Agronomy Facts 60

Nutrient Management Planning: An Overview

Nutrient management traditionally has been concerned with optimizing the economic returns from nutrients used to produce a crop. More recently, nutrient management also has begun to address ways to minimize the negative impact of nutrients on the environment. Programs such as the Chesapeake Bay Program and the Nutrient Management Act in Pennsylvania have focused attention on improving nutrient management on Commonwealth farms.

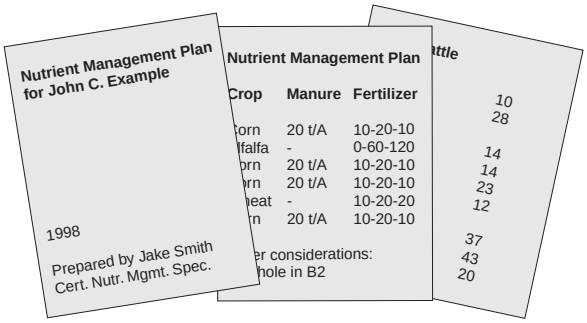
The environmental problems associated with nutrients most often are caused by animal manure. Applying manure in excess of crop needs or at the wrong time, or handling it improperly may release nutrients into the air or water, where they no longer contribute to crop production and may act as pollutants. The leaching of nitrogen through the soil can raise groundwater nitrate levels. In addition, runoff and erosion may increase nitrogen and phosphorus levels in surface waters, which can lead to eutrophication and related problems such as algae scums, odors, and loss of fish populations. Good nutrient management planning can help to avoid some of these problems.

NUTRIENT MANAGEMENT PLANNING

Nutrient management plans are not new. All farmers have a plan for using the manure produced by their animals. In many cases, however, this plan is very informal and addresses only manure disposal and possibly the crop response to the manure nutrients; environmental concerns usually are not addressed. Changing regulations now require farmers to implement more formal nutrient management plans that address environmental issues.

A basic nutrient management plan includes the following:

- An inventory of nutrient sources on the farm, including manure and crop residues.
- Nutrient analyses of each of these sources. The compositions of many of these sources may vary considerably, so "book values" may be inadequate for planning purposes.
- Handling and storage procedures for minimizing the potential for nutrient loss around the barnyard.
- Lists of crops and crop rotations by field, or crop groups and expected yields.
- Soil tests to determine the nutrient needs of the crops to be grown.
- Prioritization of the fields based on maximizing the economic benefit and minimizing the environmental impact of the manure nutrients.
- Procedures for when and how to apply the manure to maximize the economic benefit and minimize the environmental impact of the nutrients.



PENNSTATE
1855
College of Agricultural Sciences
Agricultural Research and Cooperative Extension

- A practical manure spreading rate for each field that does not apply the nutrient of greatest environmental concern in excess of the crop needs.
- Best management practices that minimize the potential for nutrient loss from the fields.
- Nutrient balances for each field to indicate any additional nutrient needs for the crop and/or any excesses that might be of concern.
- Plans for dealing with any excess manure produced on the farm.

While all manure nutrient management plans should contain these basic plan elements, the actual plans themselves will take on many forms.

DEVELOPING A NUTRIENT MANAGEMENT PLAN

A nutrient management plan can be written with paper and a pencil or developed with computer software. The key concept is that the plan allocates the available manure nutrients in a way that maximizes the economic benefit of the nutrients while minimizing their environmental impact. The basic steps in developing a nutrient management plan are as follows.

- **The first step in developing a plan for manure management is to collect information about the manure production, nutrient content, and application system(s) for the farm.**

Many factors affect the amount of manure produced and the nutrients it contains. These include the type of animal and its age, ration, and feed consumption; the animal's management, including the bedding used and the length of time the animal is confined as the manure is collected; and the handling of the manure before and during field application, including potential drying and dilution by waste water or precipitation.

Manure production can best be determined by measuring the amount of manure contained in a manure storage. On farms that do not have a storage or when it is impossible to determine the amount in a storage, manure production can be estimated from animal numbers, animal weights, and confinement times. Tables that list the average daily manure production for various types of livestock and the average amounts of nutrients in the manure are available.*

Manure nutrient content should be determined by a manure analysis. "Book" values for the nutrient content of a given type of manure are averages taken from many farms. Because of farm-to-farm variability, these averages are of little value in decision making on an individual farm. Manure sample analysis results in Pennsylvania have indicated a very wide range in nutrient content for seemingly similar samples of manure taken from different farms, and we have observed as much as 100 percent error between book values and actual manure nutrient content values.

- **The second step is to determine the nutrient requirements for the crops on the farm.**

The nutrient requirements preferably for individual fields or groups of fields with the same crop and very similar rotation and nutrient application histories must be determined. Soil tests are the best source of information about crop nutrient requirements. Soils contain a wide range of available nutrient levels, and different crops have very different nutrient requirements. The expected yield of the crop also will affect the amount of nutrient required. For example, a corn crop requires a large amount of nitrogen and a smaller amount of phosphate and potash. An alfalfa crop, however, requires no nitrogen, some phosphate, and a large amount of potash.

In general, forage crops such as hay or corn silage will use more nutrients than grain crops. A rotation of grain and forage crops will require nutrients very different from those needed by either of the individual crops grown in a field in a given year. These facts become very important when manure is used to meet crop nutrient needs. Tables of crop nutrient requirements are available. All sources of nutrients must be considered in developing a manure application plan. Other sources of nutrients must be subtacted from the crop requirments to determine a net nutrient requirement before a manure rate is detemined. These might include: fertilizer applied regardless of manure applications, such as starter fertilizer; residual nitrogen from a previous legume crops; and residual nitrogen from past manure applications.*

- **The third step is to prioritize the farm fields on the basis of their suitability for manure application.**

Using soil tests, the fields' cropping and manure application history, the planned crop rotation, and other characteristics such as field location, slope, and soil characteristics, rank the fields for manure applications from highest to lowest. Some of the factors involved in this ranking are illustrated in Table 1.

- **The fourth step is to determine the availability of manure nutrients.**

The actual fertilizer value of the manure will depend on how the manure is handled and used. The nutrients in manure are not as readily available as fertilizer nutrients are, and this must be taken into account when manure application rates are determined. Manure nitrogen is especially susceptible to losses and is very sensitive to management practices such as soil incorporation following application. For example, if dairy manure is incorporated on the same day that it is spread, about half of its N will be as readily available as commercial fertilizer N would be. If this manure is left on the surface with no incorporation for a week or more, however, only 20 percent of the N will be available for crop uptake in the current year. Tables and calculation worksheets are available to help you estimate the availability of the manure nutrients in your management system.*

---

* See the current *Penn State Agronomy Guide* for details.

Table 1. Factors involved in field prioritization for manure applications.

Nutrient Considerations

	Prioritization for Manure	
Nutrient	**High**	**Low**
crop N needs	N-requiring crops	crops not requiring N
N requirement	highest N requirement	lowest N requirement
residual N	lowest residual N	highest residual N
P soil test level	lowest P level	highest P level
K soil test level	lowest K level	highest K level

Environmental Considerations
Proximity to water bodies, sinkholes, flood plains, and drinking water sources/wellhead protection areas

Soil Limitations (See your local NRCS)
Leaching, erodibility, and runoff potential

Vegetative Cover
Presence of a growing crop, crop residue, or cover crop

Other Considerations
Distance from source to fields, neighbors, etc.

- **The fifth step is to determine the appropriate manure application rate and allocate the available manure to the fields in the established priority order.**

The rate calculations are based on meeting the net nutrient requirement for the nutrient of principal concern (usually N or P). If the rate is based on N, the manure analysis must be adjusted for N availability. The best approach to determining an environmentally sound manure application rate is to use the rate that does not apply any nutrient in excess of the soil test's recommendations. In our experience, P is usually the limiting nutrient when this approach is followed.

For fields where there is a crop rotation, base the calculations for this limit on the nutrient needs of the entire rotation rather than on the current crop only. In Pennsylvania, we typically base the manure application rate on N and try to minimize excess P and K applications based on the rotation requirements. In practice, many farmers still apply excess P and K. Since the major loss pathways for P and K are field runoff and erosion, good soil conservation practices are critical in minimizing the environmental effect of excess P and K applications in manure. For more information about making application rate calculations, see Penn State's Agronomy Facts #55, *Estimating Manure Application Rates*.

- **The sixth step is to adjust the calculated manure rates for practicality.**

This usually results in the grouping of the fields into one or a few standard manure application rates that the farmer is able and willing to apply. Manure spreader calibration information is a good guide for determining these practical rates. Using these standard rates, the available manure is allocated to the fields in priority order until all of the manure is allocated or all of the fields have been fertilized. If manure remains, a plan is developed to remove it from the farm, or the cropping program is adjusted to use up small excess amounts.

- **The seventh step is to compare the nutrients supplied in the manure to the needs of the crop to determine if additional nutrients are required or if a serious excess of any nutrient is being applied.**

Deficiencies can be handled by applying supplemental fertilizer nutrients or manure from other sources. Serious excesses must be evaluated in light of the nutrient needs of the crop rotation and the potential impact area of the nutrient loss, and may require a change in the manure application plan. The Phosphorus Index (PI) is a good tool to evaluate the risk of excess P loss to the environment.

Finally, the plan must include appropriate best management practices (BMPs) to protect water quality from nutrient contamination. These BMPs include practices such as manure handling and storage, barnyards, animal concentration areas, and stormwater runoff from field application areas. A current, implemented farm conservation plan is an important compliment to a nutrient management plan.

IMPLEMENTATION OF THE NUTRIENT MANAGEMENT PLAN

- Manure always should be spread on fields uniformly and at the planned rates.
- Manure spreader calibration is the key for implementing the nutrient management plan. Procedures for calibrating different types of manure spreaders are available.*
- Crop nutrient uptake is most efficient if manure is spread as close as possible to the time when plants will use the nutrients. The longer the manure is in the soil before the crops take up the nutrients, the more susceptible those nutrients will be to loss.
- The season in which manure is applied will affect the nutrient availability for crops. The best time is usually in the spring, just before the crop will use the nutrients. Summer also is good if application to growing crops is possible. Fall and winter are the riskiest times to spread because there is little crop growth to use the nutrients until the following growing season. A higher potential for nutrient loss also exists during these seasons because of frozen soils and high precipitation. If manure must be applied in the fall and winter, the use of a cover crop is highly recommended.

- Incorporation of manure into the soil as soon as possible after it is spread results in the greatest nutrient availability to crops and reduces nutrient losses, pollution, and odor. One-half inch of soaking rainfall without significant runoff is comparable to incorporation of surface-applied manure.
- Surface-applied manure may be lost through surface runoff. On soils with a high erosion potential, conservation practices such as stripcropping, contour farming, crop residue management, cover crops, cropland terraces, diversions, and grassed waterways can effectively reduce the loss of soil and manure nutrients.
- Be especially careful with manure management in environmentally sensitive areas such as near streams, water bodies, or sinkholes; in areas where the potential for concentrated water flow exists, particularly in the winter; and near wells and springs. Nutrient application buffer zones may be needed near these sensitive areas.
- Since the amount of manure N that becomes available in any given year is very difficult to predict, the Pre-Sidedress Soil Nitrate Test (PSNT) or the early-season chlorophyll meter test are useful tools that can help determine if the manure N is adequate to meet the needs of a corn crop. For more information about these tests, see Penn State's Agronomy Facts #17, *Presidedress Soil Nitrate Test for Corn*, or # 53, *The Early-Season Chlorophyll Meter Test for Corn.*
- Manure spreaders have been implicated as a major cause of soil compaction on many farms. Avoid compaction by staying off wet soils with heavy equipment.
- Keep good records of manure application. This will not only document your good management, but also provide valuable information you can use to make future plan adjustments.

RESOURCES

This has been a brief introduction to the key concepts of farm nutrient management planning. Successful implementation of nutrient management policy will involve full participation of a broad range of key stakeholders, including farmers, the allied agriculture industry, allied public agencies, policy makers, regulators, environmental groups, and the consuming public. The following are some useful sources of assistance and information about nutrient management.

County Conservation Districts

Technical assistance and Local Nutrient Management Program administration

- Administer the Nutrient Management Act locally
- Maintain a list of commercial nutrient management planners available to assist farmers in developing their nutrient management plan
- Review and approve nutrient management plans
- Provide cost sharing for development and implementation of nutrient management plans

Penn State Cooperative Extension

Educational programs and materials on nutrient management

- *Penn State Agronomy Guide*
  This is the primary source of information for developing a nutrient management plan. Most of the book values and factors referred to earlier can be found here.
- Nutrient management training
- Agronomy fact sheet series on nutrient management
- Soil testing and manure analysis program
- Outreach materials such as fact sheets, videos, worksheets, etc.

Pennsylvania Department of Agriculture

Nutrient management certification and financial assistance programs

- Precertification training
- Nutrient management specialist exams
- Financial assistance

Pennsylvania Department of Environmental Protection

Other environmental quality programs in the state

- *Manure Management Manual*
  This is another source of information for developing a nutrient management plan.
- Chesapeake Bay Program
- Animal Feeding Operation (AFO) and Concentrated Animal Feeding Operation (CAFO) programs

USDA Natural Resources Conservation Service

Technical assistance on choosing and installing nutrient management and soil conservation BMPs

- *Pennsylvania NRCS Field Office Technical Guide*
- *Pennsylvania NRCS Irrigation Guide*

These are other primary sources of information for developing a nutrient management plan. The *Field Office Technical Guide* is the primary source of information about manure management and conservation BMPs.

Commercial Nutrient Management Specialists

Development of nutrient management plans and plan implementation assistance

WEB SITES

nutrient.psu.edu/
Portal to various nutrient management Web sites at Penn State

panutrientmgmt.cas.psu.edu/
Main source of information on nutrient management regulations and technical information related to the Pennsylvania Nutrient Management Act. Includes links to related agency Web sites.

nutrient.das.psu.edu
Livestock nutrient management information

agenvpolicy.aers.psu.edu/default.htm
Environmental and water policy information

pswmru.arsup.psu.edu/phosphorus/nprp.htm
Phosphorus-based nutrient management information

agguide.agronomy.psu.edu/
Online version of The *Penn State Agronomy Guide*

Prepared by Douglas Beegle, professor of agronomy, Penn State University

Visit Penn State's College of Agricultural Sciences on the Web: www.cas.psu.edu

Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone 814-865-6713.

Issued in furtherance of Cooperative Extension Work, Acts of Congress May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture and the Pennsylvania Legislature. T. R. Alter, Director of Cooperative Extension, The Pennsylvania State University.

This publication is available in alternative media on request.

CAT UC156 4M0103ps3141

Produced by Information and Communication Technologies in the College of Agricultural Sciences