Research Note

LONGEVITY OF FERRIC AMMONIUM CITRATE TREATMENTS IN OAK

by E. Thomas Smiley[1] and Larry G. King[2]

Iron deficiency is a serious problem on oaks in alkaline soils. When iron deficiency is severe, it may limit life expectancy and predisposes trees to secondary pests such as anthracnose and Armillaria root rot (personal observation).

The main cause of iron deficiency is alkaline soil, which limits the availability of iron in the soil. Solubility of iron decreases by a factor of 100 for each pH unit increase. Foliar symptoms appear as interveinal chlorosis, interveinal necrosis, and branch dieback (Wallace and Lunt 1960).

Acidifying the soil or adding chelated iron can be effective treatments (Hacskaylo and Struthers 1959; Neely 1976; Whitcomb 1987). Injection of an iron solution into the xylem also has been effective (Himelick and Himelick 1980; Neely 1980; Harrell et al. 1984; Harrell et al. 1988,). Trunk injection is often the preferred treatment on highly buffered alkaline soils that are resistant to pH change and where the cost of treatment is a major factor. While the efficacy of these treatments is not in doubt, their longevity is often only 1 or 2 years.

This trial was established to monitor the efficacy and longevity of xylem-applied iron treatments, which use a higher rate of iron than is found in most commercially available products.

Materials and Methods

Street trees in Highland Park, Illinois, with susceptibility to iron deficiency were annually rated according to foliar symptoms. The foliar rating system used to evaluate the degree of iron deficiency symptom was: 0 = healthy tree, no visual chlorosis, 1 = leaves off color green, 2 = leaves yellow with green near veins, 3 = leaves uniformly yellow, little necrosis present, 4 = leaves necrotic in interveinal areas, 5 = dead branches as a result of chlorosis. Each year for 6 years, trees with a foliar rating equal to or greater than 3 were selected for treatment.

Injections were made on the lower trunk and root flares using a water-based solution of ferric ammonium citrate (FAC) and urea. Application rate was 1.0 g FAC, 0.27 g urea, and 150 mL of water per cm of trunk diameter measured at 1.4 m (diameter at breast height, dbh). Injections were made into 5 mm (7/32 in.) holes using Save-A-Tree® injectors (St. James Tree Service Ltd., Winnipeg, Manitoba, Canada) connected to a 3-gal compressed air sprayer (Solo Corp., Newport News, Virginia) at 0.1 MPa (15 psi) of pressure. On average, there were 0.6 injectors per cm of dbh; because most injectors were applied to the root flare, the distance between injectors varied depending on root configuration. All applications were made between September 20 and December 30 when temperatures were above freezing.

The foliar condition of all trees was rated prior to treatment and monitored up to 5 years. Fifteen red oaks (*Quercus rubra*) and 206 white oaks (*Q. alba*) were treated between 1990 and 1995 (Table 1) and were rated between 1990 and 1996. Data from all injection dates were pooled to eliminate the effects of single-year extremes in rainfall and temperature. Means of the pretreatment rating were compared to post-treatment ratings using a paired T-test.

Table 1. Number of red oak (*Quercus rubra*) and white oak (*Q. alba*) trees treated with ferric ammonium citrate and urea.

Year	Red oaks	White oaks
1990	2	17
1991	5	71
1992	5	97
1993	1	20
1995	2	1
Total	**15**	**206**

Results and Discussion

There were significant improvements in foliar condition following injections (Table 2 and Table 3). The mean rating for white oak went from 3 (uniformly yellow), to between 1 and 2 (off-color green) the first year after treatment. The mean rating for red oak went from class 3 to between 0 and 1 (slightly off-color green) during the same time period.

The single treatment maintained significantly better ratings for 4 years in both the red and white oaks. In the fifth year after white oak treatment, the color ratings were no longer statistically significant. However, even in the fifth year, the mean rating was one class better than at the beginning of the trial.

Summary

Iron deficiency is usually caused by high soil pH. Planting tolerant species or treating the pH problem directly are the preferred methods for managing this problem. However, altering the pH of a calcarious soil can be a lengthy and costly exercise. Trunk injection of ferric ammonium citrate and urea provides a quick, dramatic, and long-lasting reduction in symptoms of iron deficiency of both red and white oak. In addition, the low price of the materials (less than US$ 0.20 per in. of trunk diameter) also makes this an economical treatment.

Table 2. Foliar chlorosis rating (0 = healthy, 5 = dead branches) of 206 white oaks (*Quercus alba*) prior to (year 0) and after trunk injection with a combination of ferric ammonium citrate and urea.

Years after treatment	Number of trees	Mean foliar rating
0	206	3.3
1	206	1.5*
2	97	1.7*
3	103	1.8*
4	60	1.8*
5	12	2.4

*Significantly different from the pretreatment foliar rating using a paired sample T-test ($P < 0.05$).

Table 3. Foliar chlorosis rating (0 = healthy, 5 = dead branches) of 15 red oaks (*Quercus rubra*) prior to (year 0) and after trunk injection with a combination of ferric ammonium citrate and urea.

Years after treatment	Number of trees	Mean foliar rating
0	15	3.3
1	15	0.8*
2	8	1.4*
3	7	1.6*
4	5	1.0*

*Significantly different from the pretreatment foliar rating using a paired sample T-test ($P < 0.05$).

Literature Cited

Hacskaylo, J., and P. Struthers. 1959. Correction of lime-induced chlorosis in pin oak. Ohio Agric. Res. Dev. Ctr. Cir. 17. 5 pp.

Harrell, M.O., P.A. Pierce, and D.P. Mooter. 1988. *Pin oak and silver maple chlorosis treatment with ferric ammonium citrate solution.* J. Arboric. 14:156–158.

Harrell, M.O., P.A. Pierce, D.P. Mooter, and B.L. Webster. 1984. A *comparison of treatments for chlorosis of pin oak and silver maple.* J. Arboric. 10:246–249.

Himelick, E.B., and K.J. Himelick. 1980. *Systemic treatment for chlorotic trees.* J. Arboric. 6:192–196.

Neely, D. 1976. *Iron deficiency chlorosis of shade trees.* J. Arboric. 2:128–130.

Neely, D. 1980. *Trunk and soil treatments of pin oak.* J. Arboric. 6:298–299.

Wallace, A., and O.R. Lunt. 1960. *Iron chlorosis in horticulture plants, a review.* Am. Soc. Hort. Sci. 75:819-841.

Whitcomb. C.E. 1987. Establishment and maintenance of landscape plants. Lacebark Publications, Stillwater, OK. 618 pp.

[1]*E. Thomas Smiley*
Bartlett Tree Research Lab
13768 Hamilton Road
Charlotte, NC 28278

[2]*Larry G. King*
City Forester
Highland Park, IL

Résumé. La déficience en fer est un facteur limitatif pour la croissance des chênes en sol alcalin. Des injections dans le xylème de citrate d'ammonium ferrique et d'urée ont été appliquées pour en réduire la manifestation des symptômes. Les applications ont grandement réduit les symptômes la première année et ont permis de maintenir les arbres en bonne condition pour au moins cinq années.

Zusammenfassung. Der Eisenmangel ist ein begrenzender Faktor für das Wachstum von Eichen auf alkalischen Böden. Eine Injektion von Ferroammoniumcitrat und Urea in das Xylem wurde zur Reduktion von Sumptomen angewendet. Die Behandlungen verminderten größenteils die Symptome im ersten Jahr und erhielten die Bäume für mindestens fünf weitere Jahre in guter Kondition.