NUTRIENT MANAGEMENT IN PECANS

Dr. James Walworth
Professor and Extension Specialist
University of Arizona, Tucson, AZ

ABSTRACT

In the desert southwest, commercial pecan growers routinely apply supplemental nitrogen and zinc. Only 40% routinely apply phosphorus, and fewer use boron, iron, and copper. To evaluate nitrogen requirement, rates ranging from 130 to 390 lbs N/a were applied for three seasons in a mature orchard. Nitrogen treatments had little effect on leaf nitrogen concentrations, tree growth, or nut yield. The lower rate of nitrogen application was sufficient to keep leaf nitrogen levels in the sufficient range. Several studies were conducted on soil application of zinc. Results indicate that soil applied $ZnSO_4$ was relatively ineffective, whereas Zn-EDTA elevated leaf zinc levels for one to two seasons following application in pot and field studies. Relative to foliar $ZnSO_4$ applications, soil applied Zn-EDTA increased trunk and root zinc levels in young potted trees. Orchard fertigation with Zn-EDTA can effectively elevate foliar zinc concentrations in young trees, although in our study zinc concentrations have not reached sufficiency levels after two growing seasons. Further, the efficacy of fertigated Zn-EDTA has not been demonstrated on mature trees.

INTRODUCTION

In the southwestern US, nitrogen and zinc are the only nutrients actively managed on all commercial pecan orchards. Only 40% of Arizona orchards routinely apply phosphorus, and a smaller number apply boron, copper, or iron. Nitrogen and zinc application rates vary widely among growers. Several recent studies have been conducted to evaluate application rates and methods.

STUDIES

Nitrogen

Annual nitrogen application rates range from approximately 100 to 500 lbs/a. Nitrogen fertilization is considered a critical management practice impacting pecan yield and nut quality (Smith et al., 1995; Wells and Wood, 2007). Nonetheless, nitrogen rate studies in irrigated pecan orchards are scarce. Nitrogen responses to rate and timing treatments are often erratic and inconsistent, and it can take several years to significantly affect pecan yield and quality (Acuna-Maldonado et al., 2003; Smith, 2007; Smith et al., 2004). Nutrient cycling and nitrogen storage in perennial tissue may be a large part of the reason for delayed responses (Acuna-Maldonado et al., 2003; Smith et al., 2007).

Annual application of nitrogen at rates of 130, 260, and 390 lbs N/a on 35 year old 'Western' pecan trees, split in six monthly applications, were used to evaluate effects on yield, growth, and mineral composition. The nitrogen source in the first and second applications was 26-13-13 fertilizer containing urea nitrogen; urea alone was used in the four latter applications. Fertilizers were broadcast and irrigation applied immediately after each fertilizer application. Leaves were sampled monthly throughout the growing season. Out of 16 sampling dates over three seasons, foliar N was significantly affected on only three dates, and the change in leaf nitrogen concentration was minimal. Leaf nitrogen concentrations ranged from 2.90 to 3.20%, 'normal' to 'high' according to Arizona standards (Table 1). No differences in yield and nut quality were found. Three-year cumulative yield efficiency (weight of nuts/cross sectional trunk area) was 37% higher with 130 than with 390 lbs N/a. Reproductive characteristics(percentage of fruiting shoot and fruits per cluster) and leaf chlorophyll index were not affected.

Table 1. Arizona pecan leaf nutrient concentration standards. From Pond et al. 2006.

Nutrient		Low	Normal	High
Nitrogen	%	1.15 – 2.05	2.05 – 2.96	2.96 – 3.85
Phosphorus	%	0.03 – 0.10	0.10 – 0.16	0.16 – 0.23
Potassium	%	0.45 – 1.00	1.00 – 1.59	1.59 – 2.15
Calcium	%	0.72 – 1.57	1.57 – 2.43	2.43 – 3.26
Magnesium	%	0.18 – 0.39	0.39 – 0.59	0.59 – 0.80
Sulfur	%	0.07 – 0.14	0.14 – 0.20	0.20 – 0.27
Boron	ppm	4 - 74	74 - 147	147 - 217
Copper	ppm	3 – 6	6 - 10	10 - 13
Iron	ppm	6 - 43	43 - 81	81 - 118
Manganese	ppm	50 - 104	104 - 674	674 - 1227
Nickel	ppm	2.8 – 8.5	8.5 – 14.3	14.3 – 20.0
Zinc	ppm	20 - 48	48 - 257	257 - 423

Zinc

Deficiency in pecans results in rosetting, interveinal chlorosis, small, chlorotic (and necrotic) leaves, less cytoplasm, and failure of chloroplast formation (limiting photosynthesis) (Kim and Wetzstein, 2003). Pecans growing in calcareous, alkaline soils are particularly susceptible to Zn deficiency because soluble zinc reacts with carbonates and hydroxides reducing its availability to plants (Lindsay, 1972). Critical foliar zinc levels range from 40 to 50 ppm. Values from high-yielding Arizona orchards are somewhat higher, although all sampled trees received foliar zinc applications, likely skewing the Arizona values (Table 1).

In areas with acidic soil (such as the southeastern United States), both foliar sprays and soil fertilization are common methods of zinc fertilization for pecan trees (Wood, 2007). However, in alkaline and calcareous soils such as those of the desert southwest, foliar sprays are the standard zinc application practice (Smith and Storey, 1979; Smith et al, 1979). Annual commercial foliar zinc application rates in Arizona orchards range from 12 to 40 lbs Zn/a. The initial application is made at or soon after early bud break followed by regular, repeated sprays after approximately one, three, five, and eight weeks. More frequent applications are often required for young, rapidly growing trees. Pecan varieties vary widely in their tendency for zinc deficiency.

It has been suggested that foliar sprays are less effective in increasing vegetative and root growth because the zinc is only minimally translocated from the sprayed leaves (Neilsen and Neilsen, 1994). Christensen and Jackson (1981) showed that root growth is dependent on zinc supply. When $ZnSO_4$ was foliar-applied to mature pecan tree leaves, only 0.37% of the applied zinc translocated from the treated leaf; this increased to 1.0% when applied to immature leaves (Wadsworth, 1970). In contrast, when pecan seedlings were grown in a $ZnSO_4$ solution, zinc was translocated into the petioles, and lateral and midrib veins of the youngest, most active leaves.

Zinc application to pecans growing in calcareous soils has met with limited success. Storey et al (1971) determined that 140 lb of $ZnSO_4$ *per tree* was required to alleviate zinc deficiency in calcareous Texas soils. In Arizona, neither band application of 75 lb/a of Zn as $ZnSO_4$, nor 20 lb/a as Zn-EDTA, consistently increased Zn uptake in mature 'Wichita' pecans growing in a calcareous soil (Nuñez-Moreno, et al., 2009).

We conducted several studies evaluating soil application of chelated zinc. In a 2008-2009 shade house study, one year old 'Wichita' pecan trees were potted in calcareous (pH 7.6) Pima clay loam soil. Treatments included: soil-applied $ZnSO_4$ (36% zinc), Zn-EDTA (9% zinc), zinc Avail® (8% zinc with a dicarboxylic acid polymer resin), cow manure (0.84 N, 0.18 P_2O_5, 1.19 K_2O), or cow manure plus $ZnSO_4$. Also included were foliar-applied $ZnSO_4$, and an untreated control. The manure application rate was equivalent to 11.4 Mton/ha, the zinc application rate of all soil applications was equivalent to 83 lb Zn/a. Soil treatments were applied only one time, at the beginning of the study. The foliar spray was applied at approximately two-week intervals from April to August. Leaves harvested at the end of the two growing seasons were acid washed, dry ashed, and analyzed for zinc content.

Of the soil zinc applications, only Zn-EDTA significantly increased foliar zinc levels (Table 2), and this treatment was effective only during the first growing season. By the second season, the Zn-EDTA was ineffective, either due to EDTA decomposition or leaching, or because chelated Zn was displaced by another cation.

Table 2. Foliar zinc levels (ppm) in shade-house grown pecan trees.

Treatment	2008	2009
Control	32.6	11.9
Zn Sulfate	24.9	19.9
Zn EDTA	244.4	24.7
Manure	27.3	11.1
Manure + Zn	28.1	12.7
Zn Avail®	31.9	10.7
Foliar Zn	140.3	159.1
$LSD_{0.05}$	66.5	32.2

A second shade-house study was conducted to evaluate distribution of soil and foliar supplied zinc. Two-year-old 'Wichita' pecan trees budded on 'Bradley' rootstock, were potted in Pima clay loam soil. Among the treatments were soil-applied Zn-EDTA, foliar-applied $ZnSO_4$, and an untreated control (as above). At the conclusion of the growing season entire plants were harvested, divided into leaves, petioles, shoots, trunks, and roots, acid washed and analyzed for zinc content.

Foliar applied $ZnSO_4$ increased leaf zinc concentration to over 160 ppm (Table 3). Soil applied Zn-EDTA did not significantly elevate leaf zinc levels above those of the untreated controls; however leaf zinc concentration (61 ppm) was above the commonly used 40 ppm critical zinc level and within the Arizona 'normal' range. In tissues farther from the sprayed leaves, soil applied Zn-EDTA became more effective than foliar applied zinc. In petiole and stem tissues, the two application methods were similarly effective, but soil application more effectively moved zinc to the trunk and root tissues than did foliar application.

Table 3. Zinc concentrations (ppm) of leaf, petiole, stem, trunk, and root tissues of potted 'Wichita' pecan trees treated with soil-applied Zn-EDTA or foliar-applied $ZnSO_4$.

	Leaf	Petiole	Stem	Trunk	Root
Control	45.1	41.5	42.6	26.8	28.1
Zinc EDTA	60.8	77.0	61.7	36.4	54.2
Foliar Zinc	164.9	87.5	68.4	31.7	33.7
$LSD_{0.05}$	38.3	38.5	14.3	3.5	6.5

We further explored the efficacy of a one-time application of Zn-EDTA to young pecan trees at the time of transplanting into the field, as well as inoculation with two species of mycorrhizal fungi collected from another pecan orchard. 'Wichita' pecan trees were planted in Pima-Grabe calcareous silt loam with a pH of 8.3 in January, 2009. Soil-applied Zn-EDTA treatments consisted of 35 ml or 70 ml of Zn-EDTA (9% Zn) per tree, placed in the planting hole as the tree was planted. Mycorrhizal treatments, including 5.6 g/tree of *Pisolithus tinctorius* spores, 2.8 g/tree of *Scleroderma* sp. spores, or a combination of the two, were applied similarly.

In 2009, the first season following planting, the higher rate of Zn-EDTA eliminated zinc deficiency symptoms (Table 4) and leaf zinc concentration doubled relative to that of untreated control (Table 5). In the second season, the high rate of Zn-EDTA reduced, but did not eliminate deficiency symptoms and, although this treatment elevated foliar zinc to almost 30 ppm, this is below accepted critical concentrations and categorized as 'low' by Arizona standards. By the third season, effectiveness of the high zinc treatment diminished more, zinc leaflet concentrations were no longer different than control treatment levels, and zinc deficiency symptoms were only partially alleviated. In the first season after application, 35 ml/tree of Zn-EDTA reduced, but did not eliminate zinc deficiency symptoms. The mycorrhiza inoculation did not exhibit affect zinc leaf levels or visible deficiency symptoms. Trunk growth rates were accelerated in Zn-EDTA treated trees in the third year after application only (data not shown).

Table 4. Visual zinc deficiency ratings (1 = severe zinc deficiency; 5 = no deficiency) in Wichita pecans.

Treatment	7/29/2010	10/8/2010	8/1/2011
Untreated control	3.4	2.8	2.7
35 mL Zn-EDTA/tree	4.5	3.8	3.6
70 mL Zn-EDTA/tree	5.0	4.0	4.5
Pisolithus	3.8	3.2	3.0
Pisolithus & Scleroderma	3.5	2.8	3.5
Scleroderma	3.3	2.9	3.5
$LSD_{0.05}$	1.2	0.81	0.87

Table 5. Leaf zinc concentrations (ppm) in Wichita pecans that received no zinc fertilizer, 35 ml Zn EDTA/tree, 70 ml Zn EDTA/tree, *Pisolithus tinctorus*, *Pisolithus tinctorus* and *Scleroderma* sp., or *Scleroderma* sp. alone.

Treatment	9/24/2009	7/29/2010	10/8/2010	8/1/2011
Untreated control	26.7	14.7	17.0	20.5
35 mL Zn EDTA/tree	33.0	23.8	23.2	23.5
70 mL Zn EDTA/tree	56.3	28.7	26.5	22.9
Pisolithus	29.2	15.4	13.5	16.4
Pisolithus & Scleroderma	25.7	17.0	14.9	16.2
Scleroderma	23.3	17.0	15.7	20.3
$LSD_{0.05}$	15.92	9.15	7.21	--

In 2012, a field study was initiated on a newly-planted orchard with micro-sprinkler irrigated ‘Wichita’ and ‘Western Schley’ pecans. Zinc-EDTA was injected into the irrigation system 13 times each season, totaling either 1.0 or 2.0 lb Zn/a in the first year, and 0.8 or 1.6 lb Zn/a in the second year. In the first season, trees of both varieties were sampled together to avoid taking too many leaves from individual trees. First season foliar zinc levels were 16.4, 19.5, and 23.5 ppm for the untreated control, the low, and the high rates of Zn-EDTA, respectively.

In the second growing season, fertigation with Zn-EDTA increased foliar zinc concentrations from 12.7 to 28.0 ppm in Western Schley trees, and from 9.6 to 25.3 ppm in Wichita trees (Table 6). Although significantly higher than the untreated trees, these levels are in Arizona’s ‘low’ category, and below the commonly cited 40 ppm critical concentration. Zinc deficiency symptoms were alleviated, but not completely eliminated (Table 7). Leaf chlorophyll content, rate of photosynthesis, and stomatal conductance were elevated by fertigation with Zn-EDTA (data not shown).

Table 6. Foliar zinc concentrations (ppm) on August 14, 2012. Numbers in each row followed by different letters are statistically different at the 95% confidence level.

Variety	No zinc	Low rate Zn-EDTA	High rate Zn-EDTA
Western Schley	12.7 b	21.6 ab	28.0 a
Wichita	9.6 c	18.6 b	25.3 a

Table 7. Visual zinc deficiency symptoms on August 14, 2012 (5 = no symptoms; 1 = severe symptoms). Numbers in each row followed by different letters are statistically different at the 95% confidence level.

Variety	No zinc	Low rate Zn-EDTA	High rate Zn-EDTA
Western Schley	4.1 b	4.4 a	4.3 b
Wichita	3.7 b	4.4 a	4.4 a

SUMMARY

- Over a three year period, annual nitrogen applications of 130 lb N/a were adequate to maintain adequate foliar nitrogen levels.
- Soil-applied $ZnSO_4$ was not effective at increasing foliar zinc concentrations at practical rates of application.

- A single soil application of Zn-EDTA can effectively increase zinc uptake for one to two seasons.
- Soil applied Zn-EDTA can result in a greater distribution of zinc to stem and root tissues than foliar application.
- Fertigated Zn-EDTA may be an effective method for supplying zinc to pecans, but methods might need to be adjusted to raise foliar zinc levels over the level required to completely eliminate deficiencies.
- Consistent effectiveness of soil Zn-EDTA applications on mature trees has not been demonstrated.

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