Air Quality Enhancement Activity – AIR09 – Nitrification inhibitors or urease inhibitors

Enhancement Description
The use of an ammonia or ammonium fertilizers with a substance that inhibits the biological oxidations of ammoniacal nitrogen to nitrate nitrogen or the use of surface applied urea products with a substance that inhibits hydrolytic action on urea by urease enzyme that when applied to soils results in less urea nitrogen lost by ammonia volatilization (AAPFCO). This enhancement is only applicable to nitrogen applied within 30 days of planting or after consecutive warm days (i.e., greater than 75°F). This does not apply to “pop-up” or starter nitrogen sources applied at planting time.

Land Use Applicability
Cropland, Pastureland

Benefits
When ammonia or ammonium N is added to the soil, it is subject to a process called nitrification. Soil bacteria called nitrosomonas convert the ammonia (NH₃) or ammonium (NH₄) to nitrate (NO₃). This conversion is strongly temperature dependent and occurs quickly under warm soil temperature conditions. Using a nitrification inhibitor with early spring applications of ammonia or ammonium nitrogen will slow the conversion to nitrate until it can be readily used by crops. This will allow the crop to take up more of the N and ultimately reduce the release of nitric oxide (an ozone precursor) and nitrous oxide (a greenhouse gas) to the atmosphere. These conversion processes can produce nitrous oxide as a byproduct due to inefficiencies in the conversion processes. Nitrous oxide is a potent greenhouse gas which, on a molecular basis, has 310 times the global warming potential of carbon dioxide.

Using a urease inhibitor (with surface applied urea products) will reduce the volatilization and release of ammonia into the atmosphere that occurs as urea hydrolyzes. Urease is an enzyme produced by bacteria in the soil. It catalyzes the hydrolysis of urea into carbon dioxide and ammonia. Ammonia released to the atmosphere is a pre-cursor to PM2.5 particulate matter.

Conditions Where Enhancement Applies
This enhancement applies to climatic areas and soils on cropland or pastureland where nitrogen fertilizer is applied AND where either nitrification inhibitors or urease inhibitors are recommended by the Land Grant University.

Criteria
Use either a nitrification inhibitor or urease inhibitor product (depending upon the type of nitrogen fertilizer or manure used) on the treatment acres.
1. Nutrient application rates must be within Land Grant University recommendations based on soil tests and established yield goals considering all nutrient sources. The nutrient application rate must take into account the additional nitrogen that will remain available to the plant due to the inhibition of the nitrification processes.

2. Apply the nitrification inhibitor or urease inhibitor according to manufacturer recommendations.

3. The methods used to apply the nitrification inhibitor or urease inhibitor must not increase soil surface disturbance.

4. This enhancement is only applicable for nitrogen applications that take place within 30 days prior to planting time, after average daytime temperatures exceed 75°F consecutively, or when the forecast predicts 4 consecutive days with temperatures in excess of 75°F.

5. Materials which are acceptable for this enhancement must be defined by the Association of American Plant Food Control Officials (AAPFCO) and be accepted for use by the State fertilizer control official, or similar authority, with responsibility for verification of product guarantees, ingredients (by AAPFCO definition) and label claims.

Adoption Requirements
This enhancement is considered adopted when ammonia or ammonium fertilizers or urea products that contain a substance as described in the Enhancement Description above have been utilized in accordance with the Criteria of this job sheet on the land use acreage.

Documentation Requirements
1. A map showing where the enhancement was applied,
2. Date(s) of application of fertilizer with inhibitor,
3. Acres of land treated,
4. Soil test results,
5. Manure analysis results (where applicable),
6. Crops grown and yields (both yield goals and measured yield), and
7. Calibration of application equipment.

Note: In lieu of documenting each individual item listed in the Documentation Requirements, a Certified Crop Advisor plan that contains each of the items may be substituted.

References


Air Quality Enhancement Activity – AIR08 - Nitrification inhibitors or urease inhibitors

Most common active ingredient

Nitrification inhibitors
1. 2-chloro-6-(trichloromethyl)-pyridine (nitrapyrin)
2. Ammonium thiosulfate (ATS)
3. Dicyandiamide (DCD)

Urease inhibitors
1. N (n-butyl) thiophosphoric triamide (NBPT)


Nitrogen Inhibitors, What is What and Should You Consider Their Use?

Author: Robert Mullen, and Ed Lentz

Now that we finally have a hint of spring, producers start thinking about planting corn and planning on nitrogen fertilization applications. In case you have not noticed, fertilizer prices are a little higher than they were this time last year. This typically leads to questions like – “should I consider the use of an inhibitor?” The goal of this article is to cover (very briefly) the inhibitors that are out there, what they do, and where their use should be considered.

Multiple universities conduct field research with inhibitors to determine effectiveness, but lab studies conducted to determine proof of mode of action are more critical to our understanding of their usefulness. Several inhibitors have sound lab evidence that they do what they are promoted to do (and some do not), but we may struggle to find usefulness from field studies. Thus we, as university researchers, attempt to identify nitrogen sources, application methods, and application timings that are more likely to benefit from the use of these inhibitors.

Urease Inhibitors

First we will discuss urease inhibitors. Urea based nitrogen fertilizers are an organic commercial form that requires a biological enzyme to promote degradation to ammonia. Ammonia exists as a gas at normal temperature and pressure, thus it may be lost by volatilization if not exposed to water. Ammonia loss potential by volatilization for incorporated urea products is negligible because soil holds enough water to capture ammonia as ammonium that can be held on the soil’s cation exchange complex. Surface applications of urea are at risk of loss because there is no opportunity to capture the ammonia as it is produced.
Urease inhibitors can have different modes of action, and the first question we should ask is do they work? The active ingredient in the inhibitor can act as a substrate for the urease enzyme, thereby protecting free urea by allowing it to stay in solution longer, or the inhibitor can inactivate the enzyme. Agrotain® is the most common commercially available urease inhibitor. The active ingredient in Agrotain® is N-(n-butyl) thiophosphoric triamide. The mode of action is not clearly defined, but it is thought to act as a substrate for the urease enzyme. Regardless of the mode of action, laboratory evidence has shown that it does allow urea to be retained in the soil longer.

Other urease inhibitors are marketed, some may have some activity, but it is your job as a producer/consultant to determine whether or not the proposed mode of action makes sense. We would also encourage you to inquire about lab data indicating that the material being marketed does what it is supposed to do.

Even if a urease inhibitor has been demonstrated in a laboratory to have some inhibition properties on the enzyme urease, the agronomic question still remains as to its usefulness in a field setting. It really depends upon how nitrogen is to be applied (and the form) and the rate of nitrogen being applied. Higher rates of urea nitrogen (under most conditions) likely do not require urease inhibitors. Surface application of dry urea in high residue situations is a good place for the use of urease inhibitors. Dribble applications of liquid UAN may benefit from a urease inhibitor in high residue situations, but clean till fields are less likely to benefit. Injected liquid UAN (whether it is knifed or coultered) does not require stabilizers based upon current research.

**Nitrification Inhibitors**

Nitrification inhibitors are the other inhibitors marketed, but they have a completely different mode of action. Any nitrogen supplied as a commercial fertilizer is ultimately transformed to a nitrate form of nitrogen (or at least a significant fraction of that supplied). In the presence of adequate oxygen, warm temperatures (> 50 F), and some moisture, ammonium-N is converted to nitrate-N through a biochemical process (known as nitrification) that requires two forms of soil bacteria. The first bacterium *Nitrosomonas* converts ammonium-N to nitrite-N. The second bacterium *Nitrobacter* converts nitrite-N to nitrate-N. And as you know, nitrate-N is the form we are most concerned about being lost (whether by leaching or denitrification).

Nitrification inhibitors have one primary way of delaying the nitrification process, and that is eliminating the bacteria *Nitrosomonas* in the area where ammonium is to be present. There are three common nitrification inhibitors that are commercially available: 2-chloro-6-(trichloromethyl)-pyridine (nitrapyrin), dicyandiamide (DCD), and ammonium thiosulfate (ATS).

Nitrapyrin is the active ingredient found in the DOW® product N-Serve® and Instinct®. The biochemical activity of nitrapyrin and its ability to suppress growth of *Nitrosomonas* has been known.
since the 70s and it was initially registered in 1974. It is quite effective even at relatively low rates. Dicyandiamide (DCD) is the active ingredient in nitrification inhibitors such as Agrotain Plus®, SuperU®, and Guardian®. Dicyandiamide is required at a significantly larger concentration to be effective.

Since each of the products discussed above is highly sensitive to concentration, it is imperative that if they are used they are applied at labeled rates. Cutting rates is not in your best interest as an end user because a lower concentration may not allow the product to perform its job in the soil.

Applying anhydrous with nitrapyrin in the fall (which is not our recommendation for summer crops in Ohio) may realize a benefit of the nitrapyrin (as it is out in the field for a long time), but for most of us who apply anhydrous ammonia in the spring soon before planting and as a sidedress treatment, the utility of a nitrification inhibitor is difficult to justify since the risk of N loss is low. No-till situations are more likely to show positive yield results than conventional till systems for spring applied anhydrous.

Nitrification inhibitors are less likely to show an economic benefit when high N rates are used in the field. Nitrogen losses at high N application rates are not likely to affect yield as much if lower N rates are applied (fewer bushels per acre are gained with each additional level of N at the high levels).

Summary

Application timing, N source, application method, soil texture, and tillage are all factors that should be evaluated to determine where urease and nitrification inhibitors should be used. Before buying an inhibitor make sure scientific evidence backs up its claim. A producer and/or consultant should be wary of any product that does not have solid scientific data demonstrating that the inhibitor activity matches the advertised benefit.