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## A COMPARISON OF TREE TRUNK INJECTION AND IMPLANTATION OF ZINC CAPSULES FOR CORRECTION OF ZINC DEFICIENCY

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**Abstract.** Zinc sulfate was applied to pecan tree trunks through implants and pressure trunk injection. Small amounts of chelated Zn solution were also injected by means of small pressurized cartridges. The most effective and efficient method for rapid correction of Zn deficiency of pecan when measured by leaflet Zn concentration was by pressure trunk injection using 8 liters per tree of solution containing 1 g of  $ZnSO_4$ /2.5 cm of trunk circumference. Pressure trunk injection was the only method which produced adequate leaflet Zn concentrations in September. Implants of equivalent amounts of  $ZnSO_4$  increased leaflet Zn over the control by September, but leaflets were still Zn deficient and phytotoxicity of trunk cambium tissue occurred. Pressurized cartridges were ineffective due to the small amount of Zn provided.

The pecan tree is of great economic importance in the South. Income from the sale of nuts in Georgia exceeds that from any other horticultural crop. In 1978, 251 million pounds of nuts were produced in the United States with 135 million pounds being produced in Georgia. Although most nut production comes from commercial orchards (Fig. 1), a large percentage of this production comes from trees around homes and in yards (Fig. 2, 3). The noncommercial trees are used mainly for their shade and other aesthetic values, and nut production is secondary. Their large size, small number, and location makes application of nutrients and pesticides by ground sprayers or airplanes impractical, inefficient and in the case of pesticides, illegal. Soil applications or trunk injections may be the only practical means for applying chemicals to the trees. Pesticides which are currently registered for soil application have a high mammalian toxicity and are not recommended for use in urban areas.

Pecan trees require relatively high leaflet Zn concentration compared with most crops. The

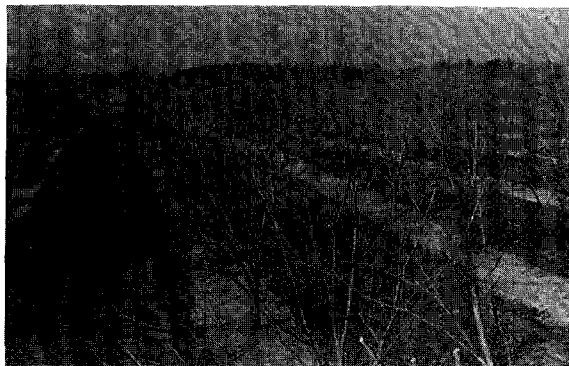


Fig. 1. A commercial pecan orchard near Albany, GA.



Fig. 2. Pecan trees used for landscape and shade around a home.

suggested adequate range for leaflet Zn in pecan trees is 50-100 ppm (Worley 1971). Zinc deficiency causes rosette, a disease which at one time affected most pecan trees in the South.

Symptoms begin with small crinkled terminal leaflets with interveinal chlorosis (Fig. 4). Extreme deficiency causes tips of limbs to die (Fig 5).

Alben et al. (1932) discovered rosette was caused by Zn deficiency, and since that time Zn applications to pecan trees have been routine. This discovery combined with development of fungicides to control scab and other leaf diseases, insecticides to control insect pests, and the development of sprayers that could apply these chemicals to large pecan trees has saved the pecan industry. Rosette can usually be easily controlled by soil application of Zn in acid soils of the Southeast, but it often takes several years to correct the deficiency after it becomes visible (Worley et al. 1972). In the alkaline soils of the Southwest, it is almost impossible to correct rosette by soil applications (Storey et al. 1971). In the Southeast, therefore, there is need for methods that will give rapid correction of Zn deficiency until soil applications take effect and in the Southwest, a method other than soil application is required. Foliar application is recommended in the Southwest (Storey et al. 1971), but several applications are required and the correction is often temporary. Trunk injections or implants may, therefore, be a method of application that will be both effective and rapid.



Fig. 3. Large 'Seedling' pecan tree near an old home site on Fred Volgt farm near Waycross, GA.

Previous research has shown that 1 g of  $ZnSO_4/2.5$  cm of trunk circumference gave rapid increases in leaflet Zn (Worley and Littrell 1979). Injected dyes were observed in the tops of pecan trees within one hour of injection initiation (Worley et al. 1976). Use of micronutrient implants have been successful in controlling micronutrient deficiency for many tree species reported in the review by Wolfe (1979); however, no studies on use of Zn were reported. There are two early reports of  $ZnSO_4$  being placed in holes bored into pecan trees (Demoree 1933; Gossard and Parson 1941). Placement of 50 g of  $ZnSO_4$  in holes bored into the tree trunk gave more rapid correction of Zn deficiency than soil application but the correction lasted only 3 months (Gossard and Parson 1941). In Texas, trunk injections of 3 ml Zn EDTA solution every 10 cm around the trunk periphery did not increase leaflet Zn (Storey et al. 1971). The research reported herein, compared the use of Zn implants with two methods of pressure trunk injection for increasing leaflet Zn concentration of Zn deficient pecan trees.

#### Methods and Materials

A Zn deficient orchard was selected with trees approximately 50 years old, located in an area that had been eroded and trees had been severe-

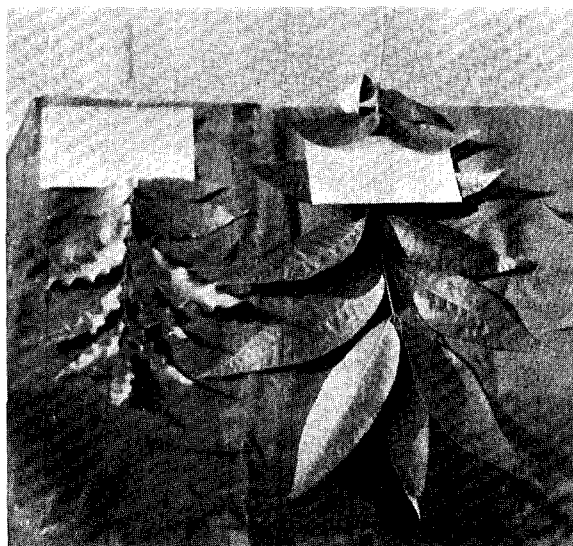


Fig. 4. Beginning stage of Zn deficiency (left) compared with normal leaf (right).

ly stunted due to neglect and Zn deficiency. The orchard had been under improved management for 6 years prior to the study. Management included spraying for insect and disease control and application of fertilizer based on leaflet analysis. Although Zn had been applied, trees were still deficient in Zn and showed symptoms of rosette. Treatments were applied on April 3, 1979 when spring shoots were approximately 2-3 cm long as follows: 1) One 2.5 × 1.2 cm implant (2 g ZnSO<sub>4</sub>) (Medicap Zn, Creative Sales, Inc., Fremont, NE 68028)/10 cm of trunk circumference in a spiral around the trunk within 1 m of the ground (1X). 2) Same as 1, but implants were spaced every 5 cm (2X). 3) One 2.5 × 1.0 cm implant (1 g ZnSO<sub>4</sub>)/10 cm of trunk circumference as in 1 (½X). 4) One g ZnSO<sub>4</sub>/2.5 cm of trunk circumference injection in 8 l of water through 6 ports in each tree at 5.3 kg/cm<sup>2</sup> pressure. 5) One pressurized cartridge containing 4 ml of 2% Zn derived from metal chelate of ethylenediamine tetraacetate dihydrate (EDTA)/12.7 cm of trunk circumference (J.J. Mauget Co., Burbank, CA 91504). 6) Control — no added Zn. Treatment 2 and 4 supplied equivalent Zn to the tree. The implants were driven just beneath the cambium layer into a drilled hole of the appropriate diameter. The capsule



Fig. 5. Severe Zn deficiency causes tips of pecan limbs to die.

containing the ZnSO<sub>4</sub> was enclosed in a plastic sleeve (Fig. 6) to facilitate insertion and to seal the hole.

The equipment for high pressure trunk injection (Fig. 7) consisted of an aluminum tank which served as a solution tank and pressurized air reservoir. This tank was fitted with appropriate valves for filling and pressurizing, with pressure gauges and a manifold for metering the solution into six injector heads. The injector head was essentially that described by Himelick (1972). Injection ports were 1.6 cm diameter holes approximately 5 cm deep. The lag screw injector head was tightened only enough to seat securely into the sapwood. Injection time was < 1 hr.

The tree trunk circumferences ranged from 80 to 160 cm. The experimental design was a randomized complete block with 5 replications. One replication was 'Delmas' cultivar and two replications each were of 'Stuart' and 'Schley.' Leaflet samples consisting of middle leaflets of leaves growing midway of current season's shoots were collected from the area of maximum limb spread by using a hydraulic lift bucket on June 27 and September 17. Trees were also rated for visual Zn deficiency symptoms on September 17. Leaflets were analyzed for Zn by dry ashing and atomic absorption spectrophotometry. Data were

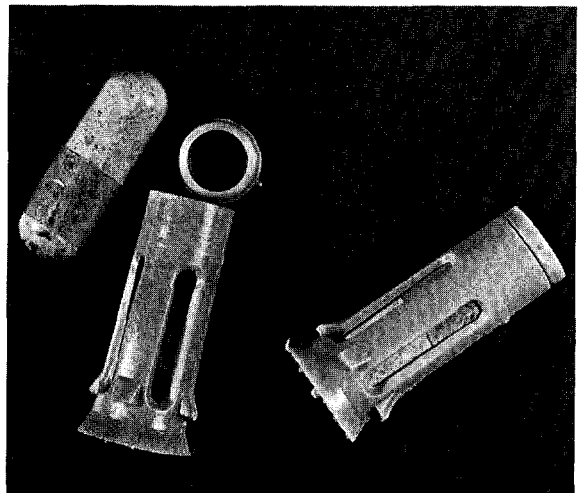


Fig. 6. Zinc sulfate capsule used as implants.

analyzed by using an analysis of variance with Duncan's Multiple Range Test. A square-root transformation was used on the leaf analysis data to meet the assumptions of normality required by analysis of variance.



Fig. 7. Equipment used for pressure trunk injection. Note the compressed air cylinder in truck, the aluminum solution tank, manifold, injector heads, and the DC-AC converter for supplying power to the electric drill.

**Results and Discussion**

Visual symptoms of Zn deficiency varied greatly among trees in the study and reflect large tree to tree variability reported previously (Worley et al. 1972). Leaflets from trees receiving the 2X rate of encapsulated Zn (treatment 2) and high pressure trunk injection (treatment 4) showed very few symptoms of Zn deficiency (Table 1). Leaflet analysis of June 27 samples showed only leaflets from trees receiving pressure trunk injections to contain a higher Zn concentration than the control. Within three months of injection, and perhaps much sooner, June leaflets had obtained very high concentration of Zn (Table 1). Leaflets from trees receiving the three implant treatments were not significantly higher than the control; however they were very close to the low end of the sufficiency range. Leaflet Zn on September 17 was greatly reduced from that obtained on June 27 for all treatments, but leaflets from trees receiving high pressure trunk injection had almost twice the Zn concentration of leaflets from trees receiving any other treatment and 3 times the Zn concentration of leaflets from the control trees. Pressure trunk injection was the only treatment with leaflets in the sufficiency range in September. Leaflets from trees receiving standard (1X) and 2X rates of Zn implants had leaflet Zn concentrations almost double the control, but they were still in the deficiency range. Leaflet Zn for trees treated with the pressurized Zn chelate

**Table 1. Effect of ZnSO<sub>4</sub> implants, pressure trunk injection of ZnSO<sub>4</sub> and pressurized cartridges of ZnEDTA on Zn deficiency symptoms and leaflet Zn concentration. Tifton, Georgia 1979.**

Treatments	Spacing	Zinc Deficiency Rating <sup>z</sup> y	Leaf Zn (ppm) <sup>y</sup>	
			June 27	Sept. 17
1. Zn implants (2 g)	10.2 cm	3.6 b	48 a	35 b
2. Zn implants (2 g)	5.1 cm	.2 a	51 a	35 b
3. Zn implants (1 g)	10.2 cm	2.4 ab	57 a	22 a
4. Pressure Trunk injection (1g/2.5 cm trunk circumference)	6 ports/tree	.4 a	130 b	63 c
5. Pressurized Cartridges <sup>x</sup>	12.7 cm	2.4 ab	30 a	23 a
6. Control	—	2.4 ab	38 a	19 a

z. Ratings were 0 = no deficiency symptoms; 9 = severe symptoms

y. Mean separation by Duncan's Multiple Range Test 5% level.

x. Mauget Inject-A-Min<sup>®</sup> Zn. Each Cartridge contained 4 ml 2.0% Zn. J.J. Mauget Co.

cartridges was not different from the control.

When the  $ZnSO_4$  is dissolved in a large volume of water (8 l) and injected into the tree under pressure, the solution apparently moves very rapidly into the tree xylem and other cavities then both upward and downward movement occurs until pressure is equalized. Transpiration from leaves creates movement of much of the injected solution toward them. Dye studies have shown solutions injected in this manner are distributed throughout the tree including roots within 24 hours (Prasad and Travnick, 1973), but dye was mainly concentrated in the leaves and conducting tissues (Prasad and Travnick, 1973). Our work with dye indicates similar results for pecan trees (Worley et al. 1976). The solution is very dilute in  $ZnSO_4$ , and apparently little phytotoxicity occurred.

The Zn implant placed a very high concentration of  $ZnSO_4$  in direct contact with living tissues as the tree sap dissolved the zinc capsule. This high salt concentration apparently killed a 5 cm wide strip of wood from 10 cm above to 15 cm below the implantation site. Often a 7-10 cm diameter cavity formed between the sapwood and bark and filled with liquid which exuded out the implantation wound, wetting the entire base of the tree trunk. Zinc applied by this method was apparently much less efficient than pressure trunk injection, perhaps due to the phytotoxicity and washing away of the Zn by the exuding sap.

Chelated Zn cartridges supplied too little Zn to the tree. The Zn from each cartridge would raise the leaflet Zn concentration of 45 kg (100 lbs) of leaves by merely 2.1 ppm. Only 7 to 13 cartridges were used/tree in accordance with the dealer's instructions. Each cartridge contained 4 ml of 2% Zn solution; therefore, little solution was available for flushing the Zn to the leaves. Obviously, a relatively small portion of injected Zn reaches the leaves; therefore, large increases in

leaflet Zn from this small amount injected would not be expected. Our results with these cartridges confirm results reported by Storey et al. (1971).

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