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Understanding Plant Nutrition: Controlled- And Slow-Release Fertilizers

Argo and Fisher take a microscope to the details that can help growers make informed decisions on nutrients.

by **BILL ARGO, PH.D.** and **PAUL FISHER, PH.D.**

USING controlled-release (CRF) and slow-release (SRF) fertilizers allows growers to supply nutrients for an extended duration without the specialized equipment needed to apply water-soluble fertilizers. These fertilizers are added to the media at mixing or applied to the media surface after planting. Nutrient runoff can be reduced using CRF and SRF, especially compared to applying water-soluble fertilizer through overhead sprinklers.

Relying on CRF alone is not always the best solution for nutrient management. For example, even distribution of CRF prills from plant to plant is difficult when growing in cell packs or trays. The correct CRF should be matched to the crop and growing environment so that nutrients are released at the rate required for optimal plant growth – too rapid a release rate can cause media-electrical conductivity to climb too high and damage roots, or too slow a release can result in nutrient deficiencies. In some cases, a combination of CRF and water-soluble fertilizer provides the best match of nutrient supply to crop needs. In this article, we will discuss how CRF and SRF influence pH and nutrition management.

Controlled-Release Fertilizer

CRFs are primarily water-soluble fertilizer salts or blended fertilizer

Table 1. Examples of four controlled-release fertilizers with similar labeled release durations.

	15-7-15 Multicote 6 extra	18-6-8 Nutricote Total Type 180	15-9-12 Osmocote Plus 5-6 Month	19-6-8 Polyon 6-Month
Total nitrogen (N)	15%	18%	15%	19%
Ammonium (NH_4-N)	8.4%	8.6%	7.0%	8.5%
Nitrate (NO_3-N)	6.6%	9.4%	8.0%	10.5%
Urea-N	Not listed	Not listed	Not listed	Not listed
% of Total N as Ammonium NH4-N	56%	48%	47%	45%
Phosphate (P_2O_5)	7%	6%	9%	6%
Potash (K_2O)	15%	8%	12%	12%
Calcium (Ca)	Not listed	Not listed	Not listed	Not listed
Magnesium (Mg)	1.2%	1.2%	1.0%	1.0%
Sulfur (SO_4-S)	7.0%	Not listed	2.3%	1.7%
Boron (B)	0.03%	0.02%	0.02%	Not listed
Copper (Cu)	0.05%	0.05%	0.05%	Not listed
Iron (Fe)	0.45%	0.20%	0.45%	0.46%
Manganese (Mn)	0.07%	0.06%	0.06%	0.19%
Molybdenum (Mo)	0.009%	0.02%	0.02%	0.004%
Zinc (Zn)	0.07%	0.015%	0.05%	0.06%
Derived From:				
Macronutrients	Ammonium nitrate, ammonium phosphate, potassium nitrate, potassium sulfate, calcium phosphate, magnesium sulfate	Ammonium nitrate, ammonium phosphate, calcium phosphate, potassium nitrate, magnesium sulfate	Ammonium nitrate, ammonium phosphate, calcium phosphate, potassium nitrate, magnesium sulfate	Ammonium nitrate, ammonium phosphate, calcium phosphate, potassium nitrate, magnesium sulfate
Micronutrients	Boric acid, copper sulfate, iron sulfate, manganese sulfate, sodium molybdate, zinc sulfate	Boric acid, copper sulfate, iron sulfate, iron EDTA1, manganese sulfate, sodium molybdate, zinc sulfate, zinc oxide	Copper sulfate, iron EDTA, manganese sulfate, sodium borate, sodium molybdate, zinc sulfate	Iron sulfate, manganese sulfate, molybdic oxide, zinc sulfate
Percentage of nutrient listed as coated (using N as an example, other nutrients had similar results)				
	13.5% coated N (90% of total)	18% coated N (100% of total)	14% coated N (93% of total)	19% coated N (100% of total)

1EDTA is a chelating agent. For more information, see article 9 in of this series in the September 2008 Greenhouse Grower.

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substrates containing N-P-K or N-P-K plus micronutrients covered in a membrane that limits the solubility of the fertilizer. The membrane technology varies between companies and can be resin-, plastic- or polymer-based. Examples of controlled-release fertilizers using different membrane technologies are found in Table 1.

Nutrients are released in two ways: Some CRFs have an initial release of nutrients either caused by imperfections in the coating of the prill or the use of uncoated fertilizer prills in the formula. Using the fertilizer in Table 1 as an example, the percentage of coated nitrogen in the formulas ranged from 90 to 100 percent (0 to 10 percent uncoated nitrogen). Some CRF formulas, for example top-dress formulas, may have 70 percent or less of the nutrients listed as coated (30 percent uncoated). Sometimes, fertilizer prills are damaged, for example, when adding to a media during mixing. Depending on the salt used to make the uncoated fertilizer, it may completely dissolve with the first watering, and therefore should be thought of as a starter fertilizer (if incorporated at planting) or a fertilizer drench (if top dressed).

To test for initial release, put a teaspoon of CRF in a liter of water and allow the solution to sit at room temperature overnight. The more the EC of the solution increases, the greater the initial release.

Nutrients are mainly released from a CRF prill following absorption of water through the membrane. The water dissolves the fertilizer inside the prill. The dissolved nutrients then diffuse back out through the coating into the soil solution.

Once the CRF prill has absorbed water, soil temperature determines the release rate of nutrients. Depending on the product, the ideal release temperature (i.e., the temperature used to predict the duration of the fertilizer release) can vary from 70°F to 78°F (21°C to 25°C). For example, one type of CRF has an ideal release temperature of 70°F. For a fertilizer with a six-month release rate, 90 to 95 percent of the nitrogen fertilizer contained in the prills will be released over six months if the temperature of the medium is maintained at an average of 70°F.

The higher the average soil temperature above the ideal release temperature, the more quickly nutrients will be released from the fertilizer prill, shortening the duration of the fertilizer. In contrast, lowering the average soil temperature below the ideal release temperature will slow the nutrient release rate and increase the fertilizer duration. Using the example above, if the average soil temperature increased from 70°F to 80°F (21°C to 26°C), the release duration would decrease from six months to four months, whereas decreasing the average soil temperature to 60°F (15°C) would cause the release duration to increase to seven to eight months.

CRF And pH Management

Once the CRF has released the nutrient into the soil solution, the effect on media pH is similar to that of any other fertilizer blend. As discussed in Part 7 (July issue) of this series, the fertilizer effect on media pH is based on the type of nitrogen found in the fertilizer formula.

For example, the water-soluble fertilizer 20-10-20 tends to be acidic because 40 percent of the total nitrogen is in the ammoniacal nitrogen (NH_4-N) form. Ammonium has an acid reaction in growing media. Using the CRF formulas in Table 1, the percentage of nitrogen in the ammoniacal form ranges from 45 to 56 percent of the total nitrogen. Therefore, the pH reaction produced by each of the fertilizers should be more acidic than using 20-10-20.

Just like any other fertilizer, the pH reaction produced by a CRF formula can be modified by a number of factors, including:

- The amount of ammoniacal nitrogen in the soil solution is influenced by the CRF formula, incorporation rate and media temperature. The more ammoniacal nitrogen being released into the soil solution, the greater the acidic effect of the fertilizer. Conversely, the less ammoniacal nitrogen being released into the soil solution, the smaller the acidic effect.
- Nitrification of ammoniacal nitrogen is inhibited by low substrate pH (starting at around 5.5), low substrate temperature (less than 60°F or 15°C) and lack of oxygen through water-logging. Therefore under these conditions, ammoniacal nitrogen is less acidic.
- Basic chemicals like residual limestone contained in the media or water alkalinity may neutralize the acidic effect produced by the ammoniacal nitrogen.

Slow-Release Fertilizer

Slow-release fertilizers (SRF) are another group of fertilizers with limited solubility. However, SRFs differ from controlled-release fertilizers in one important way. The release of nutrients from slow-release fertilizers are dependent on multiple factors, not just a single factor like media temperature. Therefore, the nutrient release from SRFs is less predictable than from controlled-release fertilizers. Examples of SRFs are given below.

Sulfur-coated fertilizers: Sulfur-coated fertilizer are urea, or urea- or ammonium-based salt blends that are coated with elemental sulfur and other materials (like wax) to produce individual fertilizer prills similar in size and appearance to controlled-release fertilizers. Nutrients are released when water penetrates the sulfur coating through pores or imperfections in the coating. Once water has penetrated the coating, nutrient release from the prill is rapid. Since the thickness of the sulfur coat will influence the time required for water penetration, sulfur-coated fertilizers usually contain a range of coating thicknesses to get an extended release duration.

Wax sealants are sometimes applied to the sulfur coating to slow water penetration. If wax is present, then microbial activity is needed to break down the wax to allow the sulfur coat to be exposed before nutrient release can occur. If a wax coating is present, anything that affects microbial activity, such as temperature, media-moisture level, media pH or media-aeration, will also influence nutrient release.

Urea Formaldehyde (UF): UF is a class of slowly soluble nitrogen fertilizers synthetically produced by combining formaldehyde with urea. The release of nitrogen from UF is a multistep process that depends primarily on microbial decomposition. Therefore, anything that affects microbial activity will affect the release of nitrogen from UF.

Isobutylidene diurea (IBDU): IBDU is a single slowly-soluble nitrogen fertilizer synthetically produced by combining isobutyraldehyde with urea. The release of nitrogen from IBDU is controlled by a process called hydrolysis and is affected by media moisture level and media pH, but not microbial activity.

Slowly soluble fertilizers: These are fertilizer salts that have a relatively low solubility when added to water. Examples of slowly soluble fertilizers include gypsum ($CaSO_4 \cdot 2H_2O$), triple superphosphate or 0-46-0 ($9Ca(H_2PO_4)_2 + CaF_2$), limestone or micronutrient oxides. The release of nutrients from slowly soluble fertilizers is dependent on the solubility of the individual fertilizer salt. In addition, the particle size of the salt will influence the release duration

Conclusion

Always read the fertilizer label or ask your fertilizer representative about important information on the fertilizer. This should include how the fertilizer is manufactured, the materials used to make the formula, how much initial release you can expect, how long the fertilizer will supply nutrients and at what temperature. Experts with knowledge of your local conditions and crop type can help match the CRF or SRF to your needs. Understanding the fertilizer you use is important to efficiently supply nutrients to your crop. **GG**

About the authors: Bill Argo (**bargo@blackmoreco.com**) is technical manager at the Blackmore Company and Paul Fisher (**pfisher@ufl.edu**) is an associate professor and Extension specialist in the Environmental Horticulture Department at the University of Florida.