Nutri-Facts

IPNI

Agronomic fact sheets on crop nutrients

Copper

NO. 10

AUSTRALIA AND NEW ZEALAND GRAINS EDITION

Copper (Cu) is a micronutrient required by plants in very small amounts for normal growth and reproduction to occur. Plants with an adequate supply of Cu are better equipped to deal with environmental stress and are more likely to reach yield and grain quality potential. Commonly applied Cu sources include fertilizer, animal manures, biosolids, and pesticides.

Copper in Plants

Copper is an essential nutrient for both plant and animal health. Its most important function in plants is its role in chlorophyll formation. It also helps to provide support to the plant by strengthening cell walls and increasing plant resistance to fungal infection by producing higher numbers of polymers and proteins. Normal Cu concentrations in plants range from 5 to 20 ppm.

Copper in Soils

Total Cu in soils commonly ranges between 2 to 400 mg Cu/kg of soil, however plant available Cu concentration dissolved in the soil solution is much lower. The availability of Cu in soils for plant uptake is affected by many factors, including:

- **Organic matter.** Crops growing on soils high in organic matter are commonly deficient in Cu despite the soil having a high total Cu concentration. Copper binds tightly to organic matter rendering it unavailable for plant uptake.
- **Texture.** Plants growing in sandy-textured soils are more likely to be deficient than those growing in soils with a higher clay content. Cu deficiency in Australia is seen most commonly in sandy soils that are low in organic matter such as the coastal soils of Western and Southern Australia[1]. Soils with a high clay content generally hold more Cu in its exchangeable form. Other soil components, such as oxides and carbonates, can further reduce Cu availability.
- **Soil pH.** Copper solubility decreases as pH increases to 7 and above. Higher pH increases the strength by which Cu is held by soil clays and organic matter, thus making it less available to crops.
- **Nutrient balance.** High concentrations of zinc (Zn), phosphorus (P), aluminium (Al), and iron (Fe) in soils can depress Cu absorption by roots and aggravate Cu deficiency. Risks of Cu deficiency can also increase when higher rates of nitrogen (N) are applied.

Copper Deficiency

Copper deficiency symptoms vary with crop type. Mild or moderate deficiency may reduce plant growth and yield making a specific diagnosis difficult. Copper is immobile in the plant, so symptoms appear first in younger growth.

Early symptoms of Cu deficiency in wheat, barley, and oats can sometimes be confused with those of frost or drought damage. Deficiency can be identified by a rolling or coiling of the new leaves with the tips of the leaves turning pale green to almost white. Head and grain formation is suppressed and if grain is produced it is shrivelled and small. Copper is particularly important for pollen biosynthesis and deficiencies result in empty heads in cereals. Although these empty head symptoms of Cu deficiency are similar to frost damage, there is no evidence that supplementary Cu will reduce frost damage.

In peas, the pods may appear to have developed normally, but the seeds will be small and shrivelled.

Varying soil types, alongside the fact that plant species differ greatly in their ability to take up Cu from the soil[2], makes soil testing for Cu difficult and unreliable unless calibrated specifically for each test. Tests have been found to be more reliable when soils sampled are as uniform as possible, especially in terms of texture and bulk density. Tests that detect total Cu may be useful to identify an extreme deficiency but otherwise are not very helpful as they do not give an indication of how much Cu is actually available to the plant.

Copper Toxicity Symptoms

Copper toxicities can occur after repeated applications of manures, biosolids, or pesticides that are high in Cu. Toxicity

IPNI International Plant Nutrition Institute

3500 PARKWAY LANE, SUITE 550
PEACHTREE CORNERS, GEORGIA 30092-2844 USA
PHONE (770) 447-0335 | WWW. IPNI.NET

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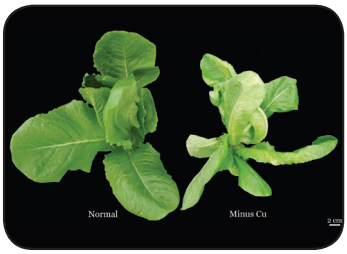
IPNI2010PPI05-2460

Healthy to severely Cu deficient wheat heads, showing signs of melanosis.

IPNI2010PPI06-1766

"Pig-tailing" of wheat leaves is a common copper deficiency symptom.



D. PITCHAY

Copper deficiency in lettuce compared with normal growth (left).

IPNI2010PPI05-2302

Copper deficiency in citrus.

in Australia has been reported in orchids after excessive chemical use and in mining areas[3,4]. Symptoms of toxicity include reduced shoot vigor, poorly developed root systems, discoloured roots, and leaf chlorosis (yellowing). They can be confused with symptoms of Fe deficiency. Crop species differ markedly in tolerance; for example, beans tolerate Cu toxicity much better than corn does.

Fertilizing Soils with Copper

Source. Copper sulfate is the most common Cu based fertilizer on the market, but there are many other materials available (**Table 1**). Copper fertilizer can be applied to the soil or to the leaves as a foliar spray. Additional sources of Cu include livestock and poultry manures, and municipal wastes or biosolids. Be cautious when applying animal manures as some contain elevated concentrations of Cu due to its addition to animal feed, or its use in foot baths to prevent foot rot.

Table 1. Common Cu sources[4].

Source	Formula	Cu, %
Copper sulfate pentahydrate	$CuSO_4 \cdot 5H_2O$	25
Copper chelate EDTA	Na_2Cu EDTA	13
Copper sulfate monohydrate	$CuSO_4 \cdot H_2O$	35
Copper acetate	$Cu(CHCOO) \cdot H_2O$	32
Copper ammonium phosphate	$CuNH_4PO_4 \cdot H_2O$	32
Cupric oxide	CuO	75
Cuprous oxide	Cu_2O	89

Rate. Where crop deficiencies have been identified, the right rate depends on the crop and specific Cu source being used. Copper fertilizers vary in their Cu content and solubility in soil, and crop types vary in their ability to extract soil Cu, but generally soil applications are in the range or 1 to 2 kg Cu/ha, while foliar applications are around 0.1 kg Cu/ha. There are variations in efficiency of uptake among foliar sources.

Time. The timing of Cu fertilizer application to the soil is flexible, but is generally applied pre-planting and a response may be visible for several years following a single application. Foliar applications are usually limited to emergency situations where the deficiency is identified after planting, or as part of a maintenance foliar fertilization program. Foliar applications in winter cereal crops should occur at stem elongation and again at boot stage. In pulses, they should be sprayed 3 to 5 weeks after emergence.

Place. Effectiveness of Cu delivery is increased by thoroughly mixing fertilizers into the root zone or by band application near the seed row. The risk of root injury increases when a high rate of Cu is band applied near the seed.

Crop Response to Copper

Crop species and cultivars vary considerably in their sensitivity to Cu deficiency and in their response to Cu application (**Table 2**). Crops that are routinely sprayed with Cu based fungicides are not expected to respond to Cu fertilizer application.

Table 2. Crop sensitivity to Cu deficiency.[1,5].

Most response	Medium response	Least response
Lucerne	Barley	Beans
Oat	Clover	Canola
Rice	Corn	Grass (forage)
Wheat	Sorghum	Lupine
		Pea
		Soybean

References

1. Price, G. (ed.). 2006. Australian Soil Fertility Manual, 3rd Ed.
2. Graham, R.D., and D.T. Pearce. 1979. Aust. J. Ag. Res. 30:791-800.
3. Merry, R.H., et al., 1986a. Plant and Soil 91:115-128.
4. Merry, R.H., et al., 1986b. Plant and Soil 95:255-269.
5. Havlin, J. et al. 2014. Soil Fertility and Fertilizers, 8th edition.
6. Marschner, R. 1995. Mineral Nutrition of Higher Plants, 2nd edition.