NEWS & VIEWS — Special Series

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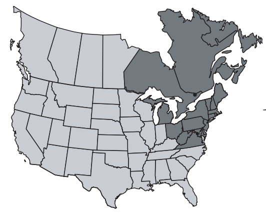
Best Management Practices for Fertilizer



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This publication is one of a series on fertilizer best management practices (BMPs), prepared by regional directors of the Potash & Phosphate Institute (PPI)/Potash & Phosphate Institute of Canada (PPIC). This effort is in cooperation with the Foundation for Agronomic Research (FAR) toward fulfilling the goals of a 3-year Conservation Innovation Grant (68-3A75-5-166) from the USDA-Natural Resources Conservation Service (NRCS). The intent of these publications is to help develop the BMP definition process in such a way that environmental objectives are met without sacrificing current or future production or profit potential and in full consideration of the newer technologies relevant to fertilizer use. The concept of applying the right fertilizer at the "right rate, right time, and right place" is a guiding theme in this series.

Best Management Practices for Fertilizer Use on Dairy Farms

DAIRY FARMS in the Northeast have made a lot of progress in adopting best management practices (BMPs) for managing their impacts on the environment. Nutrient management forms an essential component of such practices, but most BMP publications focus on manure management. **This article focuses on fertilizer management practices appropriate to the cropping systems that support dairy farms.**

Fertilizers still play an important role on dairy farms. Applying them at the right rate, the right time, and in the right place optimizes profitability and resource use efficiency. It also minimizes impact on the environment.

Nutrient cycling on dairy farms is intensive. Large amounts of nutrients are both removed from the field in the harvest of forages, and returned in the form of manure. Nutrients also flow onto the farm in the form of purchased feed inputs, and they leave the farm in the form of milk, animals, and other materials sold. Recent studies in Europe on the nutrient flows on dairy farms show that BMPs that increase profitability can be adopted while maintaining or reducing nutrient loss to the environment (Rotz et al., 2005).

While dairy is among the farm types associated with increasing trends in soil test phosphorus (P) levels, more than half of farm soils in New York still test below the critical level for crop needs (Ketterings et al., 2005). The intensity of nutrient cycling and the wide range of variability in soil fertility combine to make soil testing one of the most important BMPs for fertilizers.

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Site-specific recommendations, intensive management, improved efficiency, and environmentally sound use of crop production inputs are all important components of BMPs. It is important that these 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 one farm to the next depending on current and historic soil, climate, crop, and management expertise. Ultimately, it comes down to past research, farmer experience, and the knowledge of the local soil and climatic conditions that dictate the success of a particular BMP in a specific field.

There are three general categories into which we can group the management practices that foster the effective and responsible use of fertilizer nutrients. These are:

A) Diagnostics – determining the right rate;

B) Application – right placement and timing;

C) Minimizing nutrient loss from the field.

Within each of these categories, there are a number of specific practices that we could classify as a BMP.

A. Diagnostics

1. **Crediting nitrogen (N).** Non-legume crops like silage corn or grass forage can demand large amounts of N. Nitrogen is a mobile nutrient. Soils can be sampled for the nitrate form of N, but the sampling must usually be done just before the crop starts taking it up at high rates. The previous crop, and applications of manures and biosolids, can supply large amounts of N. In order to calculate the amount available, manures should be analyzed for both the ammonium and organic forms of N. The application method and timing of the manure also influences the amount of credit to be considered for adjusting fertilizer rates (Ketterings et al., 2005b; OMAFRA, 2002).

2. **Soil testing.** Soil sampling for less mobile nutrients including P and potassium (K) should be done every 3 years, preferably at the same point in the rotation each time. The depth is usually 6 to 8 in. and must be consistent (Keryk et al., 2005). Forage harvests remove large amounts of K so it is critical to monitor the levels of this nutrient closely, since deficiencies can cut yields. However, excesses can cause imbalances in the feed ration for dry cows. Micronutrient levels—including copper and zinc—can also be important, particularly for their influence on the composition of the diet (Brock et al., 2005).

3. **Crop scouting and plant analysis.** Transient deficiencies of nutrients can impact crop performance, and even crops that look okay may be suffering from "hidden hunger". A regular program of monitoring both visual symptoms and nutrient levels in the plant tissue can help diagnose nutrients that either limit crop yield or pose risks of excess in the dairy diet (Mills and Jones, 1996; Cherney et al., 1997).

4. **Yield goal determination.** Recommended rates of fertilizer often depend on the expected yield, or yield goal, of the crop to be grown (Janovicek et al., 2005). When these goals are unrealistic, recommendations may be inappropriate as well. The most realistic estimates of yield goal are obtained by using measured yields from the past 5 years, projecting forward any trend in yield improvement.

5. **Nutrient removal calculation.** The Penn State Agronomy guide discusses how to maintain soil test levels: *"Once an optimum level has been established, the recommendation is to maintain that level by applying P and K to offset the amount that is removed by the harvested crop"* (Penn State, 2005-2006). Forages in particular remove large amounts of nutrients. The amount removed can be determined by measuring both the yield of the crop harvested, and its nutrient content. In many cases, nutrient content may be estimated. However, nutrients like K vary considerably in their concentration. Actual nutrient removals should be measured if you expect that your soil fertility conditions differ from average.

B. Application

6. **Placement of N.** When N sources contain urea or ammonium, there is a risk of ammonia being lost to the air as a gas. This process is known as volatilization. These sources include urea, urea-ammonium nitrate, anhydrous ammonia, ammonium nitrate, and ammonium sulfate. Loss can be minimized by incorporating the fertilizer into the soil as soon as possible, or by using a controlled-release or stabilized form of urea (Grant, 2005). However, when applied to an actively growing crop in cool temperatures, as is often the case with winter cereals, losses arising from urea topdress applications to cereals or forage grasses in early spring are small. Based on laboratory research conducted over 40 years ago (Ernst and Massey, 1960) it has been concluded that ammonia losses from applied urea remain reasonably small at temperatures below 60 degrees (F) if the soil pH is 6.5 or less (Overdahl et al., 1991). Following first and second cut grass forage, however, alternative sources of N should be considered unless urea can be applied directly before irrigation or rain.

7. **Band placement of P and K.** Corn, cereals, and other crops respond most to P when their seedlings are young. Placement near the seed ensures access by the young seedlings, and placement in a band concentrates the nutrient to minimize fixation by the soil. Research suggests that combinations of N and P work most effectively (Miller et al., 1970), and that K is an important component of starter fertilizer for corn grown with reduced tillage (Vyn et al., 2002). Small amounts of a P-rich fertilizer placed with the seed of corn can provide an additional yield benefit (Lauzon and Miller, 1997). However, rates placed with the seed should be kept very low and cannot be sufficient to replace crop removal.

8. **Timing of N.** Being vulnerable to losses, N applied too early poses more risk of loss than when applied just before the period of rapid uptake. Corn typically does not begin taking up N rapidly until about 5 to 6 weeks after planting. However, the development of the seedling depends on

adequate N availability. The starter should include sufficient N to ensure vigorous growth of the seedling. A dose of about one-third of the total requirement may be applied in the starter. The remaining two-thirds is best applied as a side-dress when the seedlings are about 12 in. tall. Alternatively, if controlled release or stabilized N technologies are used, the N can be applied prior to or at planting (Grant, 2005).

9. **Management zones for variable rate application.** On some farms, the same rate and blend of fertilizer is applied to all fields growing a particular crop. Soil test levels tend to vary strongly among fields, owing to differences in past manuring history. Greater nutrient use efficiency can be obtained by increasing the ratio of N:P in the starter for fields already high in P. Within-field variability can also be high. A recent study on 23 farm fields in Ontario found substantial spatial variability in soil test P, K, and pH levels. However, mapping the spatial pattern using soil testing alone would be difficult (Lauzon et al., 2005). Management zones may best be delineated using combinations of measured data layers for each field (Doerge, 1999)

10. **Accurate rate metering.** Maintaining and calibrating the machinery used for applying fertilizers is essential to delivering the right rate. Since fertilizers can be corrosive, cleaning the equipment after use and adjusting for wear is necessary. It is also important to ensure that blends are made from materials that are consistently sized for uniform mixing and to avoid segregation.

C. Minimizing Nutrient Losses

11. **Nitrogen transport.** Nitrogen can be lost by several pathways. Nitrate-N will be leached below the root zone if water moves down through the soil too quickly. This is most likely to occur on well-drained soils of coarse sandy texture. When soils are saturated with water, nitrate can be denitrified to nitrous oxide or dinitrogen. Nitrous oxide is considered a potent greenhouse gas and a depletor of stratospheric ozone. Ammonium forms of N can be lost as ammonia gas to the air. Volatilization of ammonia from fertilizer can be controlled using BMPs for placement as described above. Nitrous oxide emissions are hard to control, but are minimized by the diagnostic BMPs that ensure the right rate is applied. For reduction of nitrate leaching, risk indexes are beginning to be developed. In New York, the Nitrate Leaching Index identifies N management implications for each site based on soil hydrological group and expected precipitation in fall and winter (Czymmek et al., 2003). Similarly in Ontario, the N Index based on soil hydrological group and crop N removal is calculated as part of a nutrient management plan. Use of these indexes ensures that high-risk soils receive the greatest attention to minimizing nitrate losses. Cover crops can help reduce risk.

12. **Phosphorus transport.** Applying P at rates that balance removal is an important aspect of minimizing losses, but not the only one. Most soils remain fertile when application rates balance removal, but some may require more or less than removal depending on the soil tendency to retain or release phosphate. In addition, attention must be paid to the transport pathways (Djodjic et al., 2005). Minimizing erosion and surface runoff by maintaining soil structure for a high water infiltration helps minimize the overland pathway. The preferential flow pathway may be more difficult to manage, but ideally slow rates of percolation should be maintained in the subsoil. In some areas, deep tillage may help reduce P losses. The use of a P index gives a relative ranking of the influence of all major source and transport factors influencing the loss of P (Sharpley et al., 2003). Its use gives the best assurance for protection of water quality. Specific indexes, with software to facilitate calculation, are available for most states and provinces.

How Does Your Fertilizer Management Rate?

Using the chart on the following pages, assess your farm's level of BMP adoption. Count two points for each "best" and one for each "making progress." Not all farms can adopt all BMPs. However, maximizing the adoption of these practices for fertilizer management helps assure the sustainability of dairy farming systems. ■

Best Management Practices for Fertilizer Use on Dairy Farms in the Northeast

Practice	Best	Making Progress	Improvements Needed
Diagnostics—Determining the Rate			
1. Crediting N	Adjust rates for previous crops, cover crops, livestock manures and biosolids applied, and/or use soil nitrate tests	Occasional or partial use of manure analysis and soil nitrate testing	No N credits considered
2. Soil testing for P, K, and other nutrients	Each field sampled every 3 years	Most fields sampled within last 5 years	Never, or last test more than 10 years ago
3. Crop scouting and plant analysis	Done regularly and systematically for each field	Occasionally done to diagnose problem areas	Rarely or never
4. Yield goal determination	Measured yields from at least 5 past years	Measured yields from at least 3 past years	Desired yield level, or not considered
5. Nutrient removal calculation	Based on measured yields and nutrient content	Based on estimated yields and nutrient content	Not considered
Application—Timing and Placement			
6. Placement of N	All sources containing urea or ammonia injected or incorporated into soil immediately, or applied in controlled-release or stabilized form, or applied to growing crops in cool temperature conditions	Urea-containing sources broadcast and unincorporated only during periods of cool temperatures	All urea broadcast and unincorporated
7. Band placement of P and K	Banded near seedling when required; small amounts seed-placed for corn	Broadcast and incorporated into soil when required	All broadcast and left on surface, or all applied only in band or seed-placed
8. Timing of N	Split application ensuring both adequate starter and remainder within 2 weeks prior to beginning of rapid crop uptake; or use controlled-release	All applied within 2 weeks prior to beginning of rapid crop uptake	All applied in one application
9. Management zones for variable rate application	Based on measured landscape, soil and crop properties	Management zones kept to 25 acres or less, each receiving specific fertilizer rate and blend	Each field one management zone regardless of size; all fields for each crop receive same fertilizer
10. Accurate rate metering	Equipment well maintained and recently calibrated and tested	Equipment well maintained	Equipment old, functioning poorly, rate adjustment “seized” at last year’s rate
Minimizing Nutrient Losses			
11. Nitrogen transport	Cover crops used in all fields where nitrate leaching risks are moderate to high	Cover crops used in all fields where nitrate leaching risks are high	Not considered
12. Phosphorus transport	Phosphorus Index calculated and maintained at medium to low risk by managing erosion and runoff in all source areas for watercourses	Conservation tillage, unfertilized buffers near watercourses	Not considered

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