Plant Nutrition Part III: Understanding Slow-Release and Controlled-Release Fertilizers

Before we proceed into the discussion of these types of fertilizers, we should clarify some terminology. We will be discussing three types of fertilizers: 1) quick-release fertilizers (QRF); 2) slow-release fertilizers (SRF); and 3) controlled-release fertilizers (CRF).

Quick Release Fertilizers

QRFs are synthetic chemical fertilizers composed of a mixture of various compounds that are in the form that is readily available for plant uptake. Under optimal conditions, the QRF's nutrients become available to plants at a consistent rate in a short period of time after being properly applied to the soil and with appropriate soil moisture. Their release curve is immediate, and the water-soluble nutrients readily leave the plant root zone, which is why applying timely side dressings of more QRF may be necessary. With QRFs, there is a rapid early release of the majority of the plant nutrients that quickly tails off. There are several benefits of quick-release fertilizers such as the fact that nutrients are immediately available to plants, and they stimulate quick shoot growth and greening. However, there are also down sides to the quick-release fertilizers as they rapidly deteriorate from the soil through the leaching of nitrates. Thus, they last only two to four weeks and if they are over-applied, they can cause fertilizer burn and harm the plants. Quick-release fertilizers are more water-soluble and make nutrients immediately available to the plants. These types of fertilizers are almost always synthetic and come in pellets or liquid forms, which help it dissolve faster in the soil water fraction. One major negative with QRFs is nutrient use efficiency (NUE). Direct application of chemical fertilizers to plants has been shown to have a low utilization efficiency as only 30–35% of the nutrients are absorbed by the plants. The rest is lost mostly through leaching and volatilization. The terms

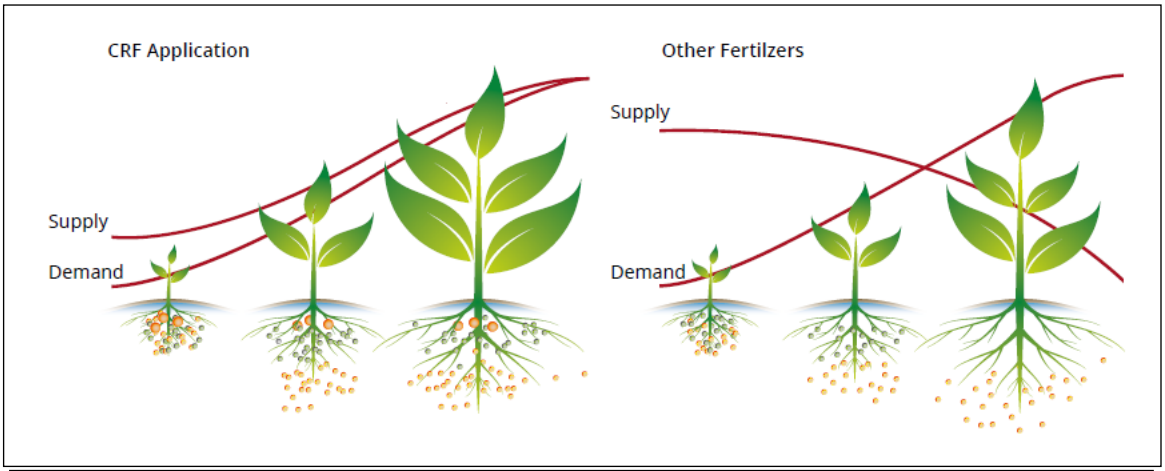

Figure 1: Release rates of CRFs vs QRFs. This illustrates how the release rate of CRFs more closely

"slow-release fertilizer" and "controlled-release fertilizer" do not mean the same thing. Slow-release fertilizers involve a slower release rate of nutrients than conventional quick release fertilizers, but the rate, pattern, and duration of release are not controlled because they depend on microbial organisms whose effectiveness is dependent on soil conditions. Controlled-release fertilizer is a term applied to fertilizers in which the factors controlling the rate, pattern and duration of release are well known and controllable due to the process of CRF manufacture.

Slow-Release Fertilizers

The nutrient release pattern of SRFs is a gradual process totally dependent on soil and climatic conditions. These include soil microbiota population and diversity, soil moisture content, soil pH, temperature, and humidity. Natural (organic) SRFs include plant

manures, such as green manure or cover crops, all animal manures (horse, cow, poultry, etc.) and compost. Because the plant nutrients are bound up in complex organic molecules, these must be broken down by microbial activity before the nutrients can be released in a form that plants can take up. In general, organic fertilizers may take a long time to release nutrients, and these nutrients may not be available when the plant needs them. The duration of nutrient release of this type of organic fertilizers mainly depends on soil microbial activity that is driven by soil moisture and temperature. Organic SRFs contain both macro-nutrients (nitrogen, phosphorus, potassium, etc.) and micro-nutrients (iron, manganese, copper, etc.). The nutrient concentrations of organic SRFs are relatively lower than those of synthetic SRF fertilizers. Synthetic SRF fertilizers would be ones in which the release of available plant nutrients is slowed by some manufacturing process. Synthetic SRFs are sparingly water-soluble and are typically in pellet or spike form. The availability of nutrients in this type of fertilizers depends on soil moisture and temperature. Nutrients are released during a time period ranging from 20 days to 18 months. Production of synthetic SRFs in spike form is taking advantage of the fact that nutrient solubility and release is directly related to available surface area for interaction with soil moisture. A high concentration of water soluble chemicals are embedded in a block matrix of proprietary materials that breakdown slowly at the surface releasing the nutrients slowly.

Controlled-Release Fertilizers

The Association of American Plant Food Control Officials defines CRFs as fertilizers that contain a plant nutrient in a form the plant cannot immediately absorb. Uptake is delayed after application, so that CRFs provide the plant with available nutrients for a longer time compared to QRFs, such as urea.

I couldn't find any Federal Regulations addressing quality control of CRFs. I also didn't find any Louisiana regulations or rules; however, some states do have rules. For instance, as required by Florida rule, at soil temperatures below 77°F, a CRF must meet the following three criteria: (1) less than 15 percent of the CRF nutrients should be released in 24 hours, (2) less than 75 percent should be released in 28 days, and (3) at least 75 percent should be released by the stated release time (40–360 days).

Controlled-release fertilizers are fertilizer granules which are covered with a semipermeable coating (a kind of membrane). After application, water penetrates through the semipermeable coating and starts to dissolve the nutrients present in the granule. The release of nutrients starts once they have been partially dissolved. Influenced by temperature and moisture, the membrane regulates the daily release of nutrients. With higher temperatures, the release of nu-

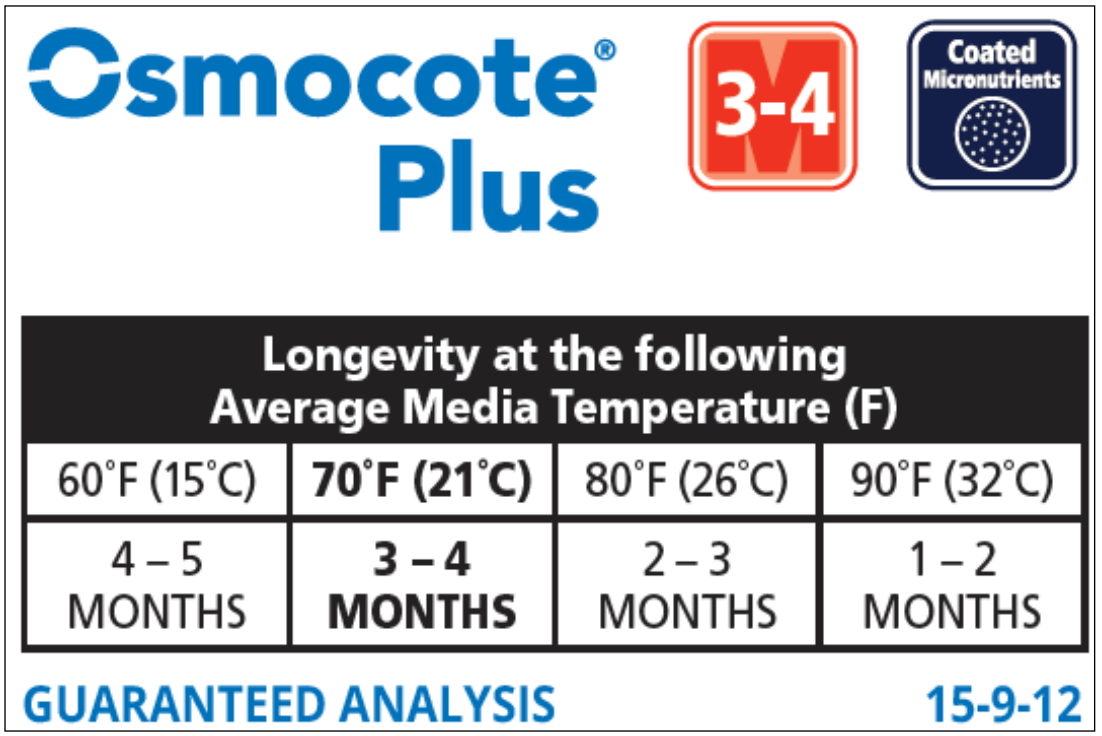

Figure 2. Information from the Osmocote Plus label. This is rated as a 3-4 month fertilizer but the label shows how different temperatures affects the fertilizer longevity.

trients will be faster, at lower temperatures it will be slower. If you read the labels on CRFs, you will see that they provide information about the release of the plant nutrients based on studies done at different temperatures. The standard for fertilization longevity is 70oF in most instances. The membrane encapsulated fertilizer particles are often referred to as prills. Different manufacturers have different proprietary forms of membranes. Some contain special "release" chemicals that help to further regulate the release of the nutrients making them less temperature dependent. However, they all still function in basically the same way (Figure 3). Water penetrates the membrane, dissolves the water-soluble nutrients and the liquified nutrient solution comes out due to osmosis. Because of how they work, CRFs should be stored in a cool dry environment, and they should be handled somewhat gingerly. Depending on what composes the membrane, prills can be cracked or damaged by rough handling. A damaged prill will no longer function in a controlled release manner; all the nutrients will be released as soon as they encounter water.

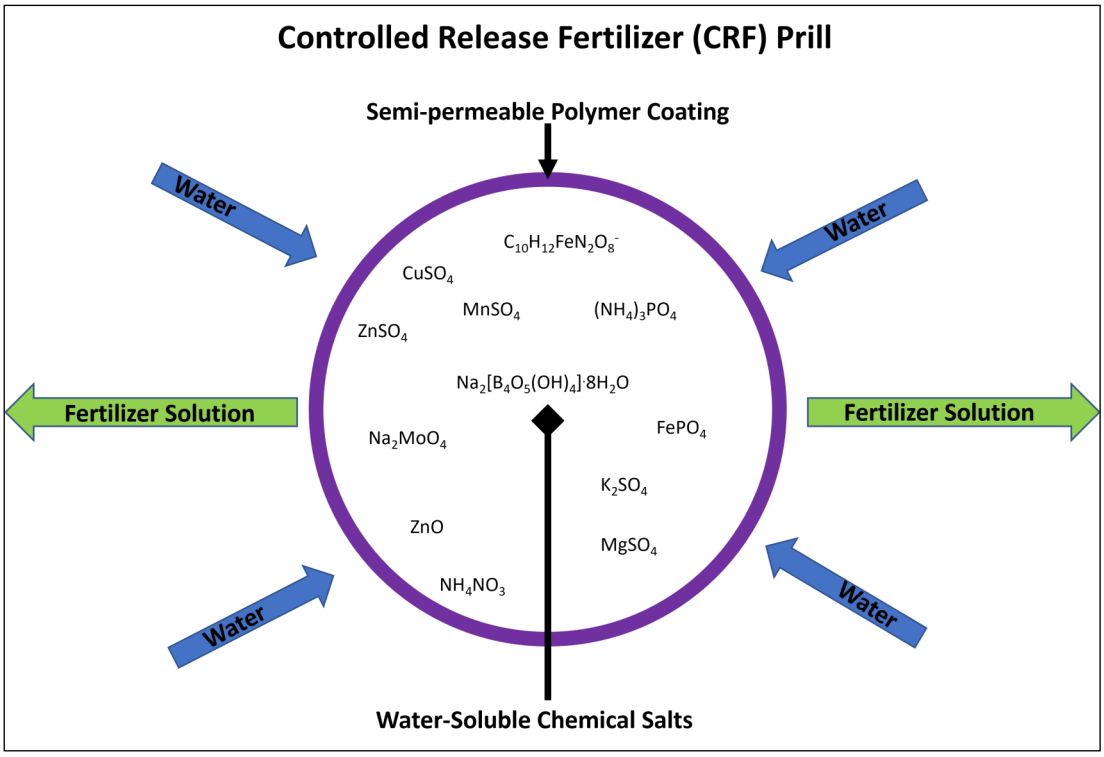

Figure 3: How CRF prills function. Water goes in through the semi-permeable membrane, salts go into solution,

Due to the high cost of manufacture, encapsulated or coated SRFs and CRFs are more expensive than standard QRFs.

~Dr. Joe Willis

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