Reducing Nitrous Oxide Emissions in New Brunswick Potato Production

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Why should I care about nitrous oxide emissions?

Nitrous oxide is an important man-made greenhouse gas. Nitrous oxide has a global warming potential almost 300 times greater than that of carbon dioxide and is known to cause destruction of stratospheric ozone. On a global basis, nitrous oxide emissions represent about 60% of agricultural greenhouse gas emissions. Agricultural soil is the greatest single source of nitrous oxide emissions.

While there are always some nitrous oxide emissions from agricultural soils, these emissions can be reduced through use of good soil and crop management practices. Some of the practices designed to reduce nitrous oxide emissions can also have economic benefits by reducing crop input costs. Managing to reduce nitrous oxide emissions not only helps our planet, it can also improve your bottom line.

Where does nitrous oxide come from?

Most nitrous oxide in agricultural soils comes from two soil microbial processes, nitrification and denitrification.

Nitrification is the transformation of ammonium to nitrate. This process is the main source of nitrous oxide in dryland crop production in semi-arid environments.

Under irrigation or in humid environments like New Brunswick, most nitrous oxide is associated with the process of denitrification. Denitrification is a process by which nitrate is converted to nitrogen gas under oxygen limited conditions. Nitrous oxide is produced as an intermediate step in this process, and can be released to the atmosphere. This process occurs naturally by bacteria that can use nitrate instead of oxygen when the supply of oxygen is limited.

It is important to remember that nitrous oxide emissions can also occur off-site. Nitrate from agricultural fields that is lost to surface or groundwater can also contribute to nitrous oxide emissions.

What controls how much nitrous oxide is produced?

Emissions of nitrous oxide from the denitrification process are influenced by a number of factors including oxygen supply, availability of nitrate, availability of carbon, and soil properties such as temperature and pH.

A limited oxygen supply is required for denitrification to occur. This can result from wet soils, for example due to heavy rainfall, snowmelt, or excessive irrigation.

Denitrification can also occur when soil microbial activity is high. Soil organic carbon provides the energy needed for growth and activity of soil microorganisms. When soil carbon availability is high, the soil oxygen supply is depleted and denitrification can occur. For example, this can occur following incorporation of fresh crop residues or liquid manure.

The denitrification process also requires a supply of nitrate. This nitrate can come from soil organic matter, crop residues, organic amendments or mineral fertilizer products. Also, when the supply of nitrate in soil is high, the denitrification process mostly produces nitrous oxide. When the nitrate supply is low, the denitrification process mostly produces nitrogen gas rather than nitrous oxide.

Table 1. BMPs for fertilizer N management to reduce nitrous oxide emissions from potato production in New Brunswick.

Right rate:

√ Use N credits for preceding crop, manure application and soil organic matter to adjust your fertilizer N rate.
√ Use petiole nitrate testing during the growing season to ensure your potato crop has a sufficient N supply.
√ Use petiole nitrate testing late in the growing season to see if your crop received an excessive N supply.
√ Identify management zones within your field to use as the basis for site-specific N management.

Right place:

√ Band fertilizer N at planting.
√ Incorporate in-season applications of granular fertilizer immediately after application.

Right time:

√ Use split N application when appropriate.

Right source:

√ Use controlled release fertilizer products when appropriate.

Other soil properties can also influence the denitrification process through their effects on microbial growth. For example, warm temperatures increase microbial activity, and can result in greater depletion of soil oxygen supply.

How can I reduce my nitrous oxide emissions?

In general, our goal is to maximize the efficiency of crop production, and reduce the risk of nitrous oxide emissions. That is, we want to optimize crop yield per unit of applied fertilizer N, and minimize the opportunities for nitrate to accumulate in soil where it can contribute to nitrous oxide emissions.

There are two general approaches which can be taken to reduce nitrous oxide emissions. The first is to manage fertilizer N effectively. The second is to use good agronomic and land use practices.

Good fertilizer N management

Good fertilizer N management can be summarized by the 4R Nitrogen Stewardship Plan (Government of Alberta 2010). That is, application of the Right Source of fertilizer N at the Right Rate, the Right Time, and in the Right Place.

Right rate:

The choice of fertilizer N rate is one of the most important decisions for growers in terms of both economics and the environment. The crop requires sufficient N to meet tuber yield and size goals, whereas excessive N application can delay tuber maturity, cause problems with vine desiccation, and reduce tuber quality, especially specific gravity.

The risk of nitrous oxide emissions increases with increasing fertilizer N rate. However, this risk is greatly increased as the fertilizer N rate is increased above the optimal N rate. In addition, off-site emissions of nitrous oxide are greatly increased by N application in excess of the optimum rate. Therefore, the best way to manage nitrous oxide emissions in potato production is to apply the optimal fertilizer N rate. While this sounds simple, this can be challenging because the optimal rate varies among fields and among years.

Selection of an optimal fertilizer N rate at planting can be done using the factsheet "Nitrogen management for potatoes: General fertilizer recommendations" (Zebarth et al. 2007a). This factsheet modifies the fertilizer N rate for a specific potato cultivar using N credits based on the preceding crop, manure application, and soil organic matter. The recommended fertilizer N rate is also decreased for fields where the crop is planted late or topkilled early.

You can also use petiole nitrate testing to evaluate your N fertility program. Monitoring petiole nitrate concentration during the growing season is a good way to ensure your crop has a sufficient N supply. If your potato crop has a high petiole nitrate concentration late in the growing season, your crop received more N than it needed, and you are at risk of low specific gravity and of high residual soil nitrate. Recommendations for petiole nitrate testing are provided in factsheet "Nitrogen management for potatoes: Petiole nitrate testing" (Zebarth et al. 2007b).

The optimum fertilizer N rate can also vary within individual fields. In some cases, site-specific N management can be used to improve fertilizer N management. The most practical approach at this time is to define management zones within your field which differ in terms of soil properties or crop yield. Each management zone can then be managed individually.

Right place:

Fertilizer N is commonly banded with the planter close to the seed. This placement is effective in enhancing crop N uptake, especially early in the growing season. Band application of ammonium-based fertilizer also slows the transformation of ammonium to nitrate, and reduces the risk of nitrate leaching early in the growing season.

In-season applications of granular fertilizer should be incorporated immediately after application through tillage or hilling operations to reduce the risk of N losses to the atmosphere as ammonia.

Right time:

Split fertilizer N application has been shown to reduce nitrous oxide emissions from potato production under wet spring conditions. However, split fertilizer N application needs to be done with caution under rain-fed potato production. Research in New Brunswick and Maine has shown that loss of yield potential can occur with split N application under dry soil conditions. The most practical approach is to apply the optimal fertilizer N rate at planting, then apply additional granular or foliar N as required based on crop response and environmental conditions.

Right source:

Banding of ammonium-based fertilizer at planting can delay the transformation of ammonium to nitrate and reduce the risk of nitrous oxide emissions early in the growing season.

Controlled release fertilizer products can be more efficient in supplying N to the potato crop, especially in sandy soils, under wet spring conditions, or following heavy summer rainfall events. This means that more of the applied N will be available to the plant, and less will be lost to the environment and off-site emissions will be decreased. A reduced fertilizer N rate is recommended when using controlled release fertilizer products, otherwise the N supply to the plant may be higher than needed and this may increase the risk of nitrous oxide emissions during the growing season.

Good agronomic and land use practices.

Use of good agronomic practices is one of the best ways of meeting the goal of maximize crop production per unit of fertilizer N applied, while minimizing the risk of nitrous oxide emissions.

It is recommended to do an annual soil test for phosphorus and potassium. Soil pH should be maintained between 5.2 and 6.2, depending on potato variety. Practices which maintain and increase soil organic matter content are critical for maintaining optimal soil physical properties. Poor soil physical properties, for example low soil water holding capacity, can reduce crop yield potential. It is also important to achieve optimum plant and stem populations for the market targeted, scout fields to ensure adequate control of pests and diseases, and regularly monitor tuber health and quality in order to take appropriate and timely management decisions that will make the difference between a normal and an above average yielding crop.

References

Government of Alberta. 2010. Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions.

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