Fertilizer Technology

Richard R. Benson,
Scotts Company

Introduction

It's only been recently that a conifer forest seedling in a production phase is being outplanted with initial fertilization. Standard practice has been to allow the seedling to develop on its own. First scheduled fertilization is often not until several years into the cycle. Yet the need for accelerated growth is required. Why do growers of the majority of other crops have an initial nutrient program while the forestry industry doesn't? One answer involves the safety aspect of an early fertility program under the limited Pacific Northwest summer precipitation regimes. Too often salinity builds up and causes plant injury. Current fertilizer technology does offer useful alternatives that can both be safe and growth enhancing.

Types of Fertilizer

There are four classes or types of fertilizers (Table 1):

Dry solubles such as ammonium sulfate or potassium sulfate are applied right out of the bag. Being soluble, they have a short period of nutrient availability, not much more than 30 days under a typical irrigation program. Blends using dry solubles often segregate due to particle size differences. Multiple applications can increase the chance of usage error (rate).

Liquid solubles are available in either liquid-bulk fertilizer tanks from blenders, for example—or in dry form such as Miracle-Gro® or Peters®. They too have a short availability before leaching or absorption and chances of usage error increase with the number of applications over a crop cycle.

Slow-release fertilizers are typically three-month fertilizers such as ureaformaldehyde (UF), isobutylidenediurea (IBDU , or sulfur-coated urea (SCU), all materials originating in the 1960's and 70's. They are excellent components of some current post-outplanting forestry fertilizer formulations.

Controlled-release fertilizers (CRFs) are the fourth type and have a release pattern well in excess of 3-4 months. They are characterized by a polymer or resin coating, examples of which are Osmocote® and Nutricote®. They are expensive, efficient (rates generally are 75% of normal grower practice and resulting yields are typically increased 10% or more), and used in numerous high value markets. Are they really expensive? Changing the perception from cost per ton to cost per plant per unit time is a measure of true value. If a $600 per ton fertilizer is applied 6x per year at a 1x rate isn't it logical that a $1200 per ton fertilizer that needs to be applied only once at a 2x rate is more economical?

Table 1. Fertilizer Characteristics by Type

Characteristic	Solubles	Slow Release	Controlled Release
Longevity	Short	Medium	Long
Ease of Use	Many applications	Several applications	Single application
Cost	Low	Medium	High
Cost of Use	High	Medium	Low

Fertilizer Considerations

There are limits to which nutrient content can be pushed into available formulations. Nitrogen, phosphorus (as P_2O_5), and potassium (as K_2O) each reach maximums of about 45-50%. Urea contains 46% nitrogen. P_2O_5 is available in several useable forms—triple superphosphate (0-50-0), monoammonium phosphate (11-52-0) or diammonium phosphate (18-46-0). K_2O can be found in the chloride form at 0-0-60, but a more "plant-friendly" source containing sulfur and a lower salt index is potassium sulfate (0-0-50). A blend of NPK using 46-0-0, 0-50-0, and 0-0-50 at one-third each gives us a formulation of 15-16-16. As other nutrients are added to this blend, such as magnesium or micronutrients, the NPK analysis is further reduced. State regulatory agencies sample product at manufacturing, distribution, and user sites and can issue fines to the manufacturer for being under-analysis. The nationwide trend is to also regulate "overformulation" and penalize producers for putting too much nutrition in the product.

Nutrition sources can be important criteria for selecting a proper fertilizer. While urea is the economic nitrogen choice, many plants prefer other sources such as ammoniacal or nitrate nitrogen. Generally, the more important the flower stage is to the grower, the more the nitrate form is required. Chrysanthemum producers, for instance, rely on ammoniacal nitrogen for the first half of the crop cycle and finish with nitrate nitrogen during the second half to enhance flowering. "Green" plant producers—foliage, woody ornamental, and conifer growers—can rely on the more economical urea and ammoniacal forms of nitrogen.

Phosphorus and potassium sources are easier choices-the materials mentioned above are commonly available and in forms useable to the plant. Potassium nitrate is an excellent alternative to potassium sulfate but is expensive and usually selected for use on high-value crops due to its nitrate content rather than potassium. Sulfur is generally found in most fertilizers and additions are rare unless high soil pH conditions are prevalent. Calcium and magnesium are popular additions but the choice depends more on irrigation water quality, soil fertility, and pH status. Micronutrients are also a common component either as single element additions, such as iron, or a full complement. Many soil types contain ample levels of some or all micronutrients and make additions unnecessary.

A general rule-of-thumb for NPK ratios is to use a 1-1-1 type for flowering plants, and a 3-1-2 type for development of green or foliage plants. Add micronutrients if chlorotic new foliage or growth is a problem. Finding where to obtain the different types of fertilizers can be awkward. As we move from the least expensive solubles to the most expensive CRFs, availability decreases. Everyone sells dry solubles, many sell liquids, few sell slow release fertilizers and fewer yet sell controlled release materials. It's a function of the time and training required by the seller to explain to the customer the benefits of the more expensive fertilizers. Therefore, most retail stores have dry solubles and many have liquids. Blenders, turfgrass, and farm suppliers have slow release fertilizers. CRFs can be found only at horticulture suppliers, those that service the nursery and greenhouse growers. CRF blends for nursery and greenhouse crops are readily available; special custom blends are available in batch amounts (usually 3+ tons) from the manufacturer.

Controlled-Release Fertilizers

Most CRFs are temperature dependent (i.e. nutrient release increases as temnerature increases). Product lifespan or longevity can he controlled by changing the physical characteristics of the coating, either the thickness or the nature of the polymer itself. Normally, the effective range of longevities a manufacturer offers is from three to sixteen months. Any requirement or crop cycle shorter than three months can utilize solubles or slow release materials. Crop cycles longer than sixteen months certainly exist, just look at the forestry market, but the manufacturer loses control over precise longevity and a "24 month" product actually becomes an "18-30 month" material.

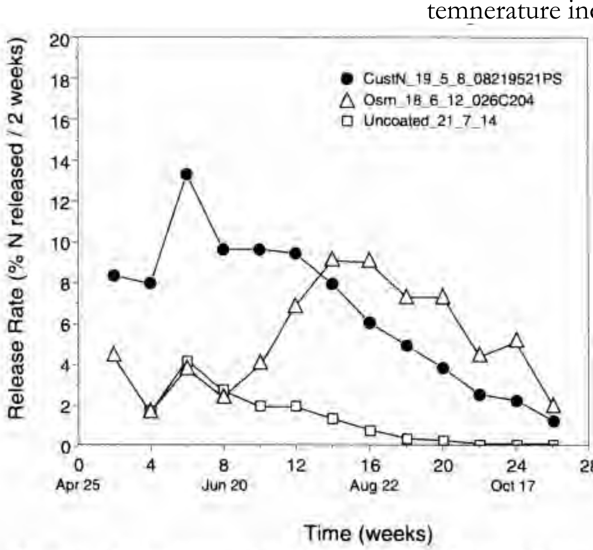

Figure 1. Release curves for 1) an uncoated soluble 21-7-14, 2) that same 21-7-14 material coated for a six-month longevity (18-6-12), and 3) an example of how that 18-6-12 curve can be given an upfront "kick" by adding a second coated material (becoming a material with a final analysis of 19-5-8). Both CRFs have six-month longevities but different release patterns.

We use a single coating thickness for the shorter longevities. However, relying on a single, thicker coating for longer periods of time builds an initial delay into the product and results in a nutrient void the first few weeks of the crop cycle. This delay increases as the coating thickness increases. Therefore, blends of short and long-term, or light and more heavily coated fractions are necessary to provide a balanced release curve over the claimed longevity (Figure 1).

CRF Rates

Table 2 describes some practical CRF characteristics under several cultural practice situations that can occur in nurseries. These concepts are applicable also to field use. Try to explain in each instance how CRF rates are affected by the following changes.

Table 2. Changes in CRF rates based on nursery situations

Change	Rate Increases	Rate Decreases
Low to high irrigation/rainfall	X	
Clay to sandy soil	X	
Slow to fast growing plants	X	
Salt-tolerant to salt-sensitive plants		X
Seedlings to established plants	X	
Container to field plants		X
Grower objective from "push" to "hold"		X
Spring to fall feeding		X
Short term to long term CRF	X	
Small to large pot	X	

Economics of CRF Use

Determining if CRF makes sense to use depends in part on the cash value of the crop and the yield increases that CRF provides. Let's compare CRF use on two crops—corn and strawberry—and try to pull in forestry.

Corn (economic yield = $122/acre)

If the cost of the current grower fertilizer practice is $52 per acre and the cost of CRF on an equivalent N/acre basis is $386 per acre, the incremental fertilizer cost per acre is $334. A 25% yield boost that CRF can provide is equal to $31 per acre. The grower invests an extra $334 per acre for only a $31 per acre return!

California Strawberry (economic yield = $32,000 per acre)

Here the cost of grower practice is $176 per acre. The cost of the CRF is $270, again on an equivalent N basis, for an incremental cost of $94 per acre. A 15% CRF yield increase results in $4,800 per acre for only an increased fertilizer cost of $94 per acre!

Forestry (economic yield = ?)

Here the cost of grower practice generally is $0 per acre. Based on a plant population of 500 per acre and a rate of one ounce per seedling the cost of a CRF outplanting program is $50 per acre including labor. A yield or growth increase of 10%(?), 20%(?), 30%(?) results in $? per acre. Only when the value of improved survival %(?), reduced time to green-up(?), response to animal browsing (?), decreased weed competition (?), and final yield increase (?) is determined will we be able to calculate the economic benefit.

Looking Ahead

The challenges for continued CRF use in forestry involve the research of proper rate, placement, fertilizer component, ratio, and longevity. As you know, many projects are underway in many locations that involve these challenges. The Scotts Company is participating at several university and industry sites to help determine solutions.

Fertilizer formulations are becoming more crop specific, that is to say, designed for a given application. We already are seeing forestry CRFs that are used only at the greenhouse seedling stage, in nursery beds, at initial outplanting, and post-outplanting. It won't be long before requests for a fertilizer having separate and yet different N, P, and K releases can be satisfied. Consider a nitrogen that has a sustained season-long release blended with a phosphorus and potassium that each have a unique but necessary release pattern, say, for example, that the P release is two months and the release for K is 12 months. All that remains is really the research that provides the release characteristics needed-perhaps we already have it. But then we still have to determine the necessary micronutrients by location by species. How about correct calcium and magnesium ratios? ... Sulfur? ... Effect of water quality? ... pH? ... We need to talk again!