Evaluating and Updating Fertilizer BMPs in the U.S.

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International Plant Nutrition Institute
--:--
Foundation for Agronomic Research
USDA-NRCS-CIG Project

- 3-Year Project--2005-2008
- Fertilizer Best Management Practices
- 6 Major cropping systems in 6 states
- Stakeholder Teams to provide guidance
- IPNI Regional Directors as Team Leaders
USDA-NRCS Conservation Innovation Grant (CIG)

Development and outreach of updated Fertilizer Best Management Practice (BMP) Guides using latest agronomic science and site-specific technology

1. IPNI Regional Directors as team leaders
   • Straw-man BMP Guides for each system (2005)
2. Stakeholder teams in each region
   • Develop new science-based, technically-current BMP Guides (2006-2007)
3. Train-the-trainer sessions (2007) for NRCS, Extension, CCAs, etc.
4. National Fertilizer Management BMP Conference
   • Part of InfoAg 2007
   • Promote adoption of new BMPs
6. Maintenance plan for after project
USDA-NRCS CIG Project

- Create BMPs for Fertilizer Management
  - **West** – *Potatoes / Idaho*
  - **Northern Great Plains** – *Spring wheat / North Dakota*
  - **Central & Southern Plains** – *Irrigated corn / Kansas*
  - **Northcentral** – *Corn & soybeans / Illinois*
  - **Southeast** – *Cotton / Arkansas*
  - **Northeast** – *Forages / New York*

- Create outreach & training programs
  - NRCS field staff
  - Extension field staff
  - CCAs, Dealers, Consultants
  - Community Colleges
  - Universities

- Recommendations for BMPs for EQIP, CSP, etc.
Project Objectives

1. Compile updated BMPs for fertilizer use for six selected major cropping systems.
2. Promote adoption of BMPs into standard training curricula and official recommendations.
3. Hold a Fertilizer Management BMP Conference, as a part of **InfoAg 2007**, to
   - **Present project results on new BMPs and their adoption**
   - **Target farmers and their advisers, fertilizer dealers, NRCS staff, and Extension staff.**
   - **Provide to participants information and training materials to use to train others.**
4. Work with NRCS state staff and Technical Guide committees to incorporate new applicable BMPs into the respective Field Office Technical Guides (FOTGs) and other publications.
5. Develop and maintain a website to get the information and documentation to farmers, their advisers, and their input suppliers, to help implement the revised Fertilizer Management BMPs.
CIG Activities

Stakeholder Meetings
- New York--7
- Arkansas--2
- Illinois--1
- North Dakota--2
- Kansas--2
- Idaho--1

Conferences/Workshops
- InfoAg Northwest
- InfoAg Midsouth
- InfoAg 2007
- 9th Int’l Conference on Precision Agriculture

• Presentations
  - SWCS Annual Meeting 2007
    • Exhibit
    • GIS Showcase Poster
  - SWCS Annual Meeting 2008
    • Oral Presentation
    • GIS Showcase Poster
    • Exhibit
  - FAR/IPNI Research Showcase
  - ASA A-9 Symposium
CIG Project Deliverables
Global Framework for Fertilizer BMPs

ECONOMIC
- Productivity
- Profitability
- Net profit
- Return on investment
- Adoption
- Soil productivity
- Yield stability

ECOLOGICAL
- Resource use efficiencies:
  - Nutrient
  - Water
- Yield
- Nutrient balance
- Nutrient loss
- Soil erosion
- Biodiversity
- Ecosystem services

SOCIAL
- Time
- Place
- Biological & Social Environment
- Working conditions
- Water & air quality
- Nutrient use efficiency:
  - Water
  - Nutrient
  - Labor
  - Energy

Global Framework for Fertilizer BMPs

Source
Rate
Place
Profits

Productivity

Quality
Energy
Labor

Biological & Social Environment

Ecosystem services

Resource use efficiencies:
- Nutrient
- Water

Yield

Soil productivity

Water & air quality

Global Framework for Fertilizer BMPs
Publications from CIG Project

- 5 Regional PPI News & Views
- BMPs for Profitable Fertilization of Potatoes
- Fertilizer BMPs for the Northern Great Plains – How to You Measure Up?
- Conserving Resources and Building Productivity…A Case for Fertilizer BMPs in the Great Plains
- Fertilizer BMPs for Cotton in the Midsouth— How Does Your Farm Measure Up?
- BMPs for Fertilizer Use on Dairy Farms
- Better Crops issue about Fertilizer BMPs
- InfoAg program 2007

- GHG Literature Review (completed 2007)
- GHG Fertilizer Nitrogen BMPs
- Nutrient Harvest
  AgriBriefs/Plant Nutrition Today 2006-2008
- Potato Fertilization
- Small Grain Fertilization publication
- BMPs for Fertilizers on Northeastern Dairy Farms
- Fertilizing Irrigated Corn
- PFU Cards, Northcentral
- Cotton ppt (as CD)
- NURD-Lite
Better Crops: BMP Focus for CIG

- BETTER CROPS WITH PLANT FOOD
  XC (90) 2006, No. 2

- Fertilizer Best Management Practices - Making the Best Better
  Paul E. Fixen and Harold F. Reetz

- Conserving Resources and Building Productivity... A Case for Fertilizer BMPs
  Mike Stewart

- Fertilizer BMPs for Cotton in the Midsouth
  Cliff Snyder

- Best Management Practices for Fertilizer Use on Dairy Farms
  Tom Bruulsema

- Best Management Practices for Profitable Fertilization of Potatoes
  Rob Mikkelsen

- Fertilizer BMPs for the Northern Great Plains - How Do You Measure Up?
  Adrian Johnston

- Fertilizer Nitrogen BMPs for Corn in the Northcentral Region
  Scott Murrell
Regional BMP Publications - Examples

Fertilizer BMPs — Suggested Practices for Semiarid North Dakota
By Tony Jensen, Adrian Johnstone, David Franzen, and Jon Nita

We are having a lot about best (beneficial) management practices (BMPs) these days. Much of this interest in BMPs for agriculture is the increasing awareness that we must manage our soils and landscapes to have a large impact on the surrounding environment. As stewards of the land, northern Great Plains farmers have implemented soil conservation practices that ensure many other resources (soil, water, and wildlife) are conserved as well. The resulting restoration in soil and water quality and nutrient conservation have improved yields, increased crop yields, and reduced environmental impacts.

Fertilizer nutrients play a major role in meeting the crop yield and quality goals of modern agriculture. With reduced tillage and crop rotation systems many nitrogen inputs have been able to extend crop rotations, reduce the use of fertilizer for maintenance, and increased the need to use nutrients removed by the increased cropping intensity. How we handle these fertilizer inputs provides the foundation for fertilizer BMPs and positive economic returns from fertilizer use.

BMPs focus on site-specific recommendations, intensive management, improved efficiency and environmentally sound use of crop production inputs. It is important that those management practices be proven in research and verified through field evaluation. It is also important to remember that BMPs are site-specific; they vary from one region to the next and vary on same land. The crop must adapt to the local soi, climate and crop patterns and management expertise. Ultimately, it is down to the farmer and the knowledge of the local soil and climatic conditions that dictate the success of a particular BMP on a specific field.

The way we handle fertilizers can have a major impact on the productivity of nutrient use by crops and potential impact on the surrounding environment. In many instances we are working to improve fertilizer efficiency by increasing the pounds per acre for each unit of nutrient applied without sacrificing yield potential. This is especially true for N. The major nutrient removed from the soil by most of our annual grain crops is nitrogen. Efficient fertilizer management means paying close attention to the "Three Rights" of fertilizer application. These four general management practices provide the effective and responsible use of fertilizer nutrients. These are:

1. The Right Rate
2. The Right Form or fertilizer
3. The Right Place
4. The Right Time

Applying these general principles will maximize nutrient transport from fields and minimize crop uptake and utilization. Within each of these general categories there are a number of specific practices that we could classify as BMPs.

1. Right Rate of Fertilizer

The amount of fertilizer to apply is the most common question asked by a farmer when selecting a soil test report, or trying to make a crop planting decision. Soil testing is the key to making a fertilizer rate decision. Without data, a guess is often used to make a fertilizer rate decision.

2. Right Form of Fertilizer

Fertilizer form refers to the physical form or state of the fertilizer. Fertilizer form is related to both the chemical properties of the fertilizer and the physical form of the fertilizer. The form of fertilizer impacts how the plant absorbs the nutrients from the fertilizer.

3. Right Place of Fertilizer

The placement of fertilizer is the most critical component of effective soil fertility management. There are many factors to consider when determining the right place for fertilizer, including the type of crop, soil type, and climate conditions.

4. Right Time of Fertilizer

The timing of fertilizer application is critical to the success of the fertilizer program. The right time for fertilizer application depends on the crop, soil, and climate conditions.

Fertilizer BMPs — Best Management for Fertilizers on Northwestern Dairy Farms
By Tine W. Bjerregaard and Quicke Simmerman

In the past 10 years, many dairy farms in the humid temperate zone of northeastern North America have implemented best management practices (BMPs) for manure and fertilizer to address nutrient transport and management to protect water quality. This introductory guide focuses on fertilizer BMPs: applying the right rates at the right times, and in the right places.

Large amounts of nutrients can be removed from the field in the form of runoff. Nutrients are retained with manure and fertilizer application, and for legumes, also through N fixation. If the amount of nutrients applied exceeds crop nutrient requirements, the difference will either be lost to the environment or accumulate in the soil. In the humid temperate zone of northeastern North America, overwintering N from one year to the next ranges from small to specific soil and site of variation in the soil. This is the result of nutrient incorporation to the soil at the end of the growing season. Simpler P and K, must often contribute to a increase in soil test levels.

While dairy farming is associated with increases in soil test P levels overall, this is not all farms fields test above the agronomic optimum. The proportion of soils exhibiting P in northeastern North America ranges from 10 to 20% in Delaware and Pennsylvania to about 30% in New York, even. But 20-50% of the P in soil is also available to the crop. If the nutrient is not used, then this can become a deficiency for the crop. The availability of N for crop growth is also affected by the amount of available N in the soil.

Low levels of organic matter can impact the growth and development of crops. Organic matter levels are related to the amount of organic matter in the soil. Organic matter levels are also related to the amount of organic matter in the soil.

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Regional BMP Publications - Examples

Kick-Off the Fall Season with Fertilization Management / Fall 2005

Fertilizing for Minimum Impact on Water Quality

Dr. Tom Brudzinski
Northeast Region Director, PFL-PNC

Fall is the best time to take soil samples. It can also be a good time to apply some fertilizer and manure, but the risk to water quality needs to be managed. Using a phosphorus (P) index, that risk can be managed for the maximum benefit to soil and crop.

Fall is the time when soil fertility management begins. Whether or not you apply fertilizers in the fall, it’s essential to get started in the planning to ensure that next year’s crops are fertilized:

* at the right rate
* in the right place
* at the right time

This is the right time to begin making decisions!

Soil Sampling

The starting point is diagnosis. Fall is an excellent time to take soil samples. It can also be a good time to apply some fertilizer and manure, and to test soil samples in advance of winter, including plant analysis. All these sources of information, combined with your plans for crops, determine next year’s nutrient needs.

Why sample in the fall?

* After harvest, soil test levels don’t change much.
* Get results in time to plan well for the next crop.

Many labs are less busy in the fall than in the spring.

Some don’t sample in the fall because they haven’t yet decided what to grow next spring. But that really shouldn’t be a reason not to sample. Some labs providing results on the Internet may allow you to change the crops as the fall progresses.


table: Soil Test Results

<table>
<thead>
<tr>
<th>P and K applied</th>
<th>No-Till</th>
<th>Fall plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>60</td>
<td>124</td>
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<tr>
<td>Fertilizers</td>
<td>165</td>
<td>155</td>
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<tr>
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</table>

IPNI - International Plant Nutrition Institute
Fertilizing for Irrigated Corn—
Guide to Best Management Practices

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  Dr. Dale Leben

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  Dr. Larry Madole and Dr. Andew Reussenne

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  Dr. Keith Lamson

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  Dr. W.B. (Benny) Gordon

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  Dr. Alex Baylis

Chapter 7. Starter Fertilizer ............................................. 7-1
  Dr. W.B. (Benny) Gordon

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  Sensor Technology .................................................... 8-1
  Dr. David R. Mengel

Cover photo courtesy of Mark Fehringer

A publication is one of a series prepared by cooperation with the staff of the International Plant Nutrition Institute (IPNI). It is not approved for use in the publication of materials. The International Plant Nutrition Institute (IPNI) is a non-profit organization that’s mission is to improve the productivity of the world’s agricultural systems by delivering the science to improve the health and productivity of plants. Its mission is to improve the productivity of the world’s agricultural systems by delivering the science to improve the health and productivity of plants. It is a nonprofit, membership-based organization that works with the scientific community, education community, and the public at large to: 1) increase the use of science and technology to improve agricultural systems worldwide, and 2) increase the capacity of developing countries to improve the productivity of their agricultural systems. It is a nonprofit, membership-based organization that works with the scientific community, education community, and the public at large to: 1) increase the use of science and technology to improve agricultural systems worldwide, and 2) increase the capacity of developing countries to improve the productivity of their agricultural systems.
On-line CEU Module for CCAs
Crop Nutrition Series

• Slide sets
• Presenter notes
• References
Nutrient Management BMPs for Protecting Production and Natural Resources

H.F. Reetz, Jr., Q.B. Rund, T.S. Murrell

FAR website:

www.farmresearch.com
NRCS Grant: FAR Leads Development of Fertilizer BMP Guidelines

NRCS Grant: FAR Leads Development of Fertilizer BMP Guidelines

FAR has been awarded a Conservation Innovation Grant from USDA-NRCS to develop a set of revised FERTILIZER BEST MANAGEMENT PRACTICES (BMPs) for six major cropping systems. A Stakeholder Team in each region, led by the respective Potash & Phosphate Institute (PPI) Regional Director, will review current fertilizer management and propose how new technology, current research, and farmer experience can be incorporated into updated recommendations. The project includes demonstrations and training sessions, publications, and website delivery to help get the new BMPs into common practice.

Stakeholder Teams

The Foundation for Agronomic Research (FAR) has been awarded a Conservation Innovation Grant (CIG) from the USDA-NRCS to develop a set of Best Management Practices (BMPs) for fertilizer management in 6 different major cropping systems in the U.S. FAR will work closely with the Potash & Phosphate Institute (PPI) in leading and coordinating the development of these BMPs, and in providing educational materials and programs to demonstrate and implement these BMPs. The project will operate from 2005 through 2008.

Stakeholder Teams will be organized in each region, chaired by the respective PPI Regional Directors, to review current accepted fertilizer BMPs. The PPI Directors have assembled the current BMPs being used in their regions. The Team will discuss and recommend ways to help incorporate modern technology and current research results into a revised set of BMPs for fertilizer management in that cropping system.

Each Team will be composed of a cross-section of local stakeholders, representing farmers (at least four per state), NRCS staff, Extension staff, local agribusinesses, crop consultants, and others as appropriate for the region. The Teams will meet at least twice a year during the project to review materials being developed, and to advise the project leaders.
International Conference on Precision Agriculture

- Biennial research conference
- IPNI & FAR Cooperating with Colorado State University
- Close to 500 participants from 48 countries
- Scientific presentations—oral and poster
- A to Z applied sessions (CIG project outreach)
- Exhibits
- Tours
- www.icpaonline.org

10th ICPA – July 18-21, 2010
Denver, Colorado
Working with Farmer Yield Data
Yield Data Analysis

I have all these yield data, what can I do with them?
Investigating consistency

- Binary grids created for each year
- Binary grids added together
  - Example: 2 years of corn net returns
  - (0,1) grid 1998 + (0,1) grid 2000
  - Interpretation of results:
    - 0 = corn not profitable in either year
    - 1 = corn profitable in 1 of 2 years
    - 2 = corn profitable in 2 of 2 years
In what areas of the field has corn been consistently profitable?

\[ \text{con}([\text{net profit 1998}] > 0, 1, 0) + \text{con}([\text{net profit 2000}] > 0, 1, 0) \]
In what areas of the field has corn been consistently profitable?
In what areas of the field have soybeans been consistently profitable?

Soybeans 1999, 2001

Red: 0 / 2
Yellow: 1 / 2
Green: 2 / 2
Nutrient Budgeting on the Farm
Software Used for Many Procedures

- Microsoft Excel
  - Widely used
  - No additional cost to perform nutrient management functions
Using the Pivot Table Feature in Excel to Summarize Removal Data
<table>
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<th>N %</th>
<th>P %</th>
<th>K %</th>
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<th>lb P2O5/b</th>
<th>lb K2O/b</th>
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</table>
Calculating Nutrient Budgets by Hand: Focus on Longer Time Periods
Examining Nutrient Budgets at Different Spatial Scales
Calculating nutrient budgets with Raster Calculator

- Total added – total removed


Interpreting nutrient budgets

Total applied – total removed

Application > removal

Application ≈ removal

Application < removal

Code

30

20

10
Interpreting soil test levels

**Code:**

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<th>Target level</th>
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</tr>
<tr>
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</table>

**Difference from target soil test level**

(Actual soil test level – target soil test level)
Evaluating nutrient budgets with soil test levels

Total applied – total removed

Code: 0 1 2

Difference from target soil test level
Spatial evaluation of nutrient budgets

- No alteration
- Input increase needed
- Input reduction needed
Example GIS Data Analysis for Illinois

- County P$_2$O$_5$ Budgets
- 3 sources: NRCS, AAPFCO, NASS
- Manure Applied
- Fertilizer sold
- Crop Removal
  - **Actual yield of major crops**
- Computations on county basis
- Aggregation to watershed basis
Nutrient Response Tool
www.ipni.net/northeast

- Excel Spreadsheet
- Fits several models
  - Linear-plateau
  - Quadratic
  - Quadratic-plateau
  - Mitscherlich
  - Sine

Crop Nutrient Response Tool - NEW version 3.0

Version 3.0 (released October 2007) has the following features:

- five response curves fit simultaneously
- four calculated estimates of nutrient use efficiency (NUE)
- capacity for up to 36 treatments per site-year
- summary capacity of 1,000 or more site-years

This evaluation tool was designed to assist in interpretation and record-keeping for on-farm field crop trials involving multiple rates of any added nutrient. Its main goal is to provide the best possible estimate of "optimum rate" for a single-year response - the most economic rate (MEWR) at which it is profitable to apply a purchased nutrient - from limited data. It can also estimate several basic forms of nutrient use efficiency (NUE): partial factor productivity, agronomic efficiency, partial nutrient balance, and recovery efficiency.

It can also function as a record-keeping tool. The summary worksheet provides a single-row storage for a thousand or more site-years.
Peer-Reviewed Publications


Literature Reviews
Scientific Terminology for Efficiency

- **Purpose:**
  Develop standard terminology for reporting nutrient use efficiencies

  - **Field measurements:**
    - Yield vs. fertilizer use
    - Nutrient uptake vs. fertilizer use

  - **Research measurements**
    - Yield response vs. fertilizer use
    - Change in nutrient uptake vs. fertilizer use

"Nutrient Use Efficiency and Effectiveness in North America: Indices of Agronomic and Environmental Benefit"

**By C.S. Snyder and J.W. Brownlee, International Plant Nutrition Institute**

**MINERAL FERTILIZERS** have made it possible to sustain the world’s growing population, sparing millions of acres of natural and ecologically-sensitive systems that otherwise would have been converted to agriculture. Today, economic and environmental challenges are driving increased interest in nutrient use efficiency. Higher prices for both crops and fertilizer have heightened interest in efficiency-improving technologies and practices that also improve productivity. In addition, nutrient losses that harm air and water quality can be reduced by improving use efficiencies of nutrients, particularly for nitrogen (N) and phosphorus (P).

The world’s population, growing in both numbers and purchasing power, is projected to consume more food, feed, fiber, and fuel—increasing global demand for fertilizer nutrients. Since fertilizers are made from non-renewable resources, pressure to increase their use efficiencies will continue. At the same time, efforts should increase to enhance fertilizer use effectiveness for improved productivity and profitability of cropping systems.

**System Efficiency**

Indices are generally categorized as ratios of crop biomass vs. inputs. Indices can be defined in many ways, depending on the intent of the analyst.

Agricultural cropping systems contain complex combinations of components, including, yield, soil microbes, plants, and crop rotations. Improvements in the efficiency of one component may not be effective in improving the efficiency of the cropping system as a whole. The System Index is defined as the aggregate of those in the long-term. Short-term indices include: a) inputs (fertilizer, water, and labor) efficiency, and b) yields over the production of long rotations, leading to increased return on inputs, decreased crop rotation costs, and increased soil productivity. System index efficiency emphasizes attention to long-term impacts.

**Best management practices (BMPs) focus on the effectiveness of fertilizers and keeping them in the field for the intended crop in a proper cropping system.** The economic and environmental challenges associated with inputs can be satisfied when the crops are grown to produce the greatest yields and convey the maximum economic return to the farmer. Input use is also critical in determining the productivity of the cropping system. This approach recognizes that improvements in the nutrient use efficiency of the components contribute to and improve the efficiency of the entire system.
Managing Crop Nitrogen for Weather

• Purpose:
Improving nitrogen recommendation models to account for weather variability

• Venue:
Symposium at the annual meeting of the American Society of Agronomy
Review of Greenhouse Gas Emissions

- Agriculture’s contribution to GHG emissions
- Effects of N rate, timing, and placement
- Enhanced N efficiency fertilizers
- Ecologically intensive production systems
Summary

• BMPs are being communicated and the scientific principles behind them reviewed
  – *Investigating the gap between the principle and the practice*

• Educational products utilize a variety of formats
  – *Computer workshops*
  – *On-line training modules*
  – *Step-by-step procedures*

• Efforts with scientists seek to improve current recommendations