Copper: An Essential Plant Nutrient
Ag Facts
Michigan State University Extension Service
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Issued July 1981
4 pages

MSU Ag Facts — Extension Bulletin E-1519, July 1981, FILE 32.333

# COPPER:

## *An Essential Plant Micronutrient*

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Plants and animals do not grow normally with insufficient or excessive amounts of copper (Cu). Although Cu fertilizers sometimes increase crop yields and improve nutritional qualities of feed, they must be used with caution because of possible toxic effects.

## COPPER IN ANIMALS

Copper toxicity in Michigan animals has been diagnosed almost as frequently as Cu deficiency. Ruminants are very sensitive to deficiencies. Deficiency symptoms vary greatly with both age and species, but color of hair may give a clue. With deficiencies, hair color fades, especially the brown and black colors. Animals suffering from Cu deficiencies also have blood deficient in hemoglobin, even though Cu is not a part of the hemoglobin molecule. Copper deficiencies are also related to slow growth, bone deformities and poor reproduction.

It is difficult to set accurate limits of concentration in diets which prevent either deficiencies or toxicities, especially with cattle and sheep, because interactions with other elements are likely to be involved. For example, if Molybdenum (Mo) levels in feed are high, extra Cu is needed to prevent a deficiency.

Manipulating Cu levels in all feeds is discouraged unless under supervision of recognized authorities.

## COPPER IN PLANTS

The functions of Cu in plants have not been completely defined, but it is known that a deficiency interferes with protein synthesis, causing an accumulation of soluble nitrogen compounds. Generalized descriptions of visual deficiency symptoms are difficult, but copper deficiencies often cause plants to wilt and turn a yellowish color. Tips of leaves may be scorched in a manner similar to frost damage. Also, carrot roots, onion bulbs or wheat grain may be off-color due to poor pigmentation. Specific symptoms for numerous plant species are described in scientific literature.

An early symptom of Cu toxicity is retarded growth rate. When toxicity is acute, symptoms similar to iron (Fe) deficiencies develop.

Crops grown in Michigan can be grouped according to responses to Cu fertilizers (Table 1). Most crops are classed as medium or low responsive crops because, under most conditions, Michigan soils supply sufficient Cu even for the highest yields. Copper requirements vary with yield and crop grown. Plant uptake generally ranges between 0.01 and 0.10 lb Cu per acre.

Normal plants contain between 8 and 20 ppm Cu. The "sufficiency range" concept is useful in diagnosing both deficiencies and toxicity levels. Levels greatly outside of the ranges reported in Table 2 are good indications of problems. Interpretation of plant analysis is facilitated when specific plant parts are sampled at the suggested stage of development.

## COPPER IN SOIL

The total Cu content of soil is not a good indication of Cu supplying power. Levels vary greatly, ranging between 10 and 200 ppm, while levels of "available" Cu are usually less than 5 ppm when the Cu is extracted with 0.1 N hydrochloric acid (HC1).

Only the organic soils in Michigan which are low in ash are known to be Cu deficient. Copper toxicities are unknown in Michigan unless caused by the excessive use of Cu-containing fertilizers or a prolonged use of bordeaux mixtures.

Theoretically, deficiencies could develop in Michigan, especially on eroded acid, sandy soil that is intensively farmed and heavily fertilized. Average extractable (0.1 N HC1)

**Table 1. Relative responses of selected crops to copper.**

*Highly Responsive Crops*

| | |
|---|---|
| Alfalfa | Spinach |
| Lettuce | Sudan grass |
| Oat | Table beet |
| Onion | Wheat |

*Medium Responsive Crops*

| | | |
|---|---|---|
| Barley | Celery | Sorghum |
| Blueberry | Clover | Sugarbeet |
| Broccoli | Cucumber | Sweet Corn |
| Cabbage | Corn | Tomato |
| Carrot | Parsnip | Turnip |
| Cauliflower | Radish | |

*Low Responsive Crops*

| | | |
|---|---|---|
| Asparagus | Pea | Rye |
| Bean | Peppermint | Spearmint |
| Grass | Potato | Soybean |

**Table 2. Copper sufficiency range.***

| *Crop* | *Sample* | *Cu ppm* |
|---|---|---|
| Corn | Ear leaf at first silk | 6-20 |
| Soybean | Upper fully-developed leaf prior to first flower | 10-30 |
| Navy bean | Upper fully-developed leaf prior to first flower | 10-30 |
| Alfalfa | Top 6 inches sampled prior to first flower | 11-30 |
| Wheat | Upper leaves sampled prior to initial bloom | 6-50 |
| Sugarbeet | Center fully-developed leaf — midseason | 11-40 |
| Vegetables | Top fully-developed leaf — midseason | 8-20 |
| Potato | Petioles of most recently matured leaf — midseason | 7-30 |

**From MSU Ext. Bul. E-486*

Cu levels were determined in samples from the profiles of soil at 135 locations in southern Michigan. From the data in Table 3, it is evident that sandy soils contain much less Cu than the fine-textured soils. Also, there is a strong tendency for Cu levels to be higher in the naturally poorly-drained "c" soils than in the somewhat poorly- and well-drained "b" and "a" soils.

Extractable Cu levels vary with soil depth, as reported in Table 4. The plow layer contains significantly more Cu than the subsoil. Levels in the parent material are exceptionally low, averaging only 0.41 ppm.

## COPPER IN MANURE

Copper levels in livestock manure are relatively low, varying between 0.1 and 0.3 pounds per ton. This amounts to more than that removed by a crop so that, under average conditions, accumulation of Cu in the soil may be expected where high rates of manure are used. With the management practices used today, there is little need for concern about a build-up to toxic levels.

## COPPER IN WATER

Very little is known about Cu levels in irrigation water. A survey by the Michigan Department of Natural Resources showed great variability among streams within a year. Average levels ranged between 1 and 35 ppm; the amounts of Cu in an acre foot of water would be less than 0.11 pound or about equal to crop uptake.

## COPPER IN MUNICIPAL SLUDGES AND WASTEWATER

A summary of total Cu levels in 57 Michigan sludges indicated extreme variability, ranging between 84 and 10,400 ppm. This range is slightly narrower than that reported from other states.

While not all Cu in sludges is available to crops, the level in some is high enough for concern about toxicities, not only from Cu but from other heavy metals. Therefore extreme caution is advised when using municipal sludges in crop production.

Municipal wastewaters contain much less Cu than sludges but, with long-term use of wastewaters, heavy metals including Cu may accumulate and become toxic to soil organisms and field crops.

## COPPER CARRIERS

There are a number of materials that can be used to supply Cu. The most common sources are reported in Table 5.

In Michigan the most common materials used are the

**Table 3. Average extractable copper levels in southern Michigan soil as related to texture and natural drainage.***

| *Dominant Profile Texture* | *Soil Management Group Symbol* | *Natural Drainage* | | | *Mean* |
|---|---|---|---|---|---|
| | | *Well Drained* | *Somewhat Poorly Drained* | *Poorly Drained* | |
| | | *a* | *b* | *c* | |
| | | | *ppm*** | | |
| Clay & clay loam | 1 & 1.5 | 1.14 | 1.38 | 2.76 | 1.76 |
| Loan & sandy loam | 2.5 & 3 | 0.64 | 0.88 | 1.95 | 1.16 |
| Loamy sand & sand | 4 & 5 | 0.70 | 0.55 | 0.63 | 0.63 |
| | Mean | 0.83 | 0.94 | 1.78 | 1.18 |

**Data from MSU Agr. Exp. Sta. Res. Rpt. 384*

***Extracted from 0.2 N HC1*

**Table 4. Average extractable copper levels in southern Michigan soil as related to profile depth and natural drainage.***

| *Horizon* | *Symbol* | *Natural Drainage* | | | *Mean* |
|---|---|---|---|---|---|
| | | *Well Drained* | *Somewhat Poorly Drained* | *Poorly Drained* | |
| | | *a* | *b* | *c* | |
| | | | *ppm* ** | | |
| Plow layer | Ap | 1.09 | 1.03 | 3.06 | 1.73 |
| Subsoil | B | 1.07 | 1.51 | 1.64 | 1.41 |
| Parent Material | C | 0.32 | 0.27 | 0.64 | 0.41 |
| | Mean | 0.83 | 0.94 | 1.78 | 1.18 |

**Data from MSU Agr. Exp. Sta. Res. Rpt. 384*
***Extracted from 0.1 N HC1*

oxides and sulfates. Both have been effective in field tests. While there is only limited data with other materials, including the chelates, all are reported to be effective.

## RECOMMENDATIONS FOR FERTILIZER COPPER

Copper recommendations are now made in Michigan only for those crops in the highly responsive group (Table 1) which are grown on organic soils. Where soil tests are in the low range (Table 6) 6 pounds of copper are recommended as part of a banded fertilizer.

On virgin organic soils or where copper has never been used on organic soil, the recommended rate should be doubled.

Because Cu is easily fixed and is not easily leached, fertilizer Cu tends to accumulate in the soil. For this reason, no extra fertilizer Cu is needed on organic soil after a total of 20 pounds has been applied for low responsive crops, 40 pounds for highly responsive crops, or the soil test level exceeds 20 ppm Cu.

Where Cu deficiencies are suspected during the growing season, foliar sprays have been successful. One-half to one pound of Cu per acre as basic copper sulfate (copper sulfate monohydrate) ($CuSo_4 \cdot H_2O$) or copper oxide (CuO) in 30 gallons of water has been successful.

## SUMMARY

Copper is an essential element for both plants and animals but is required in very small amounts. Excessive levels are easily obtained unless great care is used in supplying supplemental Cu.

In plants, Cu deficiencies are not expected in Michigan except on organic soils. Some crops are responsive to fertilizer Cu when grown on such soil. Best results have been obtained when Cu was banded.

**Table 5. Carriers of copper.***

| *Carrier* | *Formula* | *Percent copper* |
|---|---|---|
| Basic copper sulfate | $CuSo_4 \cdot H_2O$ | 13-53 |
| Copper (ic) ammonium phosphate | $Cu(NH_4)PO_4 \cdot H_2O$ | 32 |
| Copper Chelate | $Na_2CuEDTA$ | 13 |
| Copper Chelate | NaCuHEDTA | 9 |
| Copper Chloride | $CuC1_2$ | 16.9 |
| Copper Frit | Frit | 40-50 |
| Reax Copper | CuMPP | 5-6 |
| THIS Copper | CuMPP | 5 |
| Copper Silviplex | CuMPPP | 6 |
| Copper Sulfate monohydrate | $CuSO_4.H_2O$ | 35 |
| Copper Sulfate pentahydrate | $CuSO_4.5H_2O$ | 25 |
| Cupric Oxide | CuO | 75 |
| Cuprous Oxide | $Cu_2O$ | 89 |
| Rayplex Cu | CuPF | 5-6.7 |

**From the Fertilizer Handbook — The Fertilizer Institute*

**Table 6. Copper recommendations for band application on organic soils.***

| *Soil Test ppm Cu* | *1.0 N HC1 Extraction** Plant Response* | *Recommendation lbs/A* |
|---|---|---|
| Below 9 | Probable | 6 |
| 10-20 | Possible | 3 |
| 21-160 | None | 0 |
| Above 160 | Excessive (harmful) | 0 |

**From MSU Ext. Bul. E-486*
***Note that extraction strength is different than reported in Tables 4 and 5 on mineral soil.*

Livestock manure and irrigation water contain limited amounts of Cu, while some municipal sludges and wastewater effluents contain enough to be phytotoxic to plants after extended use.

Cu supplements should not be used unless deficiencies have been diagnosed.

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Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

 *1P-5M-7:81-UP-LW, Price 15 cents. Single copy free to Michigan residents.*

O-12990 *Michigan State University Printing*