Soil
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SAFE AND EFFICIENT NITROGEN USE

INTRODUCTION

Why are we so interested in nitrogen? Many wonder why, in this age of sophisticated research, computers and high tech., the matter of safe and efficient nitrogen use on dairy farms remains an issue. Can't farmers simply obtain soil, feed and manure samples, have them analyzed and then, by following the recommendation, use nitrogen containing feeds and fertilizers efficiently to achieve profitable levels of production? The answer in many cases is "no". In South Coastal BC, many aspects of nitrogen behaviour are so complex that soil and plant analytical procedures are really of little value. Nitrogen is not like phosphorus, potassium and some other nutrients, where soil testing is of real value.

There are a number of unique aspects of this area of BC which make it important that we, in agriculture, focus our attention more closely on the safe and efficient use of nitrogen.

This paper includes discussions of nitrogen behaviour, environmental issues, unique climate and soil conditions of South Coastal BC and some practical guidance on nitrogen management.

NITROGEN BEHAVIOR

Much of the nitrogen in soils and manures is tied up in complex organic compounds which must be broken down by microorganisms before the nitrogen becomes available to plant roots. Once in plant available form, these simple nitrogen compounds can be made unavailable to plant roots due to other microbial and chemical processes. Predicting the rate of all of these processes for a future growing season is a difficult and sometimes impossible task. Therefore, a farmer faced with such uncertain predictions often applies excess nitrogen to ensure high yields. Unfortunately, this practice can lead to problems of animal health and environmental degradation.

Mineralization

Mineralization is the decomposition of organic compounds such as proteins into the simple inorganic molecule, ammonia. This is an extremely important process and one that still requires a good deal of research to allow for accurate predictions of the rate and quantity of ammonia that will be produced during the growing season. The rate of decomposition is governed by the type of organic matter in the soil, soil temperature, moisture content, soil acidity, soil aeration and other factors.

However, we have done enough work to know that mineralization of soil organic matter and the organic compounds in manure can be sufficient to supply all or a very significant portion of a crop's nitrogen requirement. Therefore, if mineralization is not taken into account when determining fertilizer rates, significant over application can occur resulting in high nitrate and readily degradable nitrogen compounds in feeds, high losses of nitrogen to the environment and reduced profits due to unnecessary purchase of fertilizer.

Nitrification

Ammonium, which is the product of mineralization or which is applied to the soil in fertilizers and manures, is converted in the soil to nitrate by soil bacteria. The rate of nitrification is governed by soil temperature, moisture and pH.

Leaching

Nitrates are not held by the soil particles, so when water moves in the soil, nitrates move with it. This fact is of significant consequence to the environment of coastal BC. Due to the nitrification process, virtually all plant available nitrogen is in the nitrate form in the fall of the year. When the heavy rains come in November, December and January and soils become saturated, any downward movement of water leaches nitrates into the subsoils and eventually into surface and ground waters. We know from many years of soil analysis that all nitrates in the soil, in the fall, are gone by the next spring. Therefore, a fall or spring nitrate soil test, as used extensively on the prairies, is of absolutely no value in our coastal area for helping to predict next year's nitrogen fertilizer requirement.

Denitrification

When soils become saturated, all of the oxygen is removed from the pores in the soil. Certain bacteria can use other molecules as a source of oxygen. One such molecule is nitrate. When these bacteria strip some or all of the oxygen from nitrate they release nitrogen compounds that are in the form of gases. These bubble to the soil surface and are lost to the denitrification in the region. Research is required before farmers can take denitrification into account when fine tuning fertilizer and manure use.

Immobilization

Some forms of organic material added to soil have a very high carbon content and a low nitrogen content, e.g. wood shavings and straw. The soil microorganisms that begin to break down these materials have a high requirement for plant available nitrogen. These microorganisms are so efficient in obtaining nitrogen that, if nitrogen is in short supply, plants will be nitrogen deficient. If manures contain significant bedding, much of the nitrogen may not be available during the growing season and, therefore, extra nitrogen is required. However as the bacteria do their work, they will die and begin to release plant available nitrogen. If this is significant, the amount of soil nitrate in the fall will be high resulting in losses to the environment.

Manure Composition and Management

The nutrient content of various manures is extremely variable. In addition, manure management practices during collection, storage and application can greatly influence the amount of manure nitrogen that eventually becomes available to plants. Because of this variability, it is difficult for farmers to take the full value of manure into account when determining nitrogen fertilizer requirement. Therefore, nitrogen is often over applied which can lead to environmental contamination.

ENVIRONMENTAL ISSUES

Research in Holland indicates that only about 15 to 20 percent of the nitrogen brought onto a dairy farm, in the form of fertilizers and feeds, leaves the farm in the form of milk, meat and crops. In other words, 80 – 85 percent is either retained in the soil or lost to the environment. In recent years in Europe, they have found that the loss to the environment is very significant.

Nitrates in Drinking Water

The Canadian drinking water standard for nitrates is 10 mg/L (ppm). Well water monitoring programs conducted by federal and provincial environmental agencies have found nitrate levels in excess of the standard in some areas of the Fraser Valley. The major source of nitrates in at least some of these cases is animal manures.

Eutrophication of Surface Water

Excessive levels of nutrients, such as phosphorus and nitrogen, in surface water allow aquatic plants to flourish. When these plants die, microorganisms use up the oxygen in the water in the process of decomposition. Fish can not live in this water and the water is often no longer usable for recreation. Fish kills are not uncommon in local streams such as the Serpentine and Nicomekl Rivers in Surrey. Animal wastes and fertilizers are definitely sources of much of the nitrogen and phosphorus entering these waters.

Ammonia to the Atmosphere

In Europe, it is estimated that 20% of the acid rain is caused by ammonia and 80% of the ammonia comes from agriculture. Holland has enacted laws to control ammonia loss to the atmosphere. Although as of yet, ammonia has not been identified as a significant air pollutant in this region, it is known that the air around Abbotsford has elevated levels of ammonia. The main source is probably the poultry industry.

UNIQUE NATURE OF SOUTH COASTAL BC

Climate

Mild temperatures combined with very heavy precipitation during the winter months make the climate of the region unique in the agricultural areas of the western world. So although we look to Western Europe for relevant information, our much greater winter precipitation limits the relevance of direct comparisons. As we know, Europe has some grave agriculturally related environmental issues. Although we say, with some confidence, that our situation is much less urgent, our climate makes the risk of environmental contamination from agriculture significantly greater.

Animal Density

Again, the European situation tells us that animal numbers per hectare can not rise indefinitely without problems of excess application of nutrients and the resulting problems of forage quality and environmental degradation. Mr. Rick Van Kleeck of the Resource Management Branch has recently concluded an extensive review of animal numbers and the land available for manure spreading. Nitrogen application to land is close to the limit in the south coastal region, as a whole. There are some pockets in the Lower Fraser Valley where excess nitrogen is being applied. We can not be complacent. We will certainly end up where western Europe is today unless greater attention is paid to safe and efficient nitrogen use.

Rural / Urban Issues

The rural/urban interface is a fact of life in this region. As more and more urbanites move into the rural areas and as they look to the rural landscape for recreation, farmers will be faced with the inevitable problems that this entails. With the renewed attention to the environment, citizens want to ensure a sustainable future. As we have seen in Europe, this concern includes agriculture. Citizens are no more willing to tolerate pollution from agriculture than they are from industry.

Yield Potential

The climate, characterized by an extremely long growing season, good moisture distribution and a reasonable amount of heat, results in yield potentials for many crops that are among the highest in the country. To achieve this potential, all other production factors, including soil fertility, must be in order. Therefore, there is a tendency to apply more nutrients, especially nitrogen, than necessary as a relatively inexpensive insurance policy.

NITROGEN MANAGEMENT GUIDANCE

Fertilizer and Manure Application to Grass and Corn

The goals of fertilizer and manure use are:

a. Top yields of top quality forage.
b. Forage which will not adversely affect animal performance.
c. Maximum profit.
d. Minimal adverse environmental impacts.

I. Grass

Grass yield and quality are profoundly affected by the way in which dairy producers manage the nitrogen applied in manure and fertilizer. With the added factor of environmental contamination, research scientists in Europe have embarked upon a massive effort to devise environmentally and agronomically sound grass and nitrogen management practices. Following are some conclusions drawn from this work and recommendations on management practices.

Conclusions

1. High rates of nitrogen are required to achieve top grass yields.
2. Top yielding grass stands will generally have protein contents greater than 20%.
3. Grass with protein content above 20% has a significant risk of having excess levels of nitrate.
4. As crude protein content increases, rate of protein degradation in the rumen increases.
5. Maximum grass yields and top quality for animal performance are probably not both achievable on a regular basis.
6. The potential for nitrate leaching under productive grass stands is minimal.

Recommendations

1. Check forage for nitrate content if the crude protein level is above 20%.
2. To achieve maximum yields with acceptable quality, nitrogen fertilizer rates must be adjusted according to the amount of nitrogen being supplied from manure and the soil. The Nitrogen

Use Model is a tool that can be used to evaluate on-farm nitrogen management practices and provide guidance on fertilizer and manure management.

3. If fields have been manured and have a history of receiving manure, the maximum fertilizer rate should be 50 kg/ha nitrogen per cut. Decrease the fertilizer rate if harvested forage has more than 20% crude protein. Table 1 indicates the situation on a farm in Surrey during 1989. The addition of 46 kg/ha nitrogen raised protein and nitrate levels to 22.5% and 0.27%, respectively. Although some fertilizer nitrogen is probably necessary on this farm, it should be significantly less than 46 kg/ha per cut.
4. Summer applications of nitrogen must be based on the potential for growth. If the stand is on a droughty soil and irrigation is not available, much of the applied nitrogen will not be used and therefore may contribute to nitrate accumulation in subsequent cuts.

Table 1 Effects of fertilization on crude protein and nitrate content of grass grown at a Surrey Farm

Fertilizer Rate (kg/ha)	% Crude Protein	% Nitrate Nitrogen
0	17.7	0.04
46	22.5	0.27

II. Corn

Nitrogen management for the production of silage corn needs to be somewhat different from that for grass if the goals of high yields and environmental protection are to be achieved. Fortunately we have some local research which, combined with information from Europe, can be used to help guide fertilizer and manure use.

Conclusions

Manure and soil nitrogen has the potential to produce maximum yields without addition of additional nitrogen.
High nitrogen rates do not reduce feed quality.
The protein for loss of nitrogen to the environment is high.

Recommendations

Fertilizer rates must be adjusted to take into account the amount of nitrogen being supplied by manure and fertilizer. The Nitrogen Use Model can help to guide producers to make appropriate adjustments. An additional tool is to take a soil sample at side dress time.
Winter cover crops should be planted to catch excess nitrogen and reduce leaching losses.
Spring applied manure should be incorporated immediately to conserve nitrogen and thereby reduce the need for fertilizer.
The maximum rate of manure should be that which supplies about 75% of the crop need. If all nitrogen comes from manure, the amount of leachable nitrogen in the soil in the fall will be high.

Nitrogen Use Model

Much of what has been discussed in this paper has been communicated in various forms at different extension events many times in the past. You know that nitrogen behavior is complex, that there is a potential for pollution, that yields are high and that we need to do a better job of nitrogen management. We, in the extension and research field, have been aware of all of these issues for a long time as well. In the 1970's, Drs. Ross Bulley and Art Bomke of the University of BC and Dr. Ernie Barber and Ron Bertrand with the Ministry of Agriculture, Food and Fisheries began working on trying to come up with some practical solutions.

The outcome of this work was a nitrogen behavior computer simulation model and the Manure Management Guidelines. Under the current ARDSA program, we have been able to upgrade this model so that it now runs on a portable microcomputer. This project is in its final stages and in the near future we will have a tool that will help individual farmers to achieve the goal of safe and efficient nitrogen use.

The model simulates nitrogen behavior in manure and soils. The data produced by the model indicates yield, soil nitrogen content, nitrogen losses during manure collection, storage, application and leaching and denitrification losses from the soil.

Late Spring Soil Test

As previously discussed, a fall or early spring soil test is of no value for guiding manure and fertilizer use in South Coastal BC. This is also true for the humid areas of eastern Canada, United States and Europe. In recent years, considerable effort has gone into investigating the possibility of using a late spring soil test. For corn, this entails taking a soil sample at side dress time and using the results to determine if side dressing is necessary.

We know that there are numerous situations where fertilization is not necessary; that corn yields are the same with and without supplemental fertilization with nitrogen. Some method of identifying these nonresponsive sites is essential if we are to achieve the goal of safe and efficient nitrogen use.

Reports in the literature and our local research point to a range of 20 to 30 kg/ha nitrate nitrogen in the plough layer (0-20 cm) at side dress time as being critical. Soils with nitrate levels above this range will probably not respond to added nitrogen. Below this range there is a high probability of response.

Catch Cropping

One of the main environmental concerns in Europe is the leaching of nitrogen over the winter from soils that have been used to grow annual crops such as corn and grains. To reduce the problem, farm advisors are actively encouraging the use of catch crops. This is the practice of planting a winter cover crop for the main purpose of 'catching" soil nitrogen. The plants take up nitrogen into the roots and leaves and thereby prevent leaching and make the nitrogen available to the subsequent crop.

Catch crops should be sown in early September to be most effective. However, if sown in October after corn harvest, such crops will still be of some value for catching nitrogen. Added benefits of winter cover include improving drainage and protecting soils from water and wind erosion.

Seasonal Guidance on Manure and Fertilizer Management

December – March

1. If the land is subject to flooding and/or runoff, no manure should be applied.
2. If flooding and runoff are controlled through adequate on-farm and regional drainage, some manure can safely be applied on grassland or land seeded to a winter cover crop.
3. No manure should be applied to bare land.
4. Fertilizer nitrogen application to grassland should be based on a system which takes into account growing conditions (e.g. T sum 200 system). Ensure that manure applied since the previous fall is taken into account when determining fertilizer rate.

April – May

1. Apply and immediately incorporate sufficient manure to supply up to 75% of corn crop nitrogen requirement. Do not attempt to completely fertilize corn with manure.

June – August

1. If manure must be applied, in most cases, it can be applied only to grassland. Adjust chemical fertilizer accordingly. Manure nitrogen efficiency can be greatly increased by irrigation immediately following application, injection, or application of very wet slurries (>95% H2O).
2. Grass fertilization should be fine-tuned to keep crude protein content below 20% and thereby reduce the risk of nitrate accumulation.

September – November

1. Plant winter cover on corn land. Do this in September, if possible.
2. **DO NOT APPLY ANY MANURE ON CORN LAND**. This will considerably increase nitrate losses.
3. Try not to apply any manure at all. If manure application is essential, it should be on grassland that is well drained and not subject to flooding or run-off.

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