NUTRIENT MANAGEMENT

DESCRIPTION

Nutrients are needed to sustain healthy animals and crops. Overuse or mismanagement of nutrients, in particular nitrogen and phosphorus, can lead to nutrient pollution of ground or surface waters. Purchased feed and fertilizer are by far the largest sources of nutrient imports onto a farm, accounting for 89.5% of imported nitrogen and 96% of imported phosphorus.[107] Reliance on these external nutrient sources is becoming problematic in that 59-81% of the imported nitrogen and phosphorus remain on a dairy farm over a year's time.[108] This can result in a build-up of nutrients in the soil and an increased chance that nutrients will be transported to water sources, resulting in environmental harm to surface and ground water.

While Vermont dairy farms are certainly not the only source of this pollution, contributions from farmland can be significant and participation from the dairy farmer community is therefore essential to improve overall water quality. In Vermont, Lake Champlain, a critical water resource, is experiencing a serious decline in water quality, in part due to sediment and nutrients from agricultural runoff from barnyards, manured and fertilized fields and cropland erosion. Also, many drinking water wells on farms have been found to have nitrate-nitrogen levels exceeding the Vermont public health standard.[109]

Adopting best practices for nutrient management is important to maintaining ground water that is safe for drinking and surface waters that can support healthy aquatic ecosystems, function as industrial and commercial water supplies, and provide recreational enjoyment. This module is devoted to properly managing nutrient applications to fields. Recommendations regarding nutrient management plans, use of fertilizer and manure, and use of dietary phosphorus supplements are intended as an introduction to best management practices to improve farm performance and environmental health. Actual on-farm development and implementation of nutrient management plans should be made in cooperation with experts, such as UVM Extension representatives, feed or fertilizer specialists, or other consultants. Controlling water pollution from other nutrient sources, such as manure or silage storage areas, is addressed in the Water Management module.

INCENTIVES FOR CHANGE

- **Cost Savings.** Appropriate nutrient management can reduce unnecessary feed and fertilizer purchases, improving crop production efficiency and farm profitability. The Vermont Dairy Farm Sustainability Project found that, by reducing phosphate fertilizer application by 40% (average reduction over a 3 year period), farms could reduce total fertilizer expenditures by an average of $2800/farm or $27/acre, while maintaining farm yields.[110] One farm decreased phosphate fertilizer use by 8.3 tons/year for savings of $4200/year.[111]

- **Improved On-Farm Water Quality.** Minimizing impact on surface and ground water is beneficial to the extent that these water resources become inputs on the farm. Maintaining healthy drinking water can reduce the chance for illness, and associated costs, from contaminated water.

- **Regulatory Environment and Funding.** Currently the EPA requires that farms with large 'concentrated animal feeding operations' (CAFO) obtain a permit for operation. However, in order to get a permit, a farmer must first develop and implement a comprehensive nutrient management plan. In addition, medium size farms (200 to 699 milking cows) in Vermont must file a general permit to operate and develop a nutrient management plan that meets the NRCS 590 standard. As this and other water quality legislation becomes more stringent, dairy farms will increasingly need to demonstrate nutrient management best practices.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

NUTRIENT MANAGEMENT & RECORD KEEPING:

- ❑ 1. No nutrient management plan exists for the farm.
- ❑ 2. Nutrient management plan is based on some soil testing and University recommendations or another credible source. Recommended nutrient application rates are sometimes exceeded by over 10% as 'insurance' for a good yield level.
- ❑ 3. An approved management plan is in place and is based on soil tests over 1-3 years. Recommended application rates not exceeded by more than 10%. Detailed nutrient records are kept (soil test results, crop yields, nutrient application rates and timing, etc.)
- ❑ 4. In addition to #3, recommended application rates are never exceeded. Additionally, detailed records are used to guide and improve the nutrient management plan on an annual basis.

Record keeping can help farmers further understand, monitor, and therefore improve, farm performance. It also demonstrates good management and can provide valuable data if management practices are ever challenged. While a bit of effort needs to be invested up front, implementation and maintenance of a nutrient management and record-keeping plan will ultimately save both time (e.g. records are readily available when needed for taxes or other purposes) and money in the long term. A nutrient management plan, developed in conjunction with USDA-NRCS or the UVM Extension service, consultant or other expert resource, covers multiple nutrient flows on farms, including use of manure, fertilizer, and feed and supplements. Some best practices associated with nutrient management plans are captured in the questions in this module.

MANURE APPLICATION RATE:

- ❑ 1. Application rates are unknown or manure is applied until all manure is used up (without regard to nutrient requirements of field or crop).
- ❑ 2. Application rates are determined by crop-specific nitrogen and phosphorus needs based on soil type (University recommendations or other published standards) and realistic yield goals (goals are within 10% of 5-year average yield). To prevent over-application, some excess manure may be applied to neighboring fields, composted, or otherwise properly disposed of.
- ❑ 3. In addition to #2, application rates are loosely determined by soil nutrient need according to soil tests performed at least every 3-5 years. To prevent over-application, most excess manure is applied to neighboring fields or otherwise properly disposed of.
- ❑ 4. In addition to #3, rates are determined by strictly following application recommendations from soil tests conducted every 1-3 years and application reflects manure nutrient content, as determined by laboratory analysis. To prevent over-application, all excess manure is applied to neighboring fields or otherwise sored or composted until it can be properly disposed of.

Manure is a valuable source of nitrogen, phosphorus and potassium for crop production but it is important that the use of manure on fields focuses on crop utilization of manure nutrients rather than manure waste disposal. Over-application of manure can result in build up of nutrients in the soil and increased potential that nutrients will be leached through the soil to groundwater or transported to surface waters via runoff. The amount of manure applied should therefore be closely matched to the needs of each field.

Any excess manure remaining after application should be applied to neighboring fields or otherwise properly disposed of. As a benchmark for the amount of land that will be needed for your farm, best practice requires .5 to 1.0 animal units (AU) per acre of cropland that is environmentally, economically, and agronomically suitable for the application of manure[112]. One AU is equivalent to 1,000 pounds so a 1,400-pound dairy cow would be 1.4 AU's.[113]

To more closely match manure application rates to soil and crop needs, the farmer should base application rates on the following:

- **Soil Testing:** Soil testing, conducted at least every 1-3 years, is the best way to determine soil nutrient content and other characteristics that affect crop uptake of nutrients. UVM offers soil test kits that provide information on soil pH, available phosphorus, aluminum (which affects plant uptake of phosphorus) and other nutrients, and soil fertility recommendations. At $9/sample, soil testing is a non-time-intensive, non-costly way to better understand and manage on-farm nutrients.

- **Manure Nutrient Content:** The percentage of nutrients in manure will vary, depending on such factors as type of cow, composition of feed, additions of other substances to manure, and collection and storage methods. Because of the wide potential variation in nutrient content, a manure nutrient analysis, which can be done for $30 at UVM, is highly recommended as the best means of determining exact nutrient content for precision crop nutrient applications. If such an analysis is not possible, using published averages for manure nutrient levels is the next best alternative.

- **Type of Crop and Crop Yield:** Different crops and yield levels will result in varying crop nutrient needs. Manure use should be based on nutrient need of the crop being grown, together with realistic yield goals (within 10% of average yields from the last 5 years). Ideally, nutrient content should be matched with crop need and soil nutrient content per the results of soil testing. However, using general published standards is the next best alternative.

COMMERCIAL FERTILIZER APPLICATION RATE:

❑ 1. Application is based on historical practice; no records are kept of specific application rates.
❑ 2. Rates are determined from crop-uptake values (per University Nutrient Recommendations for Field Crops) based on realistic yield goals (goals are within 10% of 5-year average yield).
❑ 3. In addition to #2, application rates are loosely determined from soil tests performed every 3-5 years and manure nutrient credits and legume nitrogen credits (per University Nutrient Recommendations for Field Crops).
❑ 4. In addition to #3 rates are determined by strictly following application recommendations from soil tests and by annual Pre-Sidedress Nitrate Tests. Every effort is made to use only on-farm nutrient sources (manure, compost, cover crops, etc.)

Given that manure is an excellent and abundant source of crop nutrients, every effort should be made to effectively utilize manure (or other on-farm, organic nutrient sources) to satisfy crop nutrient need. However, and when inorganic commercial fertilizer is needed to supplement manure nutrients, precisely matching it to crop need will minimize fertilizer costs and nutrient build-up in soils.

As discussed in the "Manure Application Rate" section, soil testing and closely following corresponding nutrient recommendations is a best management practice. These nutrient recommendations should take into account crop type and yield (as discussed above) as well as the following:

- **Manure and Legume Nutrient Credits:** Fertilizer rates should be adjusted for nutrients provided by manure, both present and past applications, and by legume crops such as alfalfa, clover or soybeans. A percentage of nitrogen from manure applications remains in the soil in the years following application and legume crops also add nitrogen to the soil. This amount of nitrogen must be taken into account and fertilizer application rates need to be adjusted accordingly so as not to provide more nutrients than necessary for the soil. A soil test is the preferred and most accurate means of assessing soil nutrient content and corresponding need. In the absence of that, estimates for manure and legume nitrogen credits can be found in the UVM Nutrient Recommendations for Field Crops.

- **Pre-Sidedress Nitrate Test (PSNT):** The PSNT, a soil sample taken when corn plants are 8-12 inches tall, is a way to accurately understand precise nitrogen needs of the crops and to adjust nitrogen fertilizer levels for specific field conditions. The PSNT should be done on an annual basis and, at a cost of $6/sample, is not a costly investment toward proper fertilizer application levels.

MANURE & PHOSPHORUS FERTILIZER APPLICATION TIMING & TECHNIQUES:

❑ 1. Application is performed without regard to weather or proximity to on-farm water sources. Manure and phosphorus fertilizer is not incorporated into soil.

❑ 2. Some effort is made to avoid application near water sources or prior to heavy rains (that could result in manure runoff). When growing annual crops, manure and phosphorus fertilizer is incorporated after 7 days.

❑ 3. Nutrients are never applied if heavy rain is expected and are not applied to frozen soils; buffer strips separate fields and nearby water sources. When growing annual crops, manure and phosphorus fertilizer is incorporated within 4 to 7 days.

❑ 4. Nutrients are never applied if heavy rain is expected and are not applied to frozen soils; buffer strips separate fields and nearby water sources and manure not applied to edge of field. When growing annual crops manure and phosphorus fertilizer is incorporated within 1 to 3 days.

Every effort should be made to prevent manure ponding and runoff to surface water, adjacent property, or drainage ditches. It is therefore very important to incorporate manure soon after application to prevent runoff, particularly on sloped land, and to avoid applying manure if heavy rain is expected, since the rain may simply wash the manure off the field if it is sitting on the surface of the soil. Furthermore, avoiding application close to water sources and using buffer strips between fields and water sources can prevent manure and runoff from reaching the water.

Quickly incorporating manure is also valuable to making sure that it can 'do its job,' since ammonium nitrogen can evaporate out of manure if it is left on the surface. It has been found that 70% of nitrogen is retained if manure is incorporated within one day. Only 40% remains if incorporated in 2 to 3 days and only 20% of nitrogen is left in manure if it is incorporated in 4 to 7 days.[114] Manure should never be applied to frozen soils because it cannot be easily incorporated, leading to higher runoff potential and nutrient loss. An effort should be made to spread manure earlier in the season (i.e. well before the December 15 manure spreading ban) to ensure that application to frozen soils is avoided.

NITROGEN FERTILIZER APPLICATION TIMING & TECHNIQUES:

❑ 1. Broadcast applications are routinely made as time allows and without consideration to weather. Timing is not planned to optimize crop utilization of nutrients.

❑ 2. Application is based in part on some precision application techniques (sidedress or band applications) and/or proper timing to optimize crop utilization of nutrients (multiple delayed or split applications with starter fertilizer, if appropriate). An effort is made to not apply fertilizer prior to heavy rain.

❑ 3. Per #2, application strategy relies almost exclusively on precision application techniques and proper timing to optimize crop utilization of nutrients. Fertilizer is never applied prior to forecast of heavy rain.

Timing fertilizer applications to maximize crop uptake and utilizing precision application methods are other ways of ensuring the most efficient use of commercial inorganic fertilizer. The use of starter fertilizer and split applications of fertilizer should be matched to soil and climate characteristics as well as to PSNT results to maximize their benefits.

FERTILIZER & MANURE APPLICATION EQUIPMENT (Application is either custom hired or done on your own.)

- ❑ 1. Application equipment cannot be calibrated and application rates are unmonitored and unrecorded. Spillage can often be a problem.
- ❑ 2. Application equipment is calibrated periodically and application rates are monitored somewhat. Spillage is controlled and minimized. Spills, if any, are cleaned up promptly.
- ❑ 3. Application equipment is adjusted and calibrated at least once a year and application rates monitored closely and results are recorded. Spillage is minimized and spills, if any, are cleaned up promptly.

Efforts to match nutrient application amounts to soil and crop need would be wasted if the nutrient application equipment is not calibrated or otherwise cannot be relied on to provide accurate information on nutrient application rates (e.g. due to spills or leaks). As such, best management practice calls for regular calibration of the equipment, close monitoring of application rates, and avoidance of any spillage or leaks.

USE OF PHOSPHORUS SUPPLEMENTS:

- ❑ 1. Dietary phosphorus is not closely monitored nor recorded, or is maximized to guarantee production levels.
- ❑ 2. Dietary phosphorus levels are monitored but exceed National Research Council (NRC) 2001 guideline levels.
- ❑ 3. Diets are strictly regulated and monitored to ensure that cows are receiving no more than the NRC recommended amount of dietary phosphorus.

Numerous studies have found that closely following National Research Council 2001[115] recommendations for dietary phosphorus can reduce current phosphorus levels for dairy cows (which frequently exceed required amounts) without affecting production levels. The result is dramatically reduced phosphorus levels in manure, which can allow for better matching of manure nutrients to soil and crop need. Important: Any phosphorus reduction strategy must result from a collaborative effort between farmers, feed and fertilizer consultants, veterinarians and manure haulers.

LINKAGES TO OTHER MODULES

Nutrient issues are very closely tied to Water Management, Soil Health and, to a lesser extent, Animal Husbandry. The table below identifies where you can find more information on some of the topics mentioned in this module.

NUTRIENT MANAGEMENT TOPIC	OTHER MODULE(S)
Manure Storage	Water Management
Fertilizer Storage	Water Management
Dietary Phosphorus	Animal Husbandry
Soil Testing	Soil Health

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs.

- **University of Vermont Extension Program** provides laboratory testing, nutrient recommendations for field crops in Vermont and other services. Information can be accessed on the web at http://pss.uvm.edu/vtcrops/?Page=nutrientmanure.html. Soil test information is available at http://pss.uvm.edu/ag_testing/?Page=soils.html

- **Miner Institute** (http://whminer.serverbox.net/) does research and education on dairy farm and environmental conservation best practices. They published "Feeding Strategies to Reduce Phosphorus Inputs from Dairy Sources," which provides information on better utilizing dietary phosphorus. More information is available on the internet or by calling Kurt Cotanch at the Miner Institute at 518-846-7121, extension #123.

- **Livestock and Poultry Environmental Stewardship (LPES) Curriculum** provides environmental best management practice recommendations for dairy farms (http://www.lpes.org/les_plans.html). They also provide information on the new Concentrated Animal Feeding Operations (CAFO) regulations and links to funding and additional technical resources (http://www.lpes.org/CAFO.html). You can also call 1-800-562-3618 for more information.

- **The USDA Natural Resource Conservation Service (NRCS)** offers nutrient management information and tools at http://www.nrcs.usda.gov/technical/ECS/nutrient/. The program also provides funding and technical assistance for conservation efforts through Farm Bill 2002 (http://www.nrcs.usda.gov/programs/farmbill/2002/) and its affiliate programs, such as EQIP (http://www.nrcs.usda.gov/programs/eqip/). The Vermont NRCS also manages Farm*A*Syst, a program devoted to national and state-level improvements to ground water that provides comprehensive evaluation and best management sheets specifically for dairy farmers in Vermont. More information can be found at http://www.vt.nrcs.usda.gov/technical/FarmASyst/. Vermont NRCS State Office: 802-951-6796.

- **The Vermont Agency of Agriculture, Food and Markets** provides a clearinghouse of information on controlling non-point source pollution from dairy farms, including accepted agricultural practices (AAPs), best management practices (BMPs) and technical and financial assistance for projects.
  See http://www.vermontagriculture.com/pidnonpointsource.htm for more information. You can also call the Vermont Natural Resources Conservation Districts
  - Windham, Bennington, Rutland, Windsor, Counties: 802-257-5621
  - Orleans, Essex, Caledonia, Orange, Washington Counties: 802-229-2720
  - Addison, Chittenden, Lamoille, Franklin, & Grand Isle Counties: 802-388-6746

SUMMARY OF RESULTS FOR NUTRIENT MANAGEMENT

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

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QUESTION	ANSWER/SCORE
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2. Manure Application Rate	
3. Commercial Fertilizer Application Rate	
4. Manure & Phosphorus Fertilizer Application Timing & Techniques	
5. Nitrogen Fertilizer Application Timing & Techniques	
6. Fertilizer & Manure Application Equipment	
7. Use of Phosphorus Supplements	
Total Score (Out of Possible 25)	

Interpretation: The next step in understanding your farm's performance in the category of Nutrient Management is to compare your results to best practices. Below is a table that ranks your performance from overall best practice (green) to general need for improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	Interpretation
Green	21 - 25	Nutrient Management best practices are currently being employed on this farm.
Yellow	16 - 20	Farm is using some good practices regarding Nutrient Management. However there are some key areas that should be improved upon.
Red	7 - 15	Nutrient Management should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

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Footnotes

107 Weber, Greg. "Vermont Dairy Farm Sustainability Project, Inc. (VDFSP) DRAFT Summary." Provided by Greg Weber, formerly of VDFSP, via e-mail in June 2003.

108 Klausner. 1993. Quoted in Weber, Greg. "Vermont Dairy Farm Sustainability Project, Inc. (VDFSP) DRAFT Summary." Provided by Greg Weber, formerly of VDFSP, via e-mail in June 2003.

109 Vermont NRCS Farm*A*Syst. "Worksheet #3: Assessing the Risk of Groundwater Contamination from Fertilizer Storage and Handling." May 1998. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. <ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet3-Fertilizer_Storage&Handling.pdf>.

110 Jokela, Bill. "UVM Missiquoi Water Quality Factsheets: Dairy Farmers Save Dollars and Nutrients by Participating in HUA Crop Management Service." University of Vermont, Department of Plant and Soil Sciences. 15 Nov. 2002. 8 Dec. 2003. <http://pss.uvm.edu/vtcrops/LMWQ/Lmwq5.pdf>.

111 Vermont Dairy Farm Sustainability Project, Inc. 2002 update. 8 Dec. 2003. <http://www.sare.org/reporting/report_viewer.asp?pn=LNE01-151&ry=2002&rf=0>.

112 Vermont NRCS Farm*A*Syst. "Worksheet #13: Assessing the Risk of Groundwater Contamination from Nutrient Management." October 1997. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. < ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet13-Nutrient_Management_Practices.pdf>.

113 Ibid.

114 Michigan Department of Agriculture "Generally Accepted Agriculture and Management Practices for Nutrient Utilization." February 2002. Supplied via mail from Dr. Lee Jacobs, Department of Crop & Soil Sciences, Michigan State University.

115 The National Academies Press. "Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001." 2003. 22 Nov. 2003. <http://books.nap.edu/catalog/9825.html>.