Plant Micronutrients: Boron (B), Chloride (CI), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), and Zinc (Zn)

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This article (Part 4) discusses micronutrients and the use of soil tests to evaluate their levels in orchard soils. Micronutrients are essential to almonds and other nut crops, yet are required in much smaller amounts than macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) or secondary nutrients such as calcium (Ca), magnesium (Mg), or sulfur (S). The eight micronutrients are boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). They fulfill important roles in the plant. For instance, zinc is needed for plant cell expansion and it influences pollen development, flower bud differentiation, and fruit set while boron is a building block for the plant cell wall and strongly influences pollen tube germination and growth. Flower abortion in almond and walnut has occasionally been associated with boron deficiency. Nickel has recently been determined to be an essential nutrient and there are no known deficiencies in California.

Zinc, iron and manganese deficiencies are not as commonly found in the Sacramento Valley as in the San Joaquin Valley. Zinc deficiency is most common in almond and other nut crops. Other micronutrient deficiencies that are occasionally seen in almond include B, Fe, and Mn. Copper (Cu), Mo, and Ni deficiencies have not been documented in almonds; however, Cu deficiency is common in pistachios.

Five of the micronutrients (Cu, Fe, Mn, Ni, and Zn) largely exist in the soil as positively charged metal cations bound as minerals or adsorbed to the surfaces of colloids or soil particles. Several factors in orchard soils may affect the solubility and availability of these metal cations to trees. Soil pH greater than 7.5 has the major influence of reducing the tree availability of Zn, Fe, and Mn in the soil and to a slightly lesser extent Cu. Generally, organic matter increases the availability of the metal cations to plants. Dissolved organic substances bind with these metal cations to form chelates which are a soluble metal-organic complex that renders them more available for plant uptake. Organic matter with a high carbon to nitrogen ratio or high carbon to phosphorus ratio may temporarily immobilize these metal cations until the carbon decomposes. Soil pH above 7.5 and low soil moisture conditions will increase metal precipitation, reduce solubility, and nutrient availability to trees. Metal micronutrients tend to be concentrated in the upper soil horizons and are not easily leached. However, loss of soil by erosion or land leveling will result in a loss of these metal micronutrients. Acidic, sandy soils where leaching with low salt irrigation water occurs may exhibit Zn as well as B deficiencies.

The micronutrients Cl and Mo generally exist in soil as negatively charged anions. Boron generally exists in soils as a non-charged acid in acidic soils and as an anion in alkaline soils. Chlorine and B have a much higher likelihood of leaching than do the positively charged metal micronutrients. Leaching is more likely to occur in sandy soils, particularly with rainfall or low salt irrigation water. Molybdenum (Mo) exists in minerals and is strongly adsorbed to soils so it does not leach as readily as Cl and B. Molybdenum is different from most of the micronutrient cations in that it increases in plant availability as the soil pH increases.

The metal micronutrients are extracted from a soil sample with DTPA (diethylenetriaminepetaacetic acid), a chelate designed to extract the most readily available forms of the positively charged metals. Concentrations of DTPA extractable Zinc (Zn) in soils have the strongest relationship with plant growth responses when zinc fertilizers are applied to soils. Boron deficiency is more likely assessed in a soil sample using a hot water extract method while the toxicity of B is assessed in the soil-water extract from a saturated soil paste. The saturated paste soil-water extract is part of a salinity evaluation to assess risk of boron toxicity in trees and will be the subject of a future newsletter article. Since the toxicity of Cl is more likely than the deficiency, it is usually measured in the saturated paste soil-water extract too. There is no reliable soil test for Mo and because Ni deficiencies have not been observed, it is rarely tested.

Table 2 outlines low, medium, and high soil fertility levels for B, Cu, Fe, Mn, and Zn where the crop is not expected to respond, possibly respond, or be highly responsive to micronutrient additions. The micronutrients have different ranges in fertility levels and anticipated responses.

Table 2. Guidelines for interpreting micronutrient levels measured with soil fertility tests on samples taken in the top 6 inches of soil*.

Level of Expected Crop Response	Boron (B) (Hot Water Extract)	Copper (Cu) (DTPA Extract)	Iron (Fe) (DTPA Extract)	Manganese (Mn) (DTPA Extract)	Zinc (Zn) (DTPA Extract)
	Soil test level (ppm)				
Highly Responsive	0.0-0.5	0.0-0.8	0.0-5.0	0.0-2.0	0.0-0.7
Probably Responsive	0.5-1.2	0.8-1.2	5.0-15.0	2.0-10.0	0.7-1.5
Not Responsive	> 1.2	>1.2	>15.0	>10.0	>1.5

*Western Fertilizer Handbook, 9th Ed., 2002.

Micronutrient soil tests provide added perspective about the fertility levels of soils and the possibility of a deficiency. They are used effectively in some annual crops to guide management decisions. Almonds and other nut crops are perennials that can store and translocate nutrients and the root systems tend to be more extensive and make acquiring representative soil samples challenging. If a micronutrient deficiency is in question, comparative soil samples from good and poor areas can give added confidence in diagnosing the problem with soil testing. Plant leaf tissue testing and visual plant symptoms are important tools to confirm soil test results and diagnose micronutrient deficiencies. If a deficiency is identified, foliar versus soil applications of micronutrient fertilizers needs to be considered. Foliar applications of micronutrients may be more economical and efficient for managing deficiencies. Since soil pH, particularly when above 7.5 has such a major role in determining the availability of the micronutrients Zn, Fe and Mn and to a lesser extent Cu, banded acidification of soils with materials such as sulfuric acid and elemental sulfur may be a desirable long term solutions in some orchards. Conversely, liming acidic soils with pH below 5.5 may be viable if leaf tissue and soil sample analysis confirm a problem with micronutrients.