UNDERSTANDING THE VALUE OF SLOW-RELEASE FERTILIZERS

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The purpose of this article is to provide an overview of three often-asked questions related to slow-release nitrogen: (1) what are slow-release fertilizers, (2) why should I use slow-release fertilizers and (3) when should I use slow-release fertilizers? It is important to note that products mentioned in this paper do not reflect an endorsement of the product, but simply to inform which products are currently available for crop production in WI. Likewise, a lack of mention of specific products does not imply that a product is not recommended or available for use.

What Are Slow-Release Fertilizers?

Slow-release is an often overused term that encompasses several N fertilizer products which include: uncoated slow-release fertilizers (SRF), coated SRF, and bio-inhibitors. The term “controlled-release” is often used synonymously with slow-release, but has also been used to identify coated SRF or more specifically, polymer-coated urea (PCU, often referred to as poly-coated) products. Thus, a more appropriate nomenclature that encompasses all of these products is *fertilizer technologies*. The debate will continue for some time regarding how much “control” each technology has on releasing N to the plant.

Uncoated Slow-Release Fertilizers

Uncoated SRF are identified as those that slowly release N into the soil environment through chemical recalcitrance. There are two categories of such products, urea-formaldehyde reaction products and isobutylidenede diurea (IBDU). Urea-formaldehyde reaction products, such as urea-formaldehyde (ureaform) and methylene urea, rely on microbial decomposition and hydrolysis (chemical reaction with water) to release plant-available N into the soil environment. Ureaform typically has less than 15% of the total N in an immediately available form, while methylene urea has between 15 and 30% of the total N in an immediately available form. The ultimate determinant of how slowly the N will be released is based on the extent of the reaction process which produces polymer-chain molecules of varying lengths. Examples of methlyene urea containing products on the market are Nitamin® and Nitamin Nfusion® (Georgia Pacific, Atlanta, GA), which are blends of methylene urea and triazone. The IBDU is a reaction product of urea with isobutyraldehyde and relies solely on hydrolysis to release N.

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Coated Slow-Release Fertilizers

There are two popular coated SRF products: sulfur-coated urea and PCU. Sulfur-coated urea releases N into the environment through biological oxidation of the S coating, fractures in the S coating, and dissolution through the moderately porous membrane. The PCU products encapsulate urea granules with polymers. Over time, water moves through the polymer coating, dissolving the urea. The N solution then slowly dissolves out through the polymer coating. The PCU products are considered “controlled” release because the thickness of the polymer coating effectively controls the release rate and delay (soil temperature is also a controlling factor). Types of PCU include ESN® (Agrium Inc, Calgary, AB), Polyon® (Agrium Inc, Calgary, AB), and Nutricote® (Chisso-Asahi Fertilizer Co., Ltd, Tokyo, Japan).

Bio-inhibitors

Products that inhibit enzyme activity seek to delay the breakdown of urea or the conversion of ammonium to nitrate (i.e. nitrification). Nitrification inhibitor products such as nitrapyrin [2-chloro-6-(trichloromethyl)-piridine] and dicyandiamide (DCD) kill or interfere with the metabolism of the soil bacteria nitrosomonas, which are responsible for the first step of nitrification, the conversion of ammonium to nitrite. However, these products only kill or inhibit growth in a localized area around the granule. Once soil bacteria repopulate into the zone the nitrification process is no longer hindered. Nitrapyrin is sold as N-Serve ® and Instinct™ (Dow AgroSciences LLC, Indianapolis, IN).

Urease inhibitor products [e.g. Agrotain® (Agrotain, Inc., LLC, Corydon, KY)] contains N-(n-butyl) thiophosphoric triamide (NBPT) which neutralizes the effectiveness of the soil enzyme urease, which is a catalyst for the transformation of urea to ammonium. Again, this only inhibits urease activity in a localized zone around the granule. Once soil enzyme levels increase near the urea granule, urea begins to break down rapidly. Products may also be marketed as urease and nitrification inhibitors [e.g., SuperU® (Agrotain, Inc., LLC, Corydon, KY) and Nutrisphere® (SFP, Leawood, KS)].

Why Use Fertilizer Technologies?

There are two potential benefits for using fertilizer technologies: an increase in yield using a standard N application rate or maintenance of yields by applying less N. This improves net profits by increasing output or decreasing input. In either case, the result is an increase in the nitrogen use efficiency (NUE). Improving NUE is an important goal for improving the sustainability of agricultural systems. The NUE is a determining factor in economic productivity and environmental impacts of crop production. The NUE encompasses several components such as:

1. Agronomic Efficiency = (increase in yield from N fertilizer application / N fertilizer applied)

2. Nitrogen uptake efficiency = (increase in total N uptake from N fertilizer application / N fertilizer applied)

3. Nitrogen removal efficiency = (increase in grain N from N fertilizer application / N fertilizer applied)

The fundamental flaw of bulk applying N for crop production is that plants to not take up N in bulk amounts. The N fertilizer applied is subject to environmental losses (e.g., runoff, leaching, gas flux), reducing the percentage of applied N that can be used by the crop. Slow-release or bio-inhibitor fertilizers, by attribute of slowly releasing N into the environment or inhibiting microbial processes that would convert the N into forms that can be lost to the environment, decrease the potential for N loss and increase the potential for improved NUE.

When to Use Fertilizer Technologies

Before deciding whether to use a fertilizer technology, it is important to understand the main factor affecting the NUE in your system. Each category of fertilizer technology has advantages and disadvantages depending on environmental conditions, namely, soil type and seasonal weather patterns. Urease inhibitors provide the most benefit when urea is surface applied and not immediately incorporated or irrigated. A common example is in no-till corn production. If there is no potential for N volatilization, then there is little potential benefit to urease inhibitors. Nitrification inhibitors have been shown to increase yields and decrease nitrate leaching losses (Nelson and Huber, 1992), but not in all situations. When seasonal conditions are such that there is little potential for N leaching losses, then the potential benefit of nitrification inhibitors is low. Coated and uncoated SRF are beneficial when attempting to improve the NUE on your field. However, it is important to evaluate your current program to see if major improvements could be made to justify the increased cost of the SRF product. Knowing the nutrient content of the crops you are harvesting can help you determine if improvements can be made. If crop removal of N is equal to your fertilizer input of N, then improving NUE will be difficult (Bruulsema, 2009).

Another consideration is whether the product can be incorporated into your existing program. Different products are available for inclusion with dry fertilizer, liquid fertilizer, and manure. If you are interested in using one of these products, field testing is always recommended. This can be done through use of replicated strip trials. In-field replications are always preferred as they will give a more accurate assessment of the product value. Contact your county extension agent or state extension specialist if you'd like more info on specific products or information related to their testing in your area.

Further Reading

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