NUTRIENT MANAGEMENT PLANNING AND APPLICATION

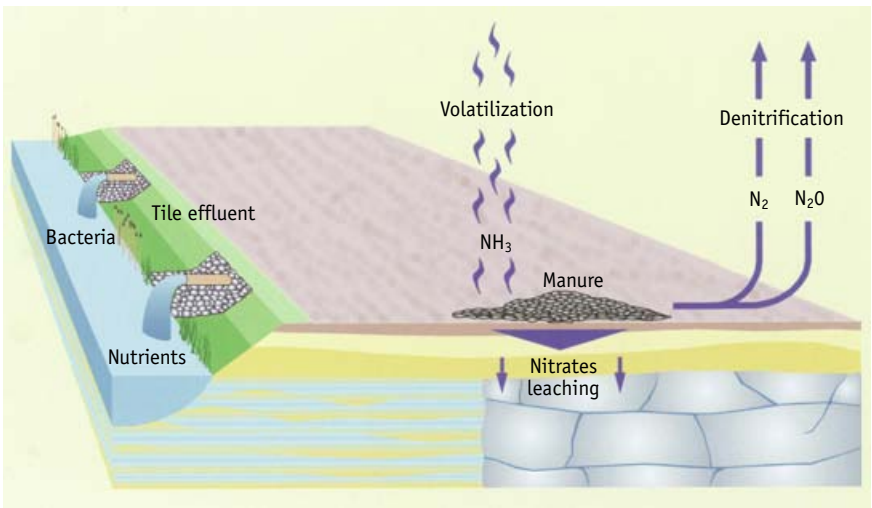
Manure is both a source of nutrients and a potential pollutant.

Manure contains valuable nutrients and organic matter that are beneficial to young, growing crops. Most (78%) of the nitrogen consumed by livestock ends up in urine and feces. Some of the nitrogen is lost as NH_3 (up to 80%) from manure. The nitrogen content of manure varies, but typically is around 2% of dry weight.

But these same nutrients can be harmful to your water supply when poorly managed.

It takes careful planning to reduce greenhouse gas emissions from applied manure and other wastes. We'll explore options in the upcoming sections.

If it's not incorporated, applied manure will release ammonia. If applied on wet soils and when the crop can't use the available nitrogen (e.g., fall-applied), it can also contribute to the production of nitrous oxides.



Ammonia can be lost from croplands directly through volatilization or indirectly through denitrification (if it's converted to ammonium and then to nitrates). Around 2% of manure is nitrogen. It comes in two forms: organic and inorganic. The inorganic fraction is ammonium/ammonia. The organic fraction will mineralize to form ammonium/ammonia. Both sources can lead to emissions of ammonia. Ammonia can react with water to form ammonium in soils and water. If the ammonium is not taken by crops and other vegetation, it can be nitrified (which is also a source of N_2O). Nitrified N can leach or denitrify to form N_2O.

Side-dress manure to reduce emissions.

If well-managed, manure additions will add SOC and nutrients, while reducing carbon and nitrogen losses from the system.

PLANNING

A nutrient management plan (NMP) is a working document and management tool that you can use to match farm-based and purchased crop nutrients with the nutrient needs of your crops. It also serves as a statement for societal assurance, demonstrating that nutrients are being applied at rates and with techniques that will minimize the risk of water pollution and greenhouse gas emissions.

10 STEPS TO MAKING IT WORK

Nutrient management planning is an in-depth process. But it doesn't have to be overwhelming – especially when you take it step-by-step.

Remember that your plan is not and should not be set in stone. Planning is a dynamic process, just as your operation is. That's why some steps are revisited, whether from season to season or year to year, as you evaluate your progress.

STEPS	DESCRIPTION	KEY COMPONENTS	
1. SET GOALS	• State your direction for nutrient management planning – helps with decision-making.	• Establish why you're doing the plan. • Seek advice. • Create a vision for what the plan will accomplish.	
2. TAKE INVENTORY	• Create a picture in time of what's currently available within your operation – if you don't know what you've got, you don't know what you need.	• Identify resources on the farm. • Describe site characteristics. • Detail current management practices.	
3. INPUT AND ANALYZE DATA	• Apply what you have against what you need to do.	• Use NMAN and MSTOR. • Determine land base requirements. • Conduct risk assessment.	
4. INTERPRET RESULTS	• Based on your data analysis, develop options – to manage risk, decrease input costs, and handle all nutrients generated.	• List possible management practices. • Identify changes to structures and facilities. • Remember the systems approach.	
5. MAKE DECISIONS	• Select options to meet your goals.	• Remember economics and common sense. • Honour personal and business goals. • Use available resources. • Set proper application rates. • Honour separation distances.	

STEPS	DESCRIPTION	KEY COMPONENTS	
6. ACT	• "Walk the talk" to meet your goals.	• Make an operational plan. • Complete day-to-day activities. • Account for the impact of outside forces (e.g., weather, markets).	
7. KEEP RECORDS	• Document what actually takes place – develop your own information for future planning, while showing accountability for your actions.	• Maintain: ○ application records ○ livestock records ○ cropping records ○ monitoring records.	
8. MONITOR	• Observe the impact of what you do to determine: ○ is production on track? ○ are ground and surface water protected? ○ are nutrients cycling properly?	• Monitor: ○ nutrient levels in soil and manure as it relates to crop performance ○ water quality in wells and tiles ○ livestock performance ○ nuisance impacts.	
9. ADJUST	• Fine-tune your plan, and upgrade technology where appropriate.	• Use information from record-keeping and monitoring. • Modify plan by repeating Steps 3 to 6.	
10. PLAN FOR THE UNEXPECTED	• Develop a contingency plan.	• Identify resources. • Communicate to others involved. • Document actions.	

SOIL TESTING

Soil testing will give you an index of likeihood of crop response to applied nutrients. Applying what your crops need, when they need it, will:

- ▸ improve crop growth
- ▸ improve crop tolerance to insects and diseases
- ▸ improve crop maturity and quality
- ▸ increase yields
- ▸ lower input costs
- ▸ protect the environment – less leaching, runoff and greenhouse gas production.

Make N-applications more precise with a soil nitrate test.

Tests are relatively inexpensive and more than pay for themselves.

✔ **Test your soils at least every three years** to manage soil pH, phosphorus, potassium and magnesium – and micro-nutrients in some cropland

- ▸ take them at the same point in the rotation and time of year for consistency.

N-TESTING

The amount of nitrate–nitrogen present in your soil at planting time can indicate a soil's capacity to supply nitrogen. In general, the higher the concentration of nitrate–nitrogen in the soil, the lower the amount of nitrogen required for optimum yields.

✔ **Modify N application rates according to nitrate test results.**

HOW TO CALIBRATE YOUR SPREADER

Based on their spreader's capacity, many farmers estimate how much manure is spread by counting the number of loads being applied to a field. Although this may seem to work well, it doesn't take into account the different densities of the manure or whether the spreader is being filled to meet the manufacturer's specifications.

You can use several methods to measure your spreading rates. One quick method for solid manure involves weighing the manure applied onto a plastic sheet placed in the path of the spreader. A method for liquid manure uses a straight-walled pail to measure depth of application.

Nutrient Use Efficient (NUE) best management practices will reduce emissions and provide nutrients when and where needed.

BMPs FOR NUTRIENT USE EFFICIENCY (NUE)

Nutrient Use Efficiency (NUE) refers to how well a crop uses available soil nutrients such as nitrogen. The more taken up and used by the crop, the less nitrogen remains in the soil to be leached, volatilized or denitrified to form nitrous oxide.

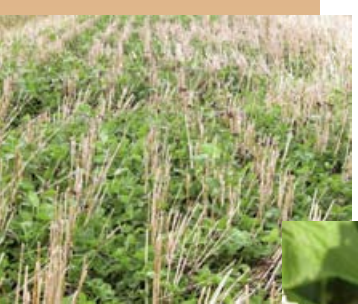
Nutrient management systems that strive to improve NUE do the following:

- ▶ make the required amount of available forms of nitrogen available when the crop needs them
- ▶ place nitrogen where the crop roots can access them
- ▶ reduce the amount of nitrate in the soil when the crop can't use it
- ▶ account for and manage all sources of plant-available N
- ▶ manage other cultural practices and conditions for NUE (e.g., soil and water management).

BENEFITS

- ▶ reduced nitrous oxide production
- ▶ increased carbon dioxide uptake by crops (growth and yield)
- ▶ increased yields and improved product quality
- ▶ lower fertilizer input and application costs – less energy and greenhouse gas produced for N-fertilizers
- ▶ less runoff and groundwater contamination

Improve NUE with legumes in your rotation.



BMPs FOR IMPROVING NUE IN FIELD CROPS

✔ **Rotate crops to maximize NUE.** Growing a legume or forage before a high N-demanding crop will improve NUE. Legumes and forages lose less plant N from the system.

Use cover crops to trap nitrates for the next crop.

✔ **Select varieties for more NUE.** Varieties that use water efficiently will improve overall NUE.

✔ **Reduce tillage.** Less tillage means that root zone placement is better – preferable to surface broadcast.

✔ **Use appropriate N source.** Use ammonium for low-yield expectations and ammonium + nitrate for high-yield expectations.

✔ **Time nutrient application appropriately.** Use split application for grains and oilseeds, but no pre-plant N if N-levels are high.

✔ **Use cover (or trap) crops in the off-season** to capture and hold plant-available N for future crop use.

BMPs FOR APPLICATION

To complete your system, consider the following best management practices for application that also reduce greenhouse gas emissions. Beyond nutrient management planning and NUE, your key considerations will be:

▸ timing – respecting season and weather conditions

▸ rate of application in relation to crop needs – minimizing spillage and ensuring the product is hitting the target

▸ method of application – minimizing loss and improving NUE.

Winter application leads to increased losses of methane, ammonia and nitrous oxides.

TIMING

✔ **Avoid late fall and winter application.** Application at these times leads to high denitrification rates. During snowmelt, the soil becomes saturated or anaerobic, leading to methane and nitrous oxide emissions.

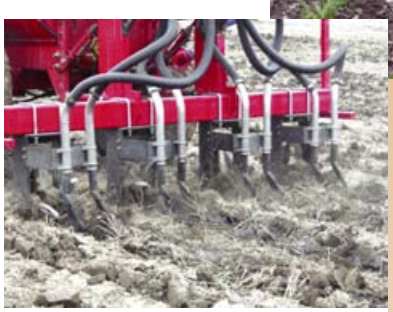
✔ **Avoid application prior to anticipated storm events and snowmelt** whenever possible to reduce nutrient loss, runoff, soil compaction and tile effluent. Avoid spreading if rainfall occurs shortly before application, or heavy rains are forecast within 12–24 hours of spreading on tile-drained lands. Note:

- ▸ runoff will wash manure to areas of standing water where denitrification and anaerobic decomposition will continue until local carbon and nitrogen sources are depleted
- ▸ it's best to incorporate before rain to reduce loss by volatilization – in cool damp weather, NH_3 loss is reduced
- ▸ avoid applying liquid manure when tiles are running.

Reduce emissions from soils with side-dress applications.

✔ **In summer, plan side-dress applications of manure to growing row crops on cereal stubble or between cuts of forages.** This avoids crop damage, and keeps applications off of crop foliage.

✔ **Incorporate manure within 24 hours of application.**



Incorporate within 24 hours or inject into root zone to reduce nutrient loss.

Where possible, lower application rates of liquid manure so as to keep soil drier and release fewer emissions.

RATES

✔ **Reduce rate to minimize denitrification.**

✔ **Consider lower rates of liquid nutrient application** (<15,000 gallons/acre). This translates into lower soil moisture conditions, so that less methane and nitrous oxide is lost.

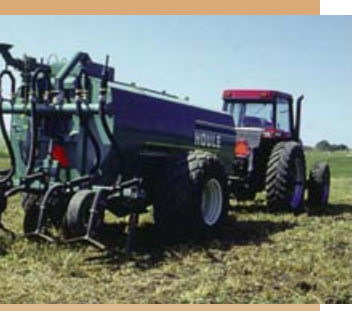
✔ **Ensure application rates of all sources of N approximate economic yield.** For organic N, add only about one-half of what the crop needs.

APPLICATION METHOD

✔ **Try for immediate incorporation** wherever possible.

APPLICATION METHOD	NITROUS OXIDE LOST kg N_2O-N/ha
Incorporation	2.7
Injection	4.8
Broadcast	5.6

Injection methods reduce ammonia loss.



✔ **Maximize soil–manure contact to reduce ammonia volatilization.** These three application methods produced less ammonia than broadcast: banding liquid manure (39% less), trailing shoe (43%), and shallow injection (57%). However, banding/injection of liquid manure may lead to more denitrification due to concentrated C+N in warm moist conditions. But injection followed by soil covering can reduce NH_3 volatilization. Injection will reduce ammonia loss.

✔ **Avoid manure fertigation.** Irrigation of manure emits excessive N_2O because of saturated conditions. If irrigating, don't spray too high above ground.

✔ **Avoid application during hot, humid or windy weather.** Odours are more intense and ammonia loss increases at these times.

✔ **Have regard for neighbours' concerns** when spreading near their homes.

✔ **Where suitable, pre-till tile-drained lands before applying liquid manure.** This will break up large pores and reduce infiltration to tiles. Care and consideration must be given to soil conservation. Maintain as much residue cover as possible. Note: pre-tillage may not be necessary if a visual system for outlet monitoring exists.

Avoid surface application on steeply sloping lands adjacent to environmentally sensitive areas.

✔ **Inspect drains** to ensure the absence of manure.

✔ **Avoid surface application on steeply sloping lands** adjacent to watercourses, lakes, ponds and wetlands.

✔ **Monitor and be prepared to react to any spills.**