

The PolyAmine Micronutrients of Northwest Agricultural Products

The Plant Anatomy, Plant Physiology, and Chemistry.

The foliar application of micronutrients provides a means of supplying nutrients to crops more rapidly than methods involving soil application. However, foliar applied micronutrients can be ineffective for the following reasons:

- 1) Low penetration rates, particularly in leaves with thick cuticles.
- 2) Run-off from waxy leaves.
- 3) Washing off by rain or irrigation.
- 4) Rapid drying of the spray solution.
- 5) Limited rates of retranslocation of some mineral nutrients, such as calcium, to other parts of the plant.
- 6) Leaf damage (phytotoxicity, necrosis, or 'burning')

NAP has specifically addressed the first point, the problem of low penetration rates, in the formulation of the PolyAmine line of micronutrients.

MICRONUTRIENTS : PLAIN, CHELATED or COMPLEXED?

In agriculture, micronutrients are applied either as the plain metal ion (e.g. Zinc Sulfate), a chelated ion (EDTA), or as a complexed ion (lignosulfonates, NAP PolyAmines). Each formulation will supply some micronutrient to the plant whether soil or foliar applied. But there are significant differences in the percentage of each that the plant utilizes.

The word chelate comes from the Greek word for claw. Chelates, such as EDTA, are large ring structures that completely surround the metallic ion. This protects the ion from reacting with other materials. This is especially important in soils that contain anions such as bicarbonate that will form insoluble salts with the metallic ion.

PLANT PHYSIOLOGY BACKGROUND

The leaf is covered with a layer of waxes, the cuticle. The major function of the cuticle is to protect the leaf from excessive water loss by transpiration.

This layer is penetrated by stomata with which the plant controls transpiration. Experimental evidence does not support the idea that foliar applied nutrients enter the leaf through the stomata. Ion uptake rates from foliar sprays are usually higher at night, when the stomata are closed, than during the day when the stomata are open.

The literature indicates that mineral nutrients enter the leaf through hydrophilic pores within the cuticle. These pores have a diameter of less than 1nm (10^{-9} m) and a density of about 10^{10} pores cm^{-2} . Most micronutrient elements of interest have diameters of about 1 angstrom (10^{-10} m) or $1/10^{\text{th}}$ nm, so restrictions to entry because of size are not an issue. However, the hydrophilic pores are lined with fixed negative charges, probably from the carboxyl group of galacturonic acids. Therefore, these hydrophilic pores act as cation exchange surfaces. The charge density increases from the outside to the inside of the pore. This helps the penetration of cations but repels anions. However, if exchange surface becomes filled with cations, penetration can slow and uptake stops. Please note that small uncharged molecules like urea (radii 0.44 nm) pass through easily. Larger molecules, such as FeEDTA are too big to penetrate these pores.

There are larger hydrophilic pores near the stomata that will allow EDTA chelates to enter the leaf. However, it is relatively slower than the penetration rate of the smaller, electrically neutral pore

NAP's RESPONSE TO ENHANCE PENETRATION

What NAP has done to increase both the rate and quantity of micronutrient penetration is to complex the metal cations in the PolyAmine materials with several small organic acids. The complex of the organic acids and the metallic cation is both small and electrically neutral (like urea). This combination passes easily through these hydrophilic pores while neither clogging the pores nor restricting further penetration. Therefore, the percentage of applied material that enters the leaf is quite high and can occur over a longer time period.

In addition, NAP has chosen these complexing agents from among those that are the naturally occurring metal complexing agents inside the plant. This

has the advantage, when compared to EDTA and other synthetic chelates, that the plant can immediately use the organic acids to maintain charge balance, for an energy source, and for a source of carbon skeletons. Since all of the organic acids come from natural sources, the plant can metabolize all of the material added.

The result of this chemistry is that a major portion of the micronutrient that hits the leaf surface is rapidly absorbed and utilized by the plant.

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