Manganese Deficiency in Pecan

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Abstract. A low leaf Mn concentration was detected in bearing pecan (Carya illinoinensis Wangenh. C. Koch) trees growing in an alluvial soil with an alkaline pH. Trees lacked vigor and leaves were pale in color, but there was no discernible leaf chlorosis or necrosis. Three foliar applications of MnSO4 beginning at budbreak, then twice more at 3-week intervals at rates of 0 to 3.3 kg·ha–1 of Mn increased leaf Mn concentration curvilinearly, and alleviated leaf symptoms. Results indicated that three foliar applications of MnSO4 at 2.15 kg·ha–1 of Mn plus a surfactant were adequate to correct the deficiency.

Manganese deficiency has not been documented in pecan, although shortages have been reported in other tree crops (Asher et al., 1984; Rogers, 1973, 1975; Rogers et al., 1974; Swietlik and LaDuke, 1991). Sparks (1978) induced a Mn shortage in container-grown pecan seedlings by withholding Mn from a complete nutrient solution used for fertilization. Dry weight of Mn-deficient trees was 15% less than that of the control 19 weeks after seedling emergence, but visual deficiency symptoms were not apparent. Leaf Mn was 71 µg·g–1 in Mn-deficient trees and 138 µg·g–1 with Mn added, indicating that the critical value to prevent growth suppression was between these two concentrations, but the critical value for visual symptoms was lower.

Manganese deficiency is more likely in calcaeous than acidic soils since Mn2+ in the soil solution decreases 100-fold for each unit increase in pH (Lindsay, 1972). Pyrolusite (MnO2) is the predominant Mn precipitate that controls Mn2+ in the soil solution in well-aerated, high-pH soils, but solution Mn2+ is also affected by other soil Mn compounds (Ellis and Knezek, 1972; Foth and Ellis, 1997). Up to 90% of the Mn in soil solution is complexed with organic matter. Organic matter is an important component of Mn availability, but if high Fe concentrations are present, Fe replaces Mn in the complex, thus causing greater Mn precipitation and low Mn availability.

Materials and Methods

We were contacted concerning an orchard located near Denison, Texas, that was in poor health. Trees were ≈30 years old, growing on a Elbon clay loam (fine, smectitic, thermic Fluventic Hapludolls). The Elbon series consists of deep, moderately well-drained, moderately slow permeable soils located on flood plains. Their reaction is mildly to moderately alkaline and calcareous. A soil test indicated that the 0- to 15- and the 15- to 30-cm layers of soil were 7.2 pH. Trees were not irrigated, and rainfall averages 1080 mm annually. The orchard was generally well managed for pests and fertilized annually with soil-applied N and foliar-applied Zn. When the trees were initially established, the orchard floor was planted to annual forages that were harvested for hay. Later, cool-season annual forages were planted in the fall, grazed with cattle, then harvested for hay, with subsequent grazing during the summer. Tree inspection indicated that shoot growth was short, with pale green foliage. There was no discernible pattern in leaf chlorosis or necrosis, other than a general pale color. The trees were bearing a large fruit crop in 1999, but not as much as in previous years. There was no discernible pattern in leaf chlorosis or necrosis.

Results and Discussion

Leaf Mn concentrations of the control were low, ranging from 1 to 18 µg·g–1. Occasionally, high Fe concentrations can induce Mn deficiency (Rogers, 1973, 1975; Rogers et al., 1974). However, leaf Fe was only 45 µg·g–1, indicating Fe was slightly low. There was a positive curvilinear increase in leaf Mn associated with the Mn foliar applications (Fig. 1), and a dramatic improvement in foliage color. No phytotoxicity symptoms were associated with any treatment. Leaf concen-

Fig. 1. The relationship between the foliar Mn application rate (x) and leaf Mn concentration (y): y = 11 + 55.768x – 6.353 * x2, r2 = 0.82, P = 0.0001.
trations of other elements were not affected by treatment. All elements, except K and Fe, were within normal sufficiency ranges (Smith, 1990). Potassium averaged 0.47%, indicating a rather severe shortage that may require several years of annual K application to correct (Smith et al., 1985).

These results document the first reported Mn deficiency under field conditions on pecan. Removal of forage and repeated soil tillage probably contributed to the shortage by depleting nutrients and soil organic matter. Foliar application of MnSO₄ (32% Mn) at 2.15 kg ha⁻¹ of Mn plus a surfactant corrected the shortage. Zinc foliar applications are common over much of the pecan belt to prevent Zn shortage, and these results indicate that ZnSO₄ (36% Zn) at 2.4 kg ha⁻¹ of Zn tank-mixed with the Mn prevented Zn shortage (leaf Zn 141 µg g⁻¹) with no detrimental effects.

**Literature Cited**

Asher, C.J., G.S. Smith, C.J. Clark, and N.S. Brown. 1984. Manganese deficiency of kiwifruit (Actinidia chinensis Planch.). J. Plant Nutr. 7:1497–1509.

Ellis, B.G. and B.D. Knezek. 1972. Adsorption reactions of micronutrients in soils, p. 59–78. In. J.J. Mortvedt, P.M. Giordano, and W.L. Lindsay (eds.). Micronutrients in agriculture. Soil Sci. Soc. Amer., Madison, Wis.

Foth, H.D. and B.G. Ellis. 1997. Soil fertility, 2nd ed. Lewis Publ., New York.

Horowitz, W. 1980. Official methods of analysis of the association of analytical chemists. 13th ed. Assn. Offic. Anal. Chemists, Washington, D.C. p. 15, section 2058.

Lindsay, W.L. 1972. Inorganic phase equilibria of micronutrients in soils, p. 41–58. In. J.J. Mortvedt, P.M. Giordano, and W.L. Lindsay (eds.). Micronutrients in agriculture. Soil Sci. Soc. Amer., Madison, Wis.

Olsen, S.R. and L.E. Sommers. 1982. Phosphorus, p. 404–430. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis. Part 2. Chemical and microbiological properties. Amer. Soc. Agron. and Soil Sci. Soc. Amer., Madison, Wis.

Rogers, E. 1973. Iron induced manganese deficiency in ‘July Elberta’ peach trees with manganese chelate. J. Amer. Soc. Hort. Sci. 98:19–22.

Rogers, E. 1975. An attempt to overcome iron-induced manganese deficiency in ‘July Elberta’ peach trees with manganese chelate. J. Amer. Soc. Hort. Sci. 100:531–535.

Rogers, E., G. Johnson, and D. Johnson. 1974. Iron-induced manganese deficiency in ‘Sungold’ peach and its effects on fruit composition and quality. J. Amer. Soc. Hort. Sci. 99:242–244.

Smith, M.W. 1990. Pecan nutrition, p. 152–158. In: B.W. Wood and J.A. Payne (eds.). Pecan husbandry: Challenges and opportunities. First Natl. Pecan Wkshp. Proc. U.S. Dept. Agr., Agr. Res. Serv., ARS-96.

Smith, M.W., P.L. Ager, and D.S.W. Endicott. 1985. Effect of nitrogen and potassium on yield, growth, and leaf elemental concentration of pecan. J. Amer. Soc. Hort. Sci. 110:446–450.

Sparks, D. 1978. Nutrient concentrations of pecan leaves associated with deficiency symptoms and normal growth. HortScience 13:256–257.

Swietlik, D. and J.V. LaDuke. 1991. Productivity, growth and leaf mineral composition of orange and grapefruit trees foliar-sprayed with zinc and manganese. J. Plant Nutr. 14:129–142.

Wetzstein, H.Y. and D. Sparks. 1983. The morphology of pistillate flower differentiation in pecan. J. Amer. Soc. Hort. Sci. 108:997–1003.