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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 $MnSO_4$ 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 $MnSO_4$ 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 calcareous than acidic soils since Mn^{2+} in the soil solution decreases 100-fold for each unit increase in pH (Lindsay, 1972). Pyrolusite (MnO_2) is the predominant Mn precipitate that controls Mn^{2+} in the soil solution in well-aerated, high-pH soils, but solution Mn^{2+} 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 when inspected in 1999, but not as much as other orchards in the vicinity. Leaf and soil samples collected from the site suggested two problems related to nutrition. Leaf analysis showed that K was low (0.6 %), although soil K was 559 kg·ha^{-1}, but symptoms were atypical of K deficiency. Leaf samples showed acute Mn deficiency (7 µg·g^{-1}) combined with low soil Mn (1.7 µg·g^{-1}). This is the first report of Mn shortage in pecan, and information concerning correction that was directly related to pecan was unavailable. Therefore, we established a study to evaluate foliar application of $MnSO_4$ (32% Mn; Tetra Micronutrients, Woodlands, Texas) on pecan.

Treatments were 0, 1.1, 2.2, and 3.3 kg·ha^{-1} of Mn, applied in 1300 L·ha^{-1} of water as a foliar application beginning on 14 Apr. 2000 (stage 7 budbreak, Wetzstein and Sparks, 1983), then two more times at 3-week intervals. Zinc sulfate (36% Zn) was tank-mixed with the Mn at 2.4 kg·ha^{-1} of Zn, and a surfactant (SurfKing Plus, Estes Corp., Oklahoma City) was added at 1.5 mL·L^{-1}. Treatments contained eight single-tree replications, with all treatments bordered in the tree row by at least two trees and between rows by an unsprayed tree row. The cultivar was ‘Crabtree’, a locally propagated selection. Leaf samples were collected in July using the middle pair of leaflets from the middle leaf on current season’s growth. Leaves were transported to the laboratory, washed in a P-free soap solution, followed by 0.1 N HCl, then rinsed twice with deionized water. Leaves were analyzed for N by macro-Kjeldahl (Horowitz, 1980), for P colorimetrically (Olsen and Sommers, 1982), and the other elements by atomic absorption spectroscopy.

Results and Discussion

Leaf Mn concentrations of the control were very 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-

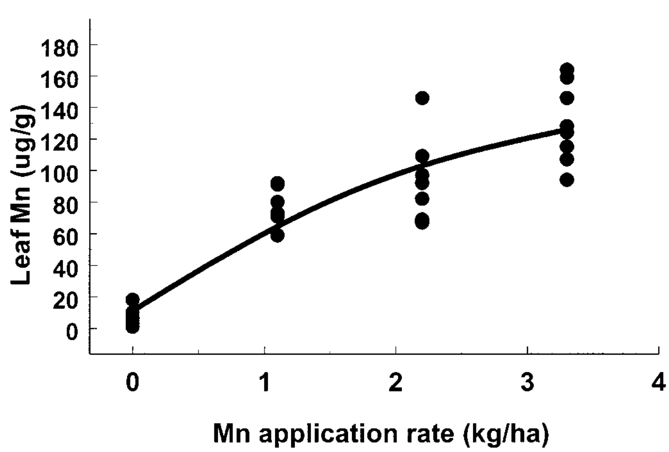

Fig. 1. The relationship between the foliar Mn application rate (x) and leaf Mn concentration (y): $y = 11 + 55.768x - 6.353 * x^2$, $r^2 = 0.82$, $P = 0.0001$.

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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 $MnSO_4$ (32% Mn) at 2.15 $kg \cdot ha^{-1}$ 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 $ZnSO_4$ (36% Zn) at 2.4 $kg \cdot ha^{-1}$ of Zn tank-mixed with the Mn prevented Zn shortage (leaf Zn 141 $\mu g \cdot g^{-1}$) with no detrimental effects.

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