Trees Nutrition Series
(Summary Sheet)

WARNELL
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Cu COPPER

element symbol

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element number	**29**
element family type	**METAL**
normal form of pure element at biological temperatures	**SOLID METAL**
average rounded atomic weight	**64**
number of native isotopes	**2**
concentration group	**DEKA-ELEMENT**
element concentration in tree (ppm)	**20**
element proportion in tree (carbon & oxygen levels = 450,000)	**45**
element concentration rank in tree (carbon & oxygen rank = 1)	**15**
relative tree concentration (compared to element in Earth's crust)	**>**
different chemical oxidation states	**2**
most stable chemical oxidation state	**2**
oxidation states within a biologic compound	**+1/-2**
oxidation states as a biologic active center	**+1/-1**
total oxidation state range in biologics	**3**

among tree essential elements --

relative atomic radius	**MEDIUM**
relative ionic radius	**MEDIUM**
relative first ionization energy	**MEDIUM**
relative atomic density	**HIGH**

other element family members (*toxic) **Ag*, Au**

most commonly available tree form Cu^{+}, $\mathbf{Cu^{+2}}$
(form in bold dominant)

solubility of element's compounds --

Cu++ insoluble = O^{--}, S^{--}, OH^{-}, $CO3^{--}$

Cu++ soluble = NO_3^{-}, SO_4^{--}, $C_2H_3O_2^{-}$

Coder Element Interaction Matrix for Trees (CEIMT) Values

(+ = positive or synergistic; - = negative or antagonistic)

B	Ca	Cl	Co	Cu	Fe	K	Mg	Mn	Mo	N_a	N_n	Ni	P	S	Si	Zn
0	+-	0	0	X	-	-	O	+-	-	+-	+-	-	+-	-	0	-

Copper (Cu) is a soft, reddish-brown metal. Copper can exist in six isotope forms, two stable, and four short-lived. Copper was known to early people and was named form Latin for “Cyprus.” It is easily worked and used for wires, pipes, paints, pesticides, antiseptics, and coins. It is mixed to produce several different materials: brass is copper and zinc; bronze is copper and tin; and monel is copper and nickel.

Copper is one of the essential metals in trees. Copper can quickly become toxic at elevated concentrations. It is used in dozens of enzyme system. Copper is used in electron transport, cell membrane health, and in CO2 fixations. In tree leaves and secondary cortex, copper is concentrated in an electron transport material which feeds electrons to light harvesting center I (LHCI) called plastocyanin. Copper is also required for the final step in electron transport for respiration where (with Fe) oxygen is converted to water. The greatest use for copper in tree cells is part of an enzyme which decomposes damaging oxygen materials (oxygen free radicals). The tree uses copper for oxidizing many different materials.

Copper is almost always found in trees as an organically bound compound (phytochelatins) usually associated with sulfur. The two forms available in trees is cuprous (Cu+) which is colorless, and the more oxidized cupric (Cu++) which is brown to blue in color. The cupric form is only found in a organic compound form in a tree. In tree soil, copper is available below a pH <6.1. As pH increase (more basic), copper become progressively more unavailable. Soils with pH >7.5 tend to be copper deficient. As a general rule, copper solubility in soil decreases 99% for each increase in pH value.

Copper deficiency cause tree shoot and root damage and death, while stimulating release of dormant buds, generating a characteristic bushy or broomed look. Tree leaves may appear small and internodes short. Leaf blade edges may be rolled and distorted. Leaves will first present with an atypical blue-green color moving to yellow. Leaf blades can develop dead spots. Young periderm can show small areas with corky patches and small lesions, sometimes with gums and resins exuded (exanthema). Copper toxicity is first noticeable as stunted root growth, dead roots, and leaf yellowing. Copper deficiency mimics potassium (K) deficiency. Copper toxicity mimics iron deficiency chlorosis.

Copper has many interactions with other tree essential elements. As phosphorus and potassium is increased, less copper is available. This effect is most noticeable with increasing phosphorus levels. As copper concentrations increase, the less zinc and molybdenum are available to trees, but the more manganese availability. Copper sulphate ($CuSO_4$) alone or in a mixture with various lime products have been used for centuries as fungicides, algicides, and higher plants. Copper sulphate is soluble in water and cheap. Continued use of copper based fungicides can lead to iron (Fe) deficiencies.

Tree Symptom Summary

Copper performs two dominant roles in trees: 1) Part of several enzymes and metabolites; and, 2) Activator / modifier of several enzymes. Deficiency symptoms can quickly occur physiologically downstream from these points.

When deficient, copper has been cited as generating the following symptoms:

tree part	primary symptom	element deficiency responsible
roots	stunted / damaged	Cu also B, Cl, Mn, N, Ni, P, K, S, Si, Zn
	gum exuded (exanthema)	Cu also Zn
shoots	stunted / damaged / killed	Cu also B, Ca, Cl, Fe, Mn, Mo, N, Ni, P, K, S, Zn
	gum exuded (exanthema)	Cu also Zn
secondary meristems	periderm cracking / atypical patches / localized growths	Cu also B, Ni
buds	released buds / brooming	Cu also Ni
	distorted / death	Cu also B, Ca, Ni
young leaves	wilting	Cu also B, Cl, K, Mo, Zn
leaves	color -- dark viens	Cu also Mn, P, Zn
	color -- yellow-brown	Cu also Cl, K, N, P
	color – general chlorosis	Cu also B, Cl, Fe, K, Mg, Mo, Mn, Ni, S, Zn
	marginal chlorosis / death	Cu also B, Ca, Cl, K, Mg, Mo, Ni
	stunted / distorted blades	Cu also B, Cl, K, Mg, Mn, Mo, N, Ni, Zn

Copper is considered an immobile element (immobile rank #3) with deficiency symptoms developing first in new tissue, although some symptoms present through out the tree. At pH 7.5 to 10.0, copper is poorly available or unavailable to trees.

symptom tissue location & age	element mobility inside tree	causal elemental deficiency
new tissues dominant	immobile	Cu also B, Ca, Co, Fe, Mn, Ni, S, Zn
all tissues equally	mobile	Cu also Cl, K, Ni, N, P, Si, Zn

When toxic, copper has been cited as generating the following symptoms:

tree part	primary symptom	toxicity responsible
roots	stunting	Cu also Mg
leaves	color -- chlorosis	Cu also B, Ca, Cl, Co, Mn, Ni

Copper shares toxic and deficiency symptoms with many other essential elements. Proper identification of the cause for toxicity or deficiency symptoms must, at the least, involve tissue analysis for deficiencies and soil testing for toxicities.