IPNI

Nutrient Source SPECIFICS

No. 26

Nitrification Inhibitors

Some compounds added to nitrogen (N) fertilizers can reduce the rate at which ammonium is converted to nitrate. Under appropriate conditions, this can help reduce N losses through denitrification and leaching.

Nitrification in Soil

Nitrification is a natural process in soils that converts ammonium to nitrite and then to nitrate. The soil bacteria *Nitrosomonas* spp. extract energy from ammonium by converting it to nitrite. A second group of bacteria, *Nitrobacter* spp. then convert nitrite to nitrate. Both types of bacteria are common in soil and it is the first reaction that limits the overall rate of nitrate production.

With moderate temperature and soil water content nitrification occurs on most soils within a few days or weeks after application of ammonium sources. The ammonium can come from urine, manures, composts, decomposing crop residues, or fertilizer containing ammonium or urea.

$$NH_4^+ \xrightarrow{\text{Nitrosomonas}} NO_2^- \xrightarrow{\text{Nitrobacter}} NO_3^-$$

Ammonium → Nitrite → Nitrate

INCITEC PIVOT FERTILIZERS

Nitrate is the dominant form of plant available N in soil and unless taken up by roots, it can be transferred to either water or the atmosphere. Nitrate can leach below the root zone with the potential to be transferred to surface or sub-surface waters. Under waterlogged conditions, nitrate can be denitrified to form nitrous oxides and dinitrogen by other soil bacteria. While dinitrogen is the most common gas in the atmosphere and inert, nitrous oxide is a powerful greenhouse gas. Some nitrous oxide can also be produced during nitrite decomposition during nitrification.

Nitrification is rapid in warm (>25°C) soils, and it largely ceases below 5°C. It occurs most rapidly where the soils are well aerated and near field capacity, and decreases with higher or lower moisture contents. In saturated soils nitrification nearly stops because of the lack of oxygen.

Regulating Nitrification

The rate of nitrification can be controlled by preserving N as ammonium, which can be held on soil colloids rather than leached. Nitrification inhibitors are compounds that delay nitrate production by depressing the activity of *Nitrosomonas* bacteria.

There are at least eight compounds recognized commercially as nitrification inhibitors although the most commonly used and best understood are 2-chloro-6-(trichloromethyl)-pyridine (Nitrapyrin), dicyandiamide (DCD) and 3,4-dimethylpyrazole phosphate (DMPP). These compounds suppress microbial activity for a few days to weeks depending on soil moisture and soil type although there are differences between them in the way they are deployed. In general, nitrification inhibitors are more effective in sandy soils, or soil low in organic matter and exposed to low temperatures.

Management Practices

Nitrapyrin can be injected directly into the soil with anhydrous ammonia or coated onto solid N fertilizers or mixed with manures. Because nitrapyrin is volatile it needs to be incorporated into the soil. Nitrapyrin is usually broken down within 30 days in warm soils.

DMPP is usually supplied pre-blended with fertilizers. It is considered a highly specific nitrification inhibitor active for 25 to 70 days, but its effect is reduced at higher temperatures. It is relatively immobile in the soil.

DCD can be coated on solid fertilizers, and is also used where manures are surface applied, and can be used post-grazing to reduce nitrate leaching from urine patches. The inhibitory effect of DCD usually lasts between 25 to 55 days, and it is readily leached, lowering its effectiveness.

A study in New Zealand showed that DCD applied to grazed pastures reduced nitrate leaching from urine patches by 59% and nitrous oxide emissions by 82%, as well as increasing herbage production by 30%.

Because there are many factors that control both the rate of nitrification and the activity of the inhibitor, there is considerable variability in the reduction in the amount of nitrate leached, the reduction in nitrous oxide produced, economic return and the potential benefits associated with their use. So, the yield benefits occur when sufficient N is preserved to provide additional growth.

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