.
- Research shows a reduction in NO_3-N concentration in tile drainage water when moving from fall to spring/split applied N fertilizer.
- In season N applications also allows rate adjustments through soil sampling or crop canopy sensing.

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Nitrogen Source

- There is little difference in NO_3 leaching or crop yield when using different sources of fertilizer or manure.

- Using slow or controlled release fertilizer sources may have an impact on improved crop efficiency and NO_3 leaching.

- Some manure sources high in solids content may have added benefits, such as:
  - soil organic carbon
  - soil structure
  - surface runoff

Nitrogen Management Considerations for High Profitability and Low Environmental Risk

Other practices

- Cover crops have the potential to reduce NO_3 leaching by taking up water and NO_3 during the time between crop maturity and planting the next crop.
- Inclusion of perennial crops or crops that require minimal N fertilization in the crop rotation can have significant effect on reducing NO_3 losses.
- In extreme cases, land may need to be taken out of crop production or converted to permanent pastures.
- Establishment of buffers at the edge of the fields, wetlands, or bioreactors to treat tile-flow water would also be complementary out-of-field strategies.
- These out-of-field practices have potential for greater impact on reducing NO_3 losses than in-field management practices.

Phosphorus Management for High Profitability and Low Environmental Risk

- Proper management of P applications is a key for optimizing yield, profitability, and water quality.

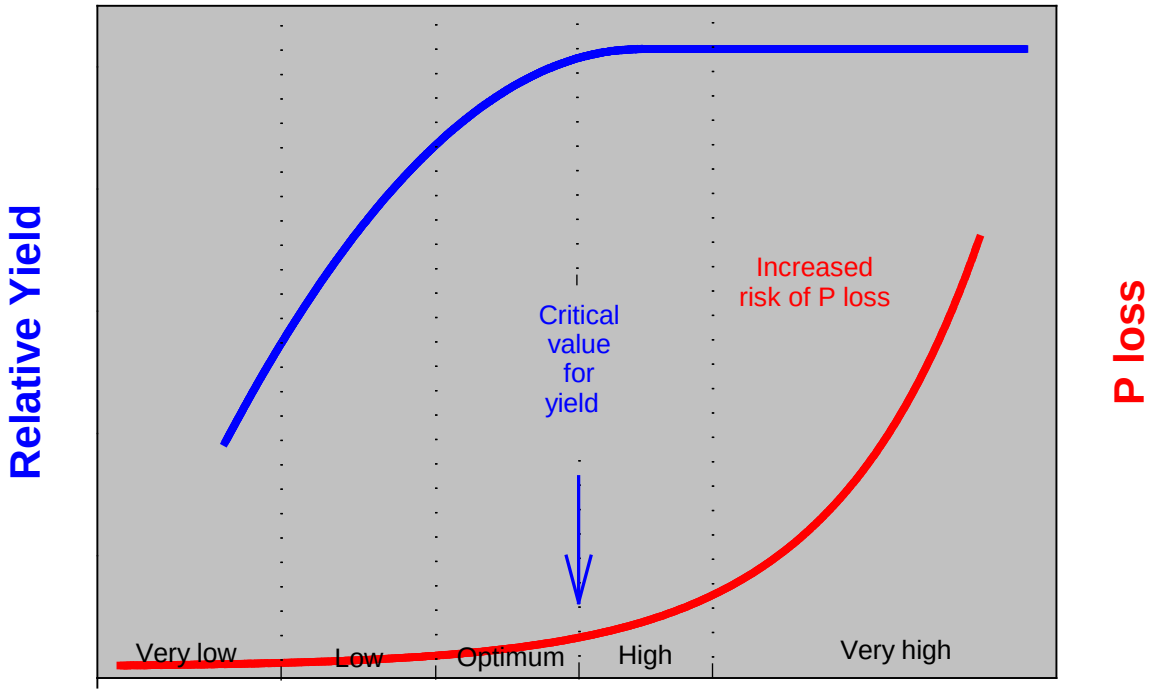
- Key P management issues involve:
  - knowing the optimum soil-test P level
  - applying fertilizer to avoid deficiencies
  - achieving the optimum soil-test level over time

- In most cases, the recommended fertilizer P application rates are those that maintain desirable soil-test P.

- The soil-test P level a farmer maintains is the most important issue for economics and water quality.

Phosphorus Management for High Profitability and Low Environmental Risk

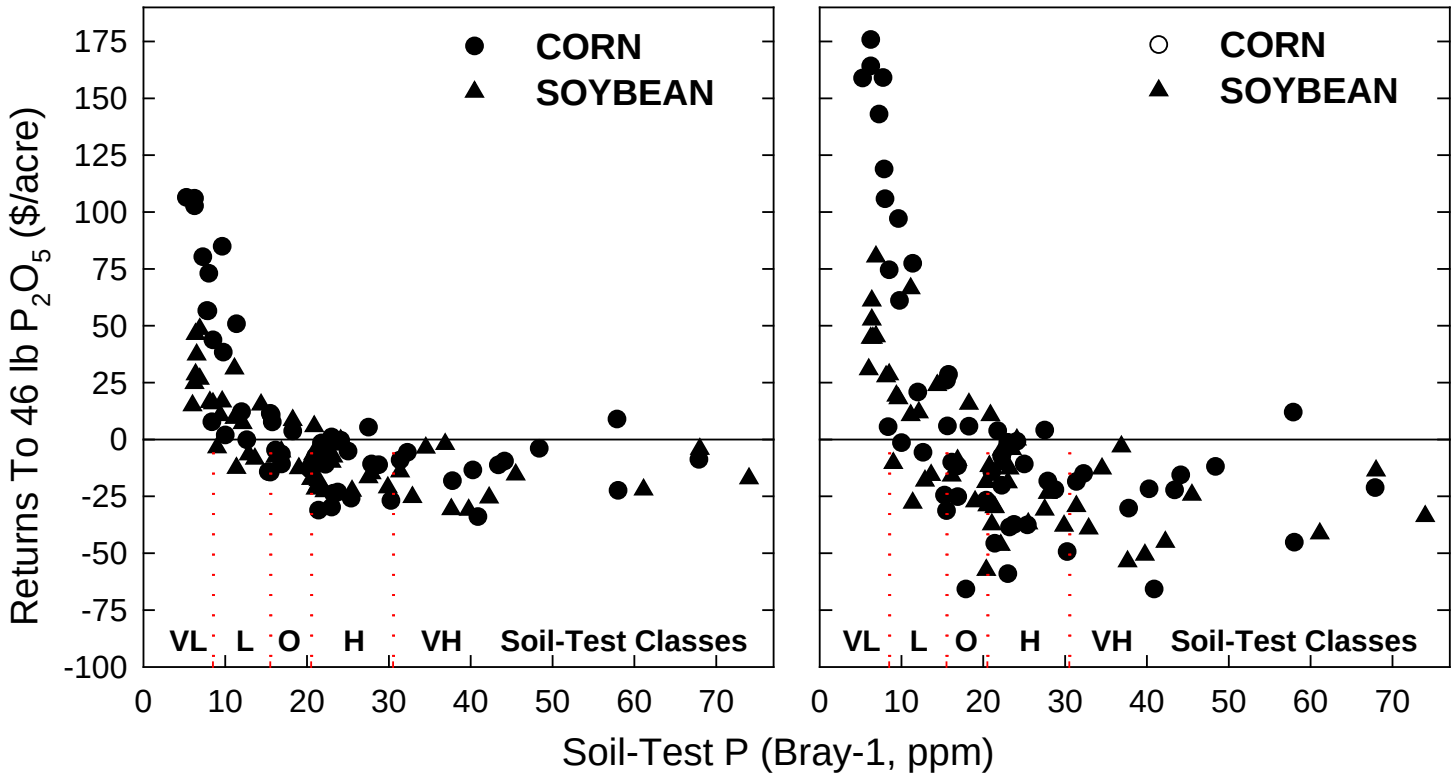
Soil-Test Phosphorus Level, Crop Yield, and Profitability



Schematic representation of the general relationship between relative crop yield and P loss with runoff.

Phosphorus Management for High Profitability and Low Environmental Risk

Soil-Test Phosphorus Level, Crop Yield, and Profitability



Net returns to P for different soil-test P levels and crop/fertilizer prices. Adapted from A.P. Mallarino, Iowa State University.

Phosphorus Management for High Profitability and Low Environmental Risk

Phosphorus Management and Water Quality

- Phosphorus is lost from fields as:
  - dissolved forms in surface runoff or subsurface drainage
  - phosphorus bound to soil particles with soil erosion

- Soil and water conservation practices are often more important than P management practices for controlling P loss from fields.

- Phosphorus risk indices have been developed that consider many factors to classify fields or field areas according to risk of P loss.

- These indices are practical quantitative tools that provide reasonable estimates of P loss risk.

- They use an integrated approach to consider soil and landscape features as well as soil conservation and P management practices.

Phosphorus Management for High Profitability and Low Environmental Risk

Phosphorus soil-test level

- Interpretation of soil-test P values for water quality issues must be different than for crop production.

- Soil-test levels higher than adequate for crops may increase the risk of P loss and water quality impairment.

- In general, the increasing risk of P loss becomes consistent for soil-test values higher than about 30 to 50 ppm.

Phosphorus Management for High Profitability and Low Environmental Risk

Phosphorus timing

- For many crops and soils, P application timing does not have a significant effect on crop yield.

- However, the time of P application during the year and also the time between the application and a runoff event can influence P loss.

- The risk of P runoff can be reduced by applying P when runoff events are unlikely.

Phosphorus Management for High Profitability and Low Environmental Risk

Phosphorus source

- Research has shown P loss is less from manure applications compared to fertilizer.

- Manure P is typically less soluble in water than fertilizer P, and that results in less dissolved P in runoff.

- Manure application can result in reduced erosion and surface runoff due to increased water infiltration when manure contains considerable bedding.

Phosphorus Management for High Profitability and Low Environmental Risk

Phosphorus placement

- There is little to no differential response to P placement methods for most crops in soils with low P-fixing capacity and where initial soil-test P levels are not very deficient.

- Phosphorus banding is generally recommended in:
  - severe P-deficient conditions
  - high clay soils
  - high fixing soils

- From a water quality perspective, P banding into soil or injection can reduce always reduces P loss by placing P below the soil surface.

- Runoff P loss may or may not be reduced with incorporation or injection because of potentially increased soil erosion.

Phosphorus Management for High Profitability and Low Environmental Risk

Variable rate phosphorus application

- Dense within-field soil sampling has shown very large spatial variability of soil test P.

- Precision agriculture technologies facilitate application of fertilizer and manure at rates adequate for different parts of a field.

- Grid or zone soil sampling methods and with variable rate application:
  - may or may not increase crop yield compared with traditional methods
  - reduces spatial variability by minimizing P application to high-testing areas within fields
  - often reduces the recommended/applied P rates

Phosphorus Management for High Profitability and Low Environmental Risk

Tillage and phosphorus incorporation into the soil

- Tillage practices generally have an impact on soil erosion.

- Research suggests that less P loss occurs with minimum tillage than conventional tillage systems, but effectiveness is highly site-specific.

Phosphorus Management for High Profitability and Low Environmental Risk

Cover crops

- Reduce P loss mainly by reducing soil erosion, but also due to P uptake.
- A cover crop can increase soil stability from root growth and protect the soil surface from raindrop impact.
- In northern regions the efficacy of cover crops is diminished because there is no winter growth, and growth in the fall and early spring can be limited.

Phosphorus Management for High Profitability and Low Environmental Risk

Sediment control structures, contour or strip cropping, buffers, and wetlands

- Terraces and ponds keep runoff water and sediment in the field.
- Contour cropping and strip cropping that alternate summer and winter grain crops or grain crops with hay reduce slope length and runoff volume and hence soil erosion and surface runoff.
- Buffers reduce sediment transport from fields, stabilize stream banks, and remove P from runoff water by trapping sediment.
- Installed wetlands are designed more to reduce NO_3, but can also be effective at reducing dissolved P.

Summary

- Sound nutrient management permits efficient and profitable crop production while reducing water and air quality degradation.

- A nutrient management plan is a site-specific decision process that integrates appropriate rate, source, timing, and placement.

- Nutrient management can be complex or simple, depending on the specific situation.

- Nutrient management plans need to be flexible, and incorporate within and out-of field practices for greatest impact on water quality improvement.

- Some amount of nutrient loss will occur even when the best nutrient management practices are employed, but excessive losses can be curtailed with implementation of a sound plan.

Summary

Nitrogen management:

- Need to consider the rate of application, and apply rates that provide maximum return to the N investment.
- Applying economic optimal rates maximizes return and reduces N effects on water quality.
- Other management practices need to focus on improving crop N use (yield production, and limiting NO_3 accumulation or keeping NO_3 in the soil system).

Phosphorus management

- The soil-test P level should be kept at optimal ranges for maximum economic crop yield
- Application methods and timing should optimize P use efficiency and economic profitability, while minimizing the risk of excess P loss from fields.
- All practices that influence erosion and water loss from fields need to be considered instead of simply addressing soil-test P and P application.