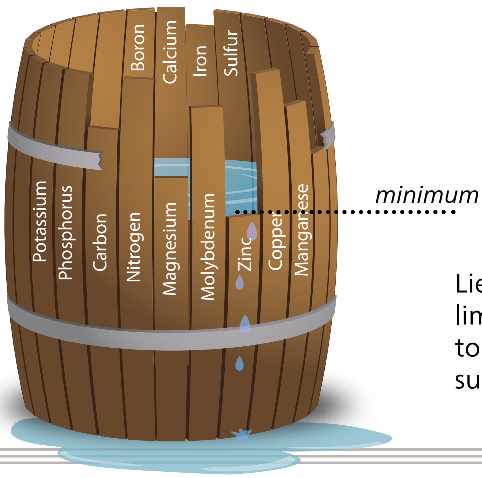
A COMPLEX BOND:

THE SCIENCE BEHIND FOLIAR NUTRITION



Crop yields depend on soil fertility.

Liebig's "law of the minimum" describes how limited nutrition in turn limits potential crop yield. Plants use essential elements in proportion to each other, and the element that is in shortest proportionate supply will determine availability of all other nutrients.

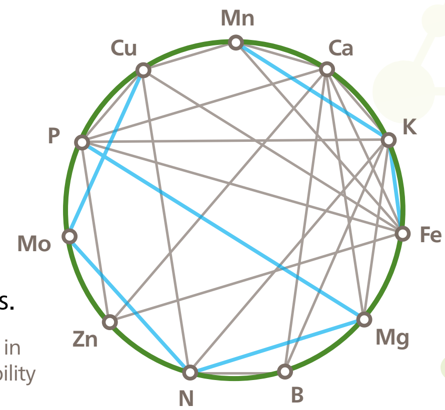
"The growth of plants is limited by the element whose concentration is below the minimum required for synthesis."
—Justus von Liebig, 1840

The complexity of nutrient interactions

Mulder's chart illustrates the complex challenges in providing a balanced supply of nutrients. An increase in one nutrient can either work synergistically, increasing the availability of some nutrients, or antagonistically, decreasing the availability of others.

Synergistic; increase in one nutrient improves availability of another nutrient

Antagonistic; increase in one nutrient reduces availability of another nutrient



Micronutrients can also interact with other chemicals in the soil, greatly affecting their absorption and limiting their availability to plants. An alternative can be foliar application of nutrients. Because plants absorb so effectively through the leaf surface, foliar liquid nutrients can deliver a high degree of efficiency. A very small quantity of a nutrient received via foliar application can achieve the same effect in the plant as a much greater amount received via the soil.[9]

Nutrient	Crop	Foliar	Soil	Source
Zinc	annuals	1	12	*Lingle & Holmberg (1956)*
Phosphorus	beans, tomatoes	1	20	*Wittwer, et al. (1957)*
Iron	sorghum	1	25	*Withee & Carlson (1959)*
Magnesium	sorghum	1	100	*Krantz (1962)*

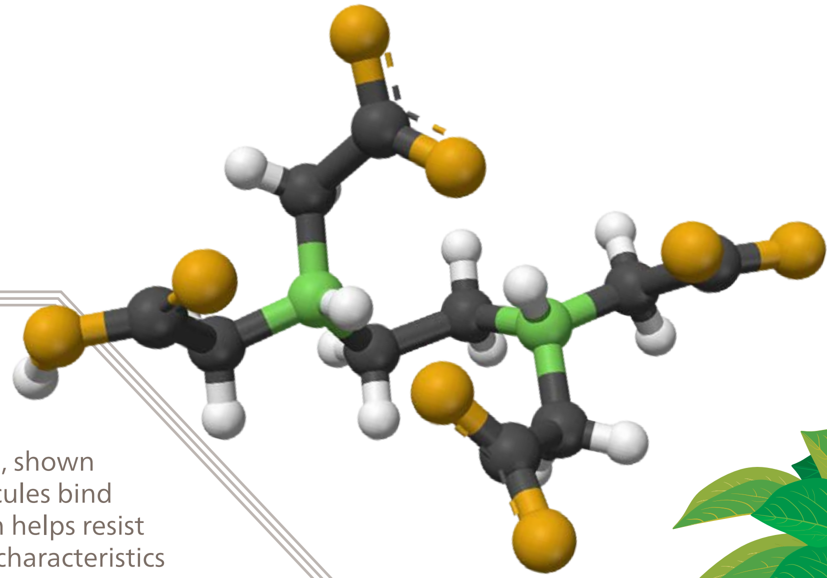
Relative nutrient amounts required for comparable effect in the plant

Micronutrient sources can be organized into three primary classes[13]**:**

1 Inorganic chelates
Sulfates, metallic salts

2 Synthetic chelates
such as EDTA

3 Organic complexes
such as amino acids



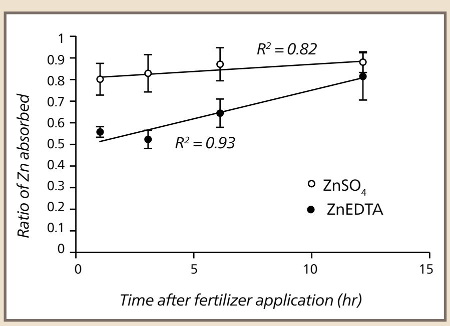
What is a chelate?

Chelation is an encapsulation process of bonding a mineral to a protein.[16] The term comes from *chēlē*, the Greek word for "claw".[9]

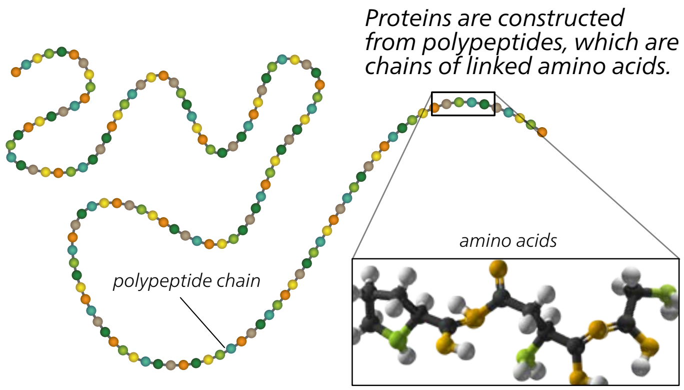
EDTA

The most common agent for chelating minerals is EDTA (Ethylenediaminetetraacetic acid), shown here. These large, synthetic molecules bind very securely with minerals, which helps resist 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. For example, iron EDTA will help cure iron deficiency in plants, but in order for the EDTA to release the iron, it may hold on to something else. Often EDTA will take up manganese in order to release the iron, thus potentially causing a mangansese deficiency.[9]

> *"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."*
>
> *—Donald Lester*



A 2007 Arkansas study revealed that a greater ratio of foliar-applied zinc sulfate was absorbed over time, as compared to zinc chelated by EDTA.[14]



What is a complex?

Complexing agents are molecules that can form bonds with minerals. In agriculture, this can be used to protect micronutrients from undesirable chemical reactions in the environment before reaching the plant. When a single ligand binds to a cation, that cation is considered "complexed".[10]

What are amino acids?

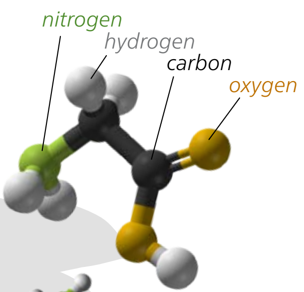
Amino acids are organic molecules often referred to as the building blocks of proteins. They link with one another to form long polypeptide chains, which in turn form the various kinds of proteins present in all living organisms.

Plants must synthesize a continuous supply of the 22 proteinogenic (protein-forming) amino acids in order to grow and develop.

Some herbicides such as glyphosate can inhibit amino acid synthesis and impair plant development; amino acid supplementation has been shown to aid in recovery.[15]

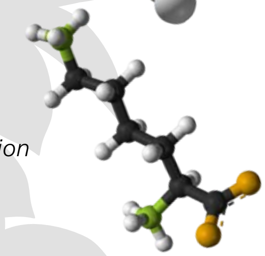
Amino acids can also serve as organic complexing agents, delivering micronutrients in a highly bioavailable, environmentally friendly form. These water soluble complexed minerals can be rapidly absorbed, translocated and metabolized by plants through the leaf surface.[4,15]

KEY AMINO ACIDS

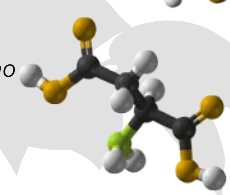


GLYCINE
High complexing power, aids in photosynthesis, precursor of chlorophyll.[5]

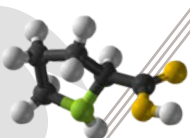
LYSINE
Important plant nitrogen reserve, aids in chlorophyll activation, stomata regulation and pollen development.[3]



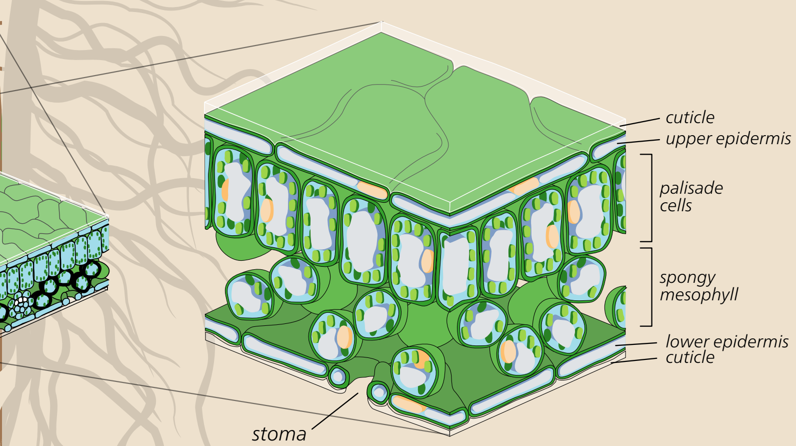
ASPARTIC ACID
Nitrogen source, essential for synthesis of other amino acids, important during early growth stages.[8]



PROLINE
Associated with resistance to fungal infection, essential for overcoming stresses such as drought, temperature extremes and salinity.[1]



> *"We want to protect these minerals; we want to hide them—like a ninja—so they can get to where they can actually be utilized."*
>
> *—Steve Elliott, Global Director, Alltech Mineral Management*

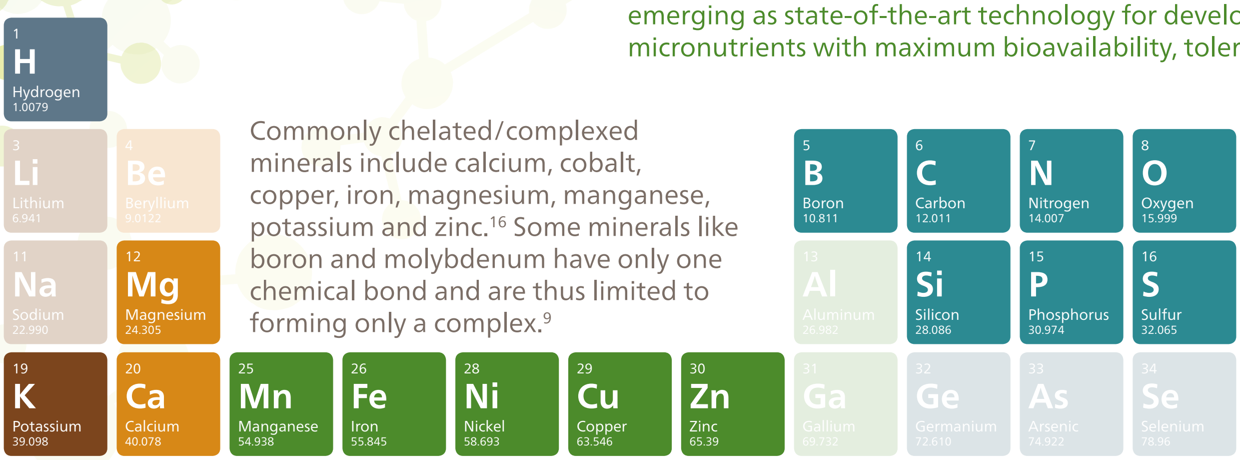


The Journey Begins at the Cuticle

The cuticle (waxy layer of fatty acids) serves as a physical and chemical barrier. The most important quality required of a nutrient molecule in this situation is electrical neutrality. Fatty acids possess negative electrical charges that will attract positively charged species. Minerals complexed with amino acids are neutral in charge, allowing them to bypass the leaf surface. Upon reaching the cell membrane, they are absorbed rapidly, as amino acids are sources of water-soluble organic nitrogen. These molecules remain intact as they travel through the leaf barrier with minimal interference. From there, they may be absorbed and used by the leaf cells, or travel on to the phloem (the vascular system used by plants for transportation), typically to new leaves, flowers, fruit and other fast-growing parts of the plant.[7]

What is bioavailability?

Bioavailability is the degree and rate at which a substance is absorbed into a living system or is made available at the site of physiological activity.[13] In foliar-applied plant nutrition, amino acid chelates are emerging as state-of-the-art technology for developing selected micronutrients with maximum bioavailability, tolerability and safety.[13]



Commonly chelated/complexed minerals include calcium, cobalt, copper, iron, magnesium, manganese, potassium and zinc.[16] Some minerals like boron and molybdenum have only one chemical bond and are thus limited to forming only a complex.[9]

> *"True amino acid chelates are emerging as state-of-the-art technology for delivering selected micronutrients with maximum bioavailability, tolerability and safety."*
>
> *—Dr. B.S. Sekhon, Punjab Agricultural University*

FURTHER READING:

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