



University of Idaho
College of Agriculture

Cooperative Extension Service
Agricultural Experiment Station

SUBJECT FILE:
PLANT NUTRITION

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Essential Plant and Animal Micronutrients

Copper in Idaho

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Copper (Cu) — like boron (B), chlorine (Cl), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) — is a micronutrient necessary for plant growth. Copper is called a micronutrient because plants require it in lesser amounts than nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca) and magnesium (Mg).

Copper has several roles in plant growth. Plants require a constant and continuous supply of copper and take it up in the Cu^{++} ion form. Copper levels in most Idaho soils are sufficient for plant growth. However, low soil copper levels have been found in some of the high organic matter (soils more than 15% organic matter) in northern Idaho (Fig. 1). In contrast, copper deficiencies in crops growing on the Snake River plain of southern Idaho have never been observed.

Crop Response

Small grains, pasture grasses and legumes have shown an occasional response to copper applications when the soil contains more than 15 percent organic matter. In Idaho, crop responses to copper have been limited to bottom land soils in Bonner and Kootenai counties.

Identification of copper deficiencies in plants growing in the field is extremely difficult. In general, the deficiency will first appear on the young leaf tissue. The leaves may turn pale yellow or be spotted; however, they often wilt and wither without showing symptoms.

Copper Fertilization

Optimum application rates of copper vary and depend on the amount of organic matter in the soil, the crop to be grown and the application method. In general, wheat requires higher copper application rates than grasses or legumes.

Several copper fertilizer materials are commercially available (Table 1). Copper sulfate is the most common copper fertilizer material used in the western United States. The copper materials can be applied directly to the soil or used as a foliar spray.

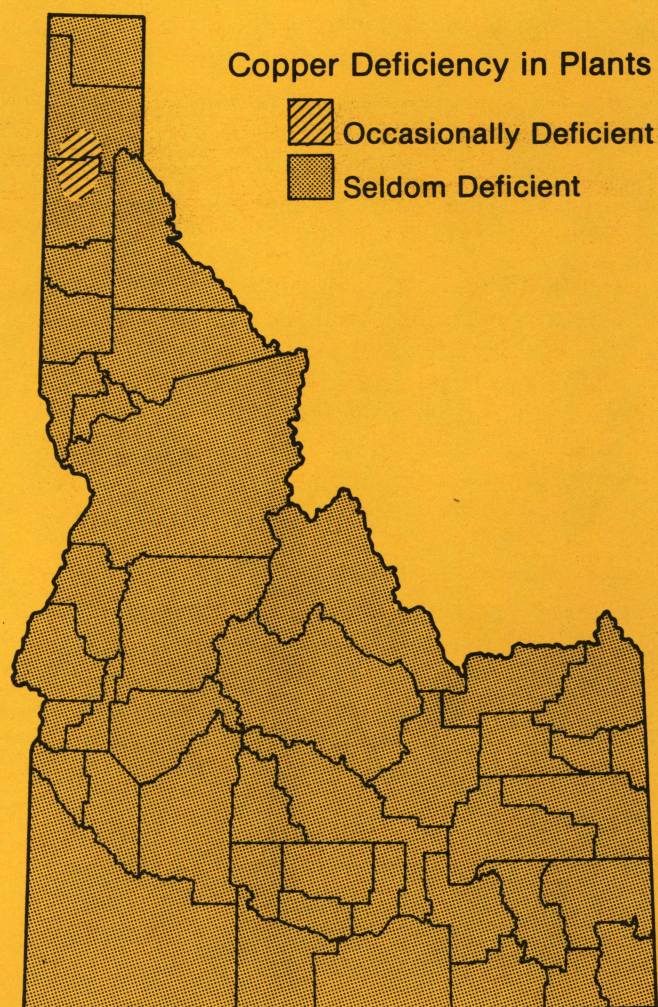


Fig. 1. Areas in Idaho where soils are either occasionally or seldom deficient in copper for plant growth.

Table 1. Common copper fertilizers available for use on Idaho crops.

Copper materials	Chemical formula	% Copper (Cu)	Rates of Cu per acre			
			3 lb	5 lb	8 lb	10 lb
			Amount of material to apply (lb/acre)			
Copper sulfate (pentahydrate)	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	25	12	20	32	40
Copper sulfate (monohydrate)	$\text{CuSO}_4 \cdot \text{H}_2\text{O}$	35	8.6	14.3	23	28.6
Cupric oxide	CuO	75	4	6.7	10.7	13.4
Chalcopyrite	CuFeS_2	35	8.6	14.3	23	28.6
Copper chelates	Na_2CuEDTA	13	23	38.5	62	77
	NaCuHEDTA	9	33	56	89	111

Soil Application. Differences in the soil's organic matter content, the crop to be grown and copper fertilizer source give differing recommended application rates. In general, application rates of 3 to 5 pounds copper per acre are recommended in copper deficient soils. Rates should be increased 25 percent if the soil organic matter content is more than 25 percent. Application rates of copper should also be increased 15 percent if a cereal such as wheat is grown. When applying an organic source of copper (chelate) to the soil, decrease the recommended rate 50 percent. The major problem with applying copper directly to the soil is the difficulty of spreading small amounts of material evenly over a field.

Foliar Applications. Common foliar spray rates range from 0.3 to 0.6 pounds copper per acre. Foliar spraying of such a small quantity of material, particularly in dryland areas, is expensive and difficult because of the small amount of material applied.

Residual Effects. Recommended soil applications of 5 pounds of copper should last for at least 5 years. Little residual effects of copper in the soil remain from foliar applications. The low rates used account for this coupled with the fact that most of the applied copper is intercepted by the growing plant and does not reach the soil, especially if most of the crop is removed at harvest.

Copper Nutrition for Livestock

Copper is classified as a trace mineral since it is required in the diet in relatively minute amounts. It is distributed within the body tissues as a minor element. Its importance as a dietary essential in nutrition was recognized in the 1930s when certain livestock diseases were shown to be prevented or cured by administering copper. With copper deficiency reported at such a diversity of locations throughout the world, it soon became apparent that forages and grains were not always deficient in copper, but symptoms of copper deficiency were observed in livestock consuming these feeds.

Then it was learned that abnormally high molybdenum levels in pasture forages can result in reduced copper absorption and tissue depletion of copper stores in cattle. This interrelationship between cop-

per and molybdenum, and certain other minerals in the diet, has led to recognition of the importance that the metabolism of copper has on the total diet.

Copper Metabolism in Animals

In general, copper is poorly absorbed by the digestive tract in animals. However, its absorption is influenced by:

1. Age and species of animal.
2. The amount and chemical form of copper ingested.
3. The level of certain minerals such as molybdenum and sulfur in the diet.
4. Prior copper status of the animal.
5. Certain other dietary factors.

The liver is the main storage organ for copper and a key organ in the metabolism of this element. In normal adults, the livers of most nonruminant animals contain 10 to 50 ppm copper (dry weight basis), while the ruminant species of cattle and sheep have a normal range of 100 to 400 ppm. Copper analysis of liver tissue best reflects the copper status of the animal, but blood is usually a more convenient tissue to collect than liver. Normal range of blood copper for most healthy animals is between 0.5 to 1.5 mg/ml. However, ruminant animals may reflect a deficiency state below 0.6 or 0.7 mg/ml of whole blood or plasma.

The functions of copper in the body are associated primarily with connective tissue maturation through a copper-dependent enzyme (lysyl oxidase). This enzyme is found almost exclusively in connective tissue. Lysyl oxidase and other copper containing enzymes are responsible for several essential functions in the body.

Copper is involved in the production of heme for the hemoglobin molecule of red blood cells, formation of elastin and collagen fibers for bone growth and the vascular integrity in major arteries of growing animals. It also is involved in the synthesis of black pigments in hair and wool and others in processes. When copper is deficient in the diet, it can result in a wide range of clinical symptoms depending upon the age and species of the animal.

General Deficiency Symptoms in Animals

Dietary copper deficiency results in anemia by reduced synthesis of hemoglobin and a shortened red blood cell lifespan. In many species, there can be a loss of black pigment in hair or wool, thus resulting in a whitening effect. Sheep deficient in copper fail to impart a crimp in the wool fibers which results in an almost straight, hair-like fiber called "steely" wool.

Spontaneous fractures of bones are quite common in cattle and sheep grazing copper deficient pasture. Uncoordination of movement (ataxia) can occur as a common acute form in the newborn or be delayed for several weeks or months before clinical symptoms. Cardiac and vascular disorders can cause sudden death in deficient animals because of the rupture of major blood vessels or replacement of heart muscle tissue with fibrous tissue resulting in "falling disease." Infertility can be caused by delayed or depressed estrus (cattle) or by development of anemia and hemorrhages in a fetus or embryo resulting in its mortality.

Copper Status of Idaho Livestock

In Idaho, copper has been identified as a trace mineral that was deficient in the diet of cattle and sheep in several geographical areas. Data from a nutritional survey of cattle herds in Idaho's northern panhandle area showed that nine out of 13 herds were classified as copper deficient with blood levels as low as .14 ppm copper. Other areas identified as being copper deficient are the Boise-Weiser and Salmon-Challis areas. Unfortunately, information is insufficient from other regions of the state to determine the copper status of herds or flocks.

Livestock production on livestock units suffering from copper deficiencies reported a variety of problems. In the younger animals, chronic diarrhea and/or poor growth rates were noted. An example of an effect of this deficiency on growth rate was a study with bull calves. After adjusting to the stress of weaning, calves gained 1.24 pounds per day during the initial 56 days of the trail. Each calf was injected with a copper product and fed 125 mg of copper sulfate per day while the other ration components remained constant. During the next 56 days, these calves gained 3.35 pounds per day.

Infertility problems in the breeding herd can be a result of a copper deficiency. Another problem can be a loss of animal condition.

Recommendations

Swine. The minimum requirement for copper in swine rations would be a 4 ppm for growing-finishing pigs. Breeding sows should be at 5 ppm copper. Research reports from both England and the U.S. have indicated a growth promotion effect of copper in pigs at high levels (100 to 250 ppm). Copper currently is not approved by the Food and Drug Administration (FDA) as a "feed additive" for swine. A petition has been officially prepared and presented, but action on that petition is still pending.

Cattle and Sheep. Ruminant species have a higher requirement for copper than other domestic livestock. Other dietary factors have a major influence on copper utilization. If molybdenum content of the diet is less than 1 ppm of the dry matter, then 6 to 8 ppm copper should be adequate. However, 8 ppm copper is inadequate when molybdenum is between 1 and 3 ppm of the diet.

Molybdenum can be concentrated as high as 20 ppm in "teart" pastures. This results in severe diarrhea in these grazing animals.

Several injectable products are commercially available on the market. Unfortunately, most of these products cause moderate to severe tissue reaction at the injection site. A new product, from Sierra Veterinary Laboratories, Inc. — copper disodium edetate — appears to have little or no tissue reaction. However, this product has not been approved by FDA except on an experimental basis.

Injectable products provide adequate copper for up to 6 months. Mineralized salt, containing copper, may not provide adequate copper when severe deficiency conditions exist. Cattle and sheep should be fed a supplement that provides up to 125 mg copper sulfate per day for mature cattle or up to 25 mg per day copper sulfate for mature sheep.

Cautionary Note. Copper is a toxic mineral. Care must be used to prevent excess doses, especially in sheep.

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