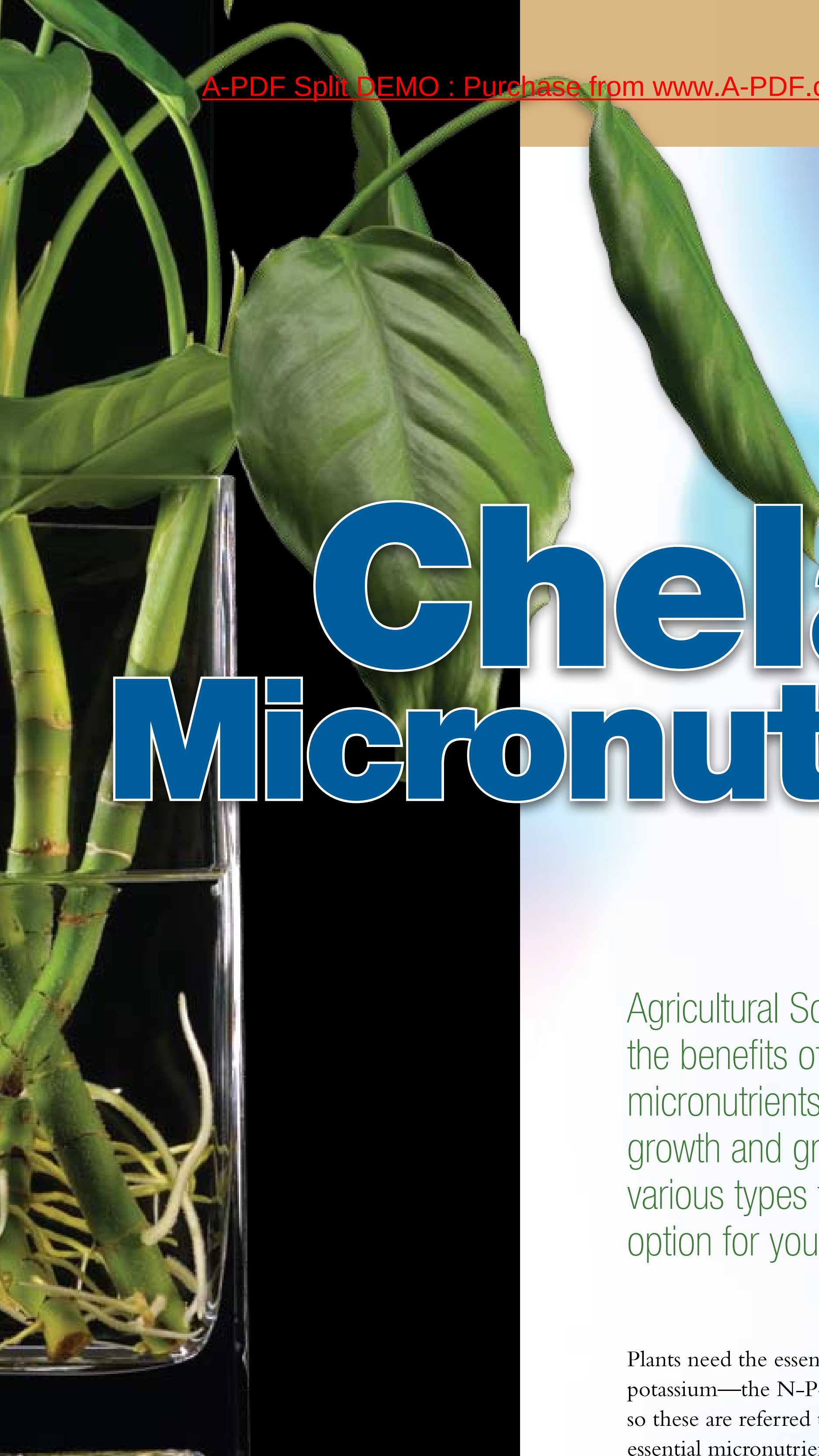


Chelated Micronutrients

by Donald Lester

Agricultural Scientist Donald Lester details the benefits of highly efficient chelated micronutrients—which aid in enhanced plant growth and greater yields—and defines the various types to help you choose the very best option for your indoor garden system.

Plants need the essential nutrients nitrogen, phosphorus and potassium—the N-P-K on fertilizer labels—in large amounts, so these are referred to as macronutrients. Plants also need essential micronutrients (also known as trace minerals) such as calcium, zinc, magnesium, iron and manganese. Micronutrients come in many different forms that affect their solubility (i.e. dissolvability) in water and their uptake and usage by plants.

Micronutrients commonly react with other chemicals and get "tied up" or precipitate in the soil. Once this happens the micronutrients are insoluble in water and will not be absorbed or used by the plant, at least not until micro-organisms or weather breaks them down into a usable form. So, you could literally add a lot of one micronutrient to the soil but the plant will use only a small amount. A good example of this phenomenon can be seen with the soft mineral, gypsum. Every year growers apply gypsum to their fields by the ton, but since it is not very soluble in water only a very small amount of calcium is available to the plant. It takes a long time for soil microbes and weather to break down these compounds so that plants can use them. Foliar applications do not suffer from this phenomenon (table one).

Fertilizer manufacturers produce several different forms of micronutrients such as salts, oxides and chelates. The chelated micronutrients are becoming popular because of their high efficiency. Knowing a bit about the various types of chelated micronutrients can help you choose the one that is right for you.

Photo by Dennis Tasa

Gypsum, a soft mineral composed of calcium sulfate dihydrate, is only mildly water soluble, so only small amount of calcium becomes available to plants.

What is a Chelate?

Chelation is a term that describes an encapsulation process. A mineral, like calcium for example, reacts with another material to form a protective shell around the desired mineral or metal (in this case calcium). The word chelate derives from the Greek word "chel", meaning a crab's claw, and refers to the pincer-like manner in which the mineral is bound. Some chelating chemicals are shaped like a letter 'C' and surround the mineral with just one molecule. This type of binding is called a "complex". When two molecules of the same material surround a mineral it is known as a chelate. It is important to note that some minerals, like boron or molybdenum, have only one chemical bond and are thus limited to forming only a complex. Strictly speaking, boron and molybdenum cannot be chelated minerals but they are often presented and sold in the market as chelated minerals.

A hold on things
The word chelate derives from the Greek word "chel", meaning a crab's claw, and refers to the pincer-like manner in which one mineral is bound by another.

Chelates need a "glue" to hold the protective shell in place. Some chelates use sodium for this purpose, but adding sodium can be detrimental to plants. In general the amino acid chelates use organic acids like citric acid. There is an important distinction to be made here about the use of the word organic. In chemistry the term organic means the material contains carbon. In the organic foods world the term organic refers to foods produced without pesticides, synthetic substances, sewage products and other restrictions.

Chelates are molecules with a neutral charge, which is very important. Micronutrients normally have an electrical charge on them. For example, calcium and magnesium are both +2 charge. Soil is generally negative in charge, especially clay soils. This means that calcium and magnesium will likely react with the soil and be insoluble and not available for plants to use. Moreover, since they are the same charge, calcium and magnesium compete with each other for entry into the plant. Pores on the leaves of plants (also known as stomates) are negatively charged, so positively charged molecules trying to penetrate the plant get tied up at the stomate entrance thus slowing absorption. But the interaction with chelates is very different. The neutral charge of chelated minerals allows them to enter the stomates unimpeded. Research into nutrient uptake has shown that some materials applied to leaves do not enter the tissues but instead remain stuck to the leaf surface like house paint. Subsequent chemical analysis of these tissues would show similar nutrient levels as those tissues that had nutrient penetration. In light of this oversight researchers now apply nutrients to the leaves and then analyze the fruits to measure the amount of nutrient movement inside the plant.

There are several types of chelates. One of the most common forms is Ethylene Diamine Tetraacetic Acid (EDTA), which has been on the market for years. EDTA is a large synthetic molecule that binds very tightly to minerals and resists chemical interactions—desirable characteristics for chelates used in the soil. But this strong bonding characteristic can be a negative attribute once

EDTA is in the plant. EDTA binds tightly. In fact, when people have heavy metal poisoning EDTA is injected into their bloodstream to chelate the metals and filter them out. Obviously patients do not want EDTA releasing heavy metals back into their body prematurely. In addition, EDTA can solve one plant nutrient deficiency and at the same time cause another. EDTA has something of a separation anxiety; it must always hold on to something. For example, iron EDTA will cure iron deficiency in plants, but in order for the EDTA to release the iron it must hold onto something else. Often EDTA will take up manganese in order to release the iron, thus causing a manganese deficiency. Furthermore, EDTA is known to take calcium from cell walls in both plants and people. For this reason people put on EDTA are often instructed to take calcium supplements as well. Plants losing calcium in this manner (primarily from their cell walls) visually manifest the loss as wilting.

"Some materials applied to leaves do not enter the tissues but instead remain stuck to the leaf surface like house paint."

Another category of chelate is the amino acid chelates. There are 20 amino acids. Amino acids are the building blocks of protein. Amino acids are moderately strong chelating agents. Once inside the plant the mineral is released and the left over amino acids that formed the protective shell are used by the plant as a source of water soluble nitrogen. After all, amino acids are building blocks in cell machinery. Everything is used, nothing is lost. Conversely, EDTA is a synthetic molecule, and plants do not naturally use EDTA. It's sort of like trans fat; the human body doesn't know what to do with it. Amino acid chelates are generally systemic in the plant meaning they move and travel to where they are needed. They can do this because amino acids are recognized by the plant as building blocks and are used in nearly every tissue in the plant. Amino acid chelates are available as liquids or powders and generally available for use in organic food production.

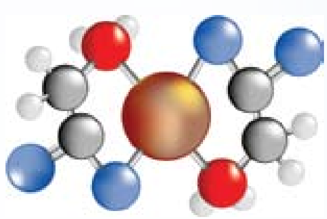
Nutrient	Crop	Foliar	Soil	Citation
Zinc ($ZnSO_4$)	annual crops	1	12	Lingle & Holmberg (1956)
Phosphorus (H_3PO_4)	beans, tomatoes	1	20	Wittwer, et al. (1957)
Iron ($FeSO_4$)	grain sorghum	1	25	Withee & Carlson (1959)
Magnesium ($MgSO_4$)	grain sorghum	1	100	Krantz (1962)
Magnesium ($MgSO_4$)	celery	1	50 to 100	Johnson, et al.(1957, 1961)

Table 1. Relative amounts of nutrient needed for comparable effect in the plant, by method of application.

Glycine chelates (also known as glycinates) are a subset of amino acid chelates. Glycine is the smallest amino acid and it is often used as a chelating agent. Since glycine is small it makes a small final product that passes through leaf pores (stomates) more easily than other larger molecules, thus enhancing plant uptake. And don't forget, glycine chelates have glycine which is an amino acid. When the glycine is separated from the mineral in the plant, the plant uses the glycine.

Glycine chelates are sometimes used in wine production because they supply not only the desired nutrients, but the glycine also supplies Yeast Available Nitrogen (YAN). This means that the yeast can break down the glycine and use the nitrogen in the formation of its cell walls.

Because chelates enter the plant easily they are extremely useful for quickly correcting nutrient deficiencies. As a rule chelates are very safe for the plant. The amino acid chelates (glycine chelates included) require large amounts of product to be applied in order to be toxic to plants. But care must be taken to avoid phytotoxicity or burning of plant tissues with EDTA.



Good things in small packages
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Using Amino Acid Chelated Micronutrients

Amino acid chelates are especially suitable for greenhouse and hydroponics systems because they are usually certified organic, readily available for uptake by plants by both roots and foliage and generally are not phytotoxic. For example, in aquaponic systems where fish are integrated into the hydroponics system it is important that nothing synthetic enter the tissues or meat of the fish. Therefore, the use of organic materials is an obvious choice, and the amino acid chelates can be applied directly to the foliage or to the nutrient solution for immediate correction of nutrient deficiencies. When shopping for chelated minerals look for the characteristics listed below.

Shopping for Chelated Micronutrients

Desirable Characteristics

- Formulation is safe for plants
- Does not promote other deficiencies
- Readily available to the plant
- No sodium
- Organic certification

Undesirable Characteristics

- Formulation is prone to burning
- Needs ion replacement to release micronutrient
- Slow uptake
- Contains sodium
- Not organically certified