Technical Bulletin

Flowable Nutrient Formulations

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Solubility and Nutrient Availability

A fundamental tenet of crop nutrition whether dealing with soil or foliar applied nutrient products, is that in order for plants to absorb and utilize essential elements, they must first be presented to the root or leaf in ionic forms. The most practical way elements are ionized is by their dissolution with water. Many nutrient products, therefore, are made to be soluble in water and solubility is often equated with "availability".

As far back as 1934, Parker and Johnston at the University of California's Riverside Experiment Station demonstrated that supposedly 'insoluble" materials like zinc oxide and zinc carbonate, as well as the more soluble zinc sulfate and basic zinc sulfate, were effective in correcting zinc deficiency. More recent work in California by Dr. Peter Christensen on grapes has pointed to combinations of zinc oxide and zinc sulfate as the best and safest sources for foliar application to vineyards.

Flowable nutrient formulations are high analysis suspensions which are commonly derived from insoluble compounds such as oxide, carbonates, and hydroxides. So-called 'insoluble nutrients or nutrient complexes can and do provide nutrients in an available, i.e. soluble, form to the plant leaf – they just do it over a prolonged period of time. How do we know this for a fact? Back in 1957, Dr. FM Turrell did radioisotope research at the University of California (Riverside) in the department of Plant Biochemistry. In his work Dr. Turrell "spiked" or labeled radioactive zinc-phosphate, P32, which is very low in water solubility. The product was applied to grapes, corn, and lemon and navel oranges trees. A single leaf of each plant was treated with the material.

Three weeks later, untreated leaves were sampled both and above and below the treated leaf; plant roots were also sampled. All of these untreated plant parts showed radioactive phosphorus in them; clear proof that the products had been solubilized, absorbed and translocated by the leaf and plant as a normal course of events. Even nematodes in the soil, were found to be "contaminated with radioactive phosphate.

Nothing is truly insoluble. Given enough time and chemical activity, virtually any compounds can be solubilized, at least to some degree. Chemical reactions on the surfaces of compounds are what solubilize them into individual ions. Therefore, if a compound can be divided into numerous small particles, there will be many more surfaces for the chemical reactions responsible for solubilizing the material to occur.

The practical significance of this relationship between particle size and surface area is that if particle size is made extremely small, then there is exponentially more surface area on which chemical activity leading to solubilization takes place: Increasing surface area…increased chemical activity…increased ionization…increased nutrient availability. High quality flowable suspensions contains micron size particles for improved nutrient availability.

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An effective foliar nutrient product must carefully regulate the amount of even soluble nutrients present at any time. Though it may be difficult to believe, excessive concentration of even completely soluble materials on the leaf surface can lead to burn or phototoxicity. But by using so-called “insoluble” nutrient formulations, the rate of soluble nutrient release on the leaf surface is controlled.

If the product is properly formulated, these “insoluble” nutrients, over a period of time, gradually “release” (solubilize) their nutrients onto the leaf. This “controlled solubility” of the formulated “insoluble” nutrient is specifically designed to avoid possible phototoxicity while providing critical nutrient to supplement and optimize the normal root feeding of the plant. Availability, is therefore, not a meaningful term for comparing soluble and “insoluble” materials.

In summary, the essential feature of any plant nutrient product is to effectively get the nutrient into the plant. To do this, it should:

- Provide the nutrient in a form to the plant that can be readily absorbed and easily utilized
- Accomplish this safely, without causing foliage injury or other phytotoxic effects
- Not over supplying one element at the expense of other nutrients or further induce unfavorable nutrient imbalances
- Provide enough nutrient to satisfy the plant nutrient demand at the correct timing in the growth cycle.