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Balchem® Plant Nutrition Research Paper

Copper Nutrition and Metalosate® Copper

by Jeremy O'Brien

Copper in the Soil

Copper occurs in the soil almost exclusively in the divalent form. The largest fraction of copper is usually present in the crystal lattices of primary and secondary minerals. In addition, copper occurs in organic compounds, is present as an exchangeable cation on soil colloids, and is a constituent of the soil solution. The copper concentration of the soil solution is usually very low, and it has been observed that more than 98% of soil solution copper is complexed with organic matter. Copper is, in fact, more strongly bound to organic matter than are other micronutrient cations and copper complexes play an important role in regulating copper mobility and availability in the soil.[1]

Figure 1. Summer Dieback in Stone Fruit. Photo Courtesy of Kiyoto Uriu Reproduced by Permission from Nutrient Deficiencies and Toxicities of Plants Image CD-Rom, 2000, American Phytopathological Society, St. Paul, MN.

Since copper is strongly bound to soils, it is very immobile in the soil. The result is that copper added to the soil as a result of the use of copper containing fertilizers is thus largely restricted to the upper soil horizons.

Copper Utilization by Plants

The general requirement for copper by plants is relatively small, in the range of 2-20 ppm, in the dry plant material. Copper uptake is a metabolically mediated process, and evidence shows that copper strongly inhibits the uptake of zinc and vice versa. Copper is not readily mobile in the plant although it can be translocated from older to younger leaves. Relatively high concentrations of copper occur in chloroplasts. About 70% of the total copper in the leaf is bound in these organelles. Evidence suggests that copper may play a part in the synthesis or the stability of chlorophyll and other plant pigments although the mechanism is not clear. Copper appears to participate both in protein and carbohydrate metabolism.[2]

Copper Deficiencies

Plants differ in their sensitivity to copper deficiency. Generally, the most responsive plants to copper fertilizers are oats, spinach, and wheat. Stunted growth, distortion of young leaves, necrosis of the apical meristem, bleaching of young leaves, and "summer dieback" in trees are typical visible symptoms of copper deficiency.

Figure 2. Leaf Tips of Wheat Discolored and Distorted From Copper (Cu) Deficiency. Photo [Annotation Removed] Courtesy of R. Mahler Reproduced by Permission from Nutrient Deficiencies and Toxicities of Plants Image CD-Rom, 2000, American Phytopathological Society, St. Paul, MN.

An increase in the number of auxiliary shoots in dicotyledons are secondary symptoms caused by necrosis of the apical meristem. Summer dieback has been described as the dying off of twigs and growing points on the terminal shoots of trees.

Copper deficiency affects grain, seed, and fruit formation much more than vegetative growth. The main reason for the decrease in the formation of generative organs is the nonviability of the pollen from copper-deficient plants. When the copper supply is adequate, the anthers containing pollen and the ovaries have the highest copper content in the flowers and obviously the highest copper demand.

Impaired lignification of cell walls is the most typical anatomical change induced by copper deficiency in higher plants. This gives rise to the characteristic distortion of young leaves, bending and twisting of stems and twigs and an increase in the lodging susceptibility of cereals, particularly with a high nitrogen supply.[3]

Nitrogen application accentuates copper deficiency; and when nitrogen supply is high, the application of copper fertilizers is required for maximum yield. Nitrogen also has specific effects on copper availability and mobility including a decrease in the rate of retranslocation of copper from old leaves to areas of new growth.[4]

Correcting Copper Deficiencies with Metalosate® Copper

As previously stated, plants require very low concentrations of copper in their tissue to function properly. As a result, copper deficiencies are relatively easy to correct with applications of Metalosate Copper.

The research data that Albion has collected over the years indicates that in most situations Metalosate Copper is applied in combination with other Metalosate products. One example of such a case was a field trial that Albion performed in Eastern Washington on yellow storage onions. It is very common for onions to suffer from copper deficiency. This is demonstrated in Figure 3.

In this field trial one application of Metalosate products was applied by air. A tissue sample was collected from the field at the four-leaf stage. The sample was analyzed by Albion's plant and soil laboratory and then a T.E.A.M.® report was generated. It recommended that the following be applied: Metalosate Calcium 48 oz./acre (3.5 L/Ha), Metalosate Copper 8 oz./acre (0.58 L/Ha), and Metalosate Magnesium 24 oz./acre (1.75 L/Ha).

At harvest onions were collected from eight randomly selected spots in the field (four in the treated area and four in the untreated area). The onions were then sized and graded and the yield per acre was calculated based on the size of the treatment replications.

Figure 3. Copper-deficient Onion Bulbs with Thin, Pale Yellow Outer Scales (Right).
Photo Courtesy of D. D. Warncke Reproduced by Permission from Nutrient Deficiencies and Toxicities of Plants Image CD-Rom, 2000, American Phytopathological Society, St. Paul, MN.

The treated onions showed an increase in the total number of colossal- and jumbo-sized onions and a reduction in the number of medium onions. The application did not cause an overall production of significantly more onions per acre, but it did produce significantly more onions in the larger-size classifications per acre.

The following information is based on the totals taken from four repetitions within each treatment. The difference in total weight between the two treatments is statistically significant. A two-sample t test performed on the data shows p value of <0.05. This demonstrates a less than 5% chance that the difference was due to natural variation in the field. Essentially, it is telling us that the difference was a result of the treatments applied.

Metalosate Copper played a key role in achieving the significant increase in onions that sell for a premium. It is essential to consider all of the nutrients required by plants when making fertility recommendations. Copper is one nutrient that is often overlooked because plants require it in such small quantities; however, it is just as important to the overall production and nutrient balance in the crop as any of the other nutrients.

For more information on Metalosate Copper or any of the Metalosate products please contact your local Albion Plant Nutrition representative.

Table 1. Results of Metalosate® Copper Study on Onions Showing Significant Increase in Onions that Sell for a Premium

Treatment	Colossal			Jumbo			Medium			Prepaks			Total Weight [a]	Yield
	#	Wt[a]	%[b]	#	Wt[a]	%[b]	#	Wt[a]	%[b]	#	Wt[a]	%[b]		
Grower's Standard Practice	5	6.9 (3.1)	2.4	119	90.3 (41.0)	58.0	72	25.8 (11.7)	35.1	9	1.6 (0.7)	4.4	124.6 (56.5)	37.0 (82.9)
Albion® Metalosate® Program	17	23.6 (10.7)	7.8	133	103.9 (47.1)	61.3	56	21.4 (9.7)	25.8	11	1.9 (0.9)	5.1	150.8 (68.4)	44.8 (100.4)

a – Weight in pounds (kilograms)
b - % of total yield
c – Tons/acre (metric tons/hectare) calculated based on area harvested from plots

References

1. Mengel, K., & Kirkby, E.A. (2001) Principles of Plant Nutrition (5th ed.) (p. 463). Dordrecht: Kluwer Academic Publishers.
2. Mengel, K., & Kirkby, E.A. (2001) Principles of Plant Nutrition (5th ed.) (p. 467). Dordrecht: Kluwer Academic Publishers.
3. Marschner, H. (2002) Mineral Nutrition of Higher Plants (2nd ed.) (p. 343). San Diego, CA: Academic Press.
4. Marschner, H. (2002) Mineral Nutrition of Higher Plants (2nd ed.) (p. 340, 341). San Diego, CA: Academic Press.