

# SLOW RELEASE FERTILIZERS 101

ROBIN ROSE

*Robin Rose is Director of the Nursery Technology Cooperative and Professor in the Department of Forest Science, Oregon State University, Corvallis, Oregon 97331; (541) 737-6580.*

*robin.rose@orst.edu*

*Rose, R. 2002. Slow Release Fertilizers 101 . In: Dumroese, R.K.; Riley, L.E.; Landis, T.D., technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—1999, 2000, and 2001. Proceedings RMRS-P-24. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 304-308. Available at: <http://www.fcnet.org/proceedings/2001/rose.pdf>*

## Key Words

Native plant nurseries, forest nurseries, plantations, fertilizer types, fertilizer research

Slow release fertilizers have been in common use within the horticultural industry for decades. Probably the mostly commonly heard of product is Scott's Osmocote which has been around for a quite a long time. However, some time ago slow release fertilizers moved out of the potted greenhouse environment and onto golf courses, suburban lawns and bushes, and orchards. Slow release fertilizers are here to stay, but there still seems to be a lot of users who do not understand them.

The purpose of this paper is to: 1) demystify some of the characteristics of slow release fertilizers; 2) provide some useful information about the differences in a few products; and 3) offer up some generic advice on how best to utilize these fertilizers effectively. Believe it or not, slow release fertilizers are a daunting subject loaded with all sorts of interesting technologies. As with many products, the end user gets glowing product support brochures without ever seeing any of the research literature. Most of the product literature I have read is accurate. Too often the problems growers face with slow release fertilizers are associated with inexperience and ignorance of fertilizer technology in addition to operational experimentation. Maybe this little paper will lead a few nursery managers, growers, and conservationists to go to the library.

The term used in this paper will be slow release fertilizers even though many literature sources call them controlled release fertilizers or CRF. Delayed release might even be a better term. As you will read later, some slow release fertilizers are not very slow as the temperature goes up. Some products are not very controlled if they have been

exposed to water vapor in storage. Some are hardly delayed after being mishandled. Rather than get into the semantics of the situation, slow release will be utilized throughout this paper.

Right from the start it needs to be clearly established that slow release fertilizers can be used with a vast array of plants. It is wrong to assume that these fertilizers are mostly suited to the greenhouse business. I have personally used them successfully in Taiwan with several native tree species with heavy soil in polybag containers—hardly the most ideal growing system. In actuality there is a whole frontier of opportunities to use slow release fertilizers effectively in native plant nurseries with a focus on restoration ecology and conservation. Slow release fertilizers have already started to find their way into plantation forestry. In my opinion the factor holding back the expanded use of slow release fertilizers into many arenas is the lack of a will to experiment after minor set backs.

## THE PRILL

A good place to begin a discussion of slow release fertilizers is the tiny delivery system called the prill. The prill is the 2 to 3 mm wide particle that may be round or jagged looking that contains the fertilizer. It may be coated or non-coated. Not much thought is ever given to prills since it is so easy to view them as so many glass bead-like particles of a highly uniform nature. Actually, they are not that uniform at the micro level in that they can vary in size, vary in coating thickness, vary in weight, and vary in volume. Prills that are small tend to release faster than larger ones. A bag of slow release fertilizer contains a population of

prills. With all this variation, it is a foregone conclusion that fertilizer release is going to vary on a micro level as well.

### **ADVANTAGES AND DISADVANTAGES**

Slow release fertilizers have specific advantages and disadvantages when examined as a class of fertilizers. It is through an understanding of these characteristics that the best operational practices can be developed. Not all nursery situations require or should utilize these fertilizers.

What are some of the advantages? This technology does a fine job of metering out nutrients over a period of time under controlled moisture conditions. Increased nutrient efficiency and utilization are the prime advantages. A prill right up next to the root under optimum moisture and temperature conditions can provide a very high dose of fertilizer right where the plant needs it. Leaching of nutrients can be greatly reduced. The product on a plant basis is not as expensive as perceived.

What are the disadvantages? Prills can be damaged by abrasion and fail to perform properly. Improperly stored prills can take on moisture and start the release process prior to use. Salt build up can occur under dry conditions or if the plants are not being irrigated properly. If there is a salt problem, it is impossible to remove the fertilizer from the media. Salt toxicity at out planting can become a problem if the plants are held over in cold storage for too long. There is no easy means by which to determine if the product is damaged or may prove ineffective in some way.

It is not a matter of comparing advantages to disadvantages that should determine the use of slow release fertilizers. One can find equal numbers of each upon which to base a decision or decide to bias one over the other. The best advice is to start to carefully and methodically test out certain types of fertilizers over a range of concentrations. Keeping good records is the first step in figuring out what will work best under a given set of circumstances. However, before getting into experimentation, it is best to get a general understanding of some of the different kinds of slow release fertilizers.

### **TYPES OF SLOW RELEASE**

Think of slow release fertilizers as coming in several varieties. There are inorganic, organic,

synthetic inorganic, and coated forms. Of the coated forms, there are polymer and resin coated, but there have been lots of different kinds of materials that have been used as coatings.

**Inorganic:** An example of an inorganic slow release fertilizer was MagAmp or magnesium ammonium phosphate. Potassium analogues have also been made.

**Organic:** Organics have been around for thousands of years starting with animal manure, animal byproducts like hoof and horn, fish, fish emulsions, seaweed, bone meal, human sewage sludge, and all sorts of composted combinations of bark, wood, and plant materials.

**Synthetic Organic:** Ureaform is the reaction of urea with formaldehyde in the presence of a catalyst. Ureaforms consist of methylene urea polymers that vary in chain length and the release characteristics are controlled by the ratio of urea to formaldehyde (Hauke 1985). A good example is Nitroform. IBDU or isobutylidene diurea fits in with this general group.

**Coated:** All sorts of products have been used as coatings such as sulfur (sulfur coated urea), polymer-coated NPK (Osmocote, Agriform), and petroleum-coated (Nutricote).

### **RATE AND PATTERN OF RELEASE**

#### **Mode of Release**

All growers understand readily soluble fertilizers. Those are the ones that go into solution quickly and are immediately available. Everyone has heard of ammonium nitrate and mixes like Peters 20-20-20. Surprisingly, there are all too many practitioners of the nursery arts who are not quite sure about urea. Urea is not a slow release fertilizer and is completely soluble. Once applied, the urease enzyme (present in organic matter and plant tissue) in the presence of water hydrolyzes the compound to ammonium, carbon dioxide and ammonia gas. The ammonium is then converted to nitrate via nitrobacter bacteria. The nitrate is absorbed by the plant. Ammonium at media or soil pHs > 7 lead to conversion to ammonia gas and escape into the atmosphere. At pHs < 7, nitrogen converting bacteria turn it into nitrate. As an aside, free ammonia penetrates plant cells very quickly and is quite toxic (Bunt pg102 1988). Since so many slow release fertilizers have urea in them, this is a good reaction to understand.

Without getting too complicated here, slow release fertilizers give up their nutrients due mostly to two interlocking factors: moisture and temperature. Bacteria do play a role with some products, but even the bacteria need moisture and temperature in order to function. Generally, the higher the temperature and the more moisture available, the faster the release takes place. The coating also makes a big difference as will be discussed further in this paper.

One of the little known “secrets” of release in slow release fertilizers is that the time to total release is figured out on the basis of 70 F. The manufacturers use this temperature as a guide and it works well in the context of horticultural operations (Cabrera 1997). However, this information is not worth much in most field situations.

### **Sources of Variation in Release**

Variation in release comes from several commonly understood processes: 1) abrasion: when the prills rub against soil or sand in mixes, too much the coating gets damaged; 2) thickness of coating: while coating of prills is a fine art, there is still variation in thickness which can alter the degree to which prills release; 3) moisture: if bags of some slow release fertilizers are left open portions of the material can start to hydrate and will release sooner than others once they are placed in the media (Kelly et al 1998); and 4) age: the longer the prills are stored the more likely their characteristics are likely to be adversely impacted by moisture, temperature, and handling.

### **Coatings**

One of the first coatings was sulfur, which is where sulfur-coated urea got its name. Many coatings were tried in the past, including waxes, oils, plastics, and resins. Most manufacturers refer to their products as being polymer coated, when in actuality the coating may be a resin or polyurethane. The word polymer merely refers to a compound of high molecular weight derived from a host of smaller molecules. Some polymer coatings need release controlling agents like ethylene-vinyl acetate and surfactants to allow for the proper diffusion of nutrients. Tremendous research dollars are spent every year on attempts to discover polymers for all sorts of uses, not just those associated with slow release fertilizers. Unfortunately, the ultimate coating that will

release nutrients on command has yet to be discovered.

### **SOME COMMON PRODUCTS**

The following is a short synopsis of fertilizer descriptions. These are all interesting and useful products. No one product is endorsed over another. The purpose here is to provide some useful information about each that may help growers and nursery managers to safely utilize these products.

#### **Osmocote**

This product has been in use for a very long time and is practically a household name. The name was likely derived from the concept of osmosis through a coating, which is exactly what polymer coated slow release fertilizers do. The coating uses an alkyd resin coating technology which “involves coating a soluble fertilizer core with a thermoset copolymer of dicyclopentadiene and glycerol ester (linseed oil) dissolved in an aliphatic hydrocarbon solvent” (Goertz 1993). The thicker the coating, the longer the release will take to occur. The prill gets wet and then begins to expand. Once the expansion begins the process of release is irreversible. As the pores in the coating open up, the saturated solution inside begins to move out of the prill into the surrounding media or soil solution. Osmocote tends to release more quickly as the temperature begins to rise, assuming similar levels of moisture. There are numerous products on the market. There are formulations and coatings that are said to be able to release for up to 18 months.

O.M. Scott and Sons Co (Scotts) makes a latex coated product designed for high temperature growing conditions.

#### **Polyon**

This is the trade name given to the polyurethane coating on Simplot products under the brand name Apex. Release is by osmotic diffusion. It is an interesting process by which the product is made. It is called reactive layer coating or RLC. Two reactive monomers are applied to the fertilizer, which form an ultrathin membrane. For technical details refer to Goertz (1993). In short, two solvent-free liquids react, polymerize right on the substrate fertilizer *in situ* in a drum and form a polyurethane coating. Production costs are lower

using this system. Polyon is supposed to be less temperature dependent as well when it comes to release.

### **Nutricote**

This product uses the technology from the Chisso-Asahi Fertilizer Company in Japan. The coating is a thermoplastic resin such as polyolefins, poly(vinylidene chloride), and copolymers (Goertz 1993, Hauck 1985).

### **Ureaform**

This product is a synthesis of urea and formaldehyde. There are numerous ureaform products on the market. Basically, ureaforms are white and odorless solids. The product is made up of methylene urea polymers. Ureaforms are broken down by soil bacteria. The shorter-chained polymers are water-soluble and break down quickly, while the long-chained polymers take much longer to break down. One product is Nitroform from Nu-Gro Technologies, Inc. Some 71% of Nitroform is water-insoluble nitrogen.

### **IBDU**

This product has a name no one can pronounce so they call it IBDU. It comes about from the condensation of urea and isobutyraldehyde, which is less than .1% soluble in water. The commercial product is around 31% nitrogen. Some commercial products with IBDU are Woodace and Agriform Pellets.

### **Combinations of Slow Release**

It stands to reason that with such an array of immediately soluble and long term slow release fertilizers, the possibility exists to blend them for optimum nutrient availability. To date, not a lot has been published on this subject although it is most likely that many growers have worked out various combinations that work well under specific local conditions.

### **RESEARCH CHALLENGES**

Slow release fertilizers have been used for decades in the horticultural growing environment. However, the application of these products to forest trees and native plants has been very slow in coming. It is time that this situation changed and growers began the process of experimentation on a larger scale. There will be many failures that will go unreported along with stunning successes

that everyone will hear about at meetings. What is called for is a more open effort to discern the best technologies for given nursery and field situations by species.

Here are some ideas to work on in the future.

- Finding the right fertilizer combinations for any given set of conditions. It makes sense that we should be able to put a slow release fertilizer into the growing media at the time of sowing and have the fertilizer start to release some 14 months later at the time of out planting. We might also want three-month slow release fertilizers that work up to the time of hardening off and then quit, followed by another product that would release for a month during root development in the fall.
- Finding the right fertilizer combinations for specific species. We already know that some species are likely to be adversely impacted by various nutrients at high dosages. Some species are going to be more salt tolerant than others as well.
- Finding ways to deal with dry climates and alternating wet and dry conditions. Slow release fertilizers suffer from the same problem as readily soluble fertilizers when the ground or growing media gets dry. Salt levels rise dramatically in the field as soil moisture drops. What is needed is to develop fertilizer recipes for out planting situations, whether it is forest trees or native plants, as part of a restoration project after a fire. Soil moisture by slow release fertilizer studies could tell us a lot about what to do and not do in field situations.
- Finding ways to get nutrients other than Nitrogen into seedlings after out planting. Nitrogen is not the only nutrient that plants need. While nitrogen is very important to plant growth, phosphorus and potassium are also important. Getting more phosphorus into plants can be a real problem even when using slow release fertilizers, since phosphorus is too often tied up very quickly in some soils.

### **SUMMARY**

We have a lot of exciting opportunities ahead where slow release fertilizers are concerned. There are multitude of species and fertilizer products to try out in the nursery and the field.

## REFERENCES

- Cabrera, R.I. 1997. Comparative evaluation of nitrogen release patterns from controlled-release fertilizers by nitrogen leaching analysis. *HortScience* 32(4):669-673.
- Goertz, H.M. 1993. Controlled Release Technology, p. 251-274. *In: Kirk-Othmer Encyclopedia of Chemical Technology*, Vol.7. 4<sup>th</sup> Ed. Wiley, New York.
- Hauck, R.D. 1985. Slow-release and bioinhibitor-amended nitrogen fertilizers. P. 293-322. *In: Fertilizer Technology and Use*, 3<sup>rd</sup> Edition, Soil Science Society of America, Inc., Madison, Wisconsin
- Kelly, M.G., S.L. Warren, and T.E. Bilderback. 1998. Irrigation volume, application, and controlled-release fertilizers: I. Effect on plant growth and mineral nutrient content in containerized plant production. *J. Environ. Hort.* 16(3):176-181.