PIN OAK AND SILVER MAPLE CHLOROSIS TREATMENT WITH FERRIC AMMONIUM CITRATE SOLUTION[1]

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Abstract. Trunk injections of a commercially available ferric ammonium citrate solution were found to be effective in correcting chlorosis of pin oak and silver maple. Two previously evaluated treatments for chlorosis of pin oak were tested again for comparison. Trunk injections of manganese sulfate, a fungicide, and an N-P-K fertilizer were also tested on silver maple, but did not improve foliage color.

Résumé. L'injection dans le tronc d'une solution commercialisée de citrate d'ammonium ferrique fut prouvée effective afin d'éliminer les chloroses du chêne des marais (*Quercus palustris*) et de l'érable argenté (*Acer saccharinum*). Deux traitements utilisés par le passé pour les chloroses du chêne des marais furent encore évalués pour fin de comparaison. L'injection dans le tronc de sulfate de magnésium, un fongicide, et l'application d'un fertilisant (N-P-K) furent aussi évalués sur l'érable argenté, mais n'ont pas amélioré la coloration du feuillage.

Chlorosis is a common problem of trees and shrubs in many parts of the United States. The chlorosis of pin oak is usually caused by a deficiency of iron brought about by alkaline soils. Many studies have evaluated treatments for correcting chlorosis of pin oak, and most have found iron injections and implants to be very effective (1, 2, 7, 8, 9, 10, 12). The chlorosis problem of silver maple seems to be less well understood, and its cause appears to vary depending on location. In Ohio, manganese implant treatments are effective in improving the chlorosis problem of silver and red maple (11), and manganese implants are effective also in treating declining sugar maples in Michigan (4), but similar and additional manganese treatments have not been effective in correcting the chlorosis of silver maple in Nebraska (1).

The study reported here evaluated a new product containing a liquid forumlation of ferric ammonium citrate for its effectiveness in correcting chlorosis of pin oak and silver maple. This product was compared on pin oak with two iron treatments already known to be effective. An additional manganese treatment, N-P-K treatment, and fungicide treatment were tested on silver maple also.

Methods

The study involved 30 silver maples *(Acer saccharinum.)* and 48 pin oaks *(Quercus palustris)* located in Omaha, Nebraska. Silver maples ranged in size from 11.5 in. (29 cm) to 43.2 in. (110 cm) in diameter (dbh). Pin oaks ranged in diameter from 2.8 in. (7 cm) to 18.8 in. (48 cm). Most of the trees were growing in street easements. All of the trees were in an urban environment. Treatments were assigned using a randomized complete blocks design, blocking by location. Within each block, trees were selected that had approximately similar diameters.

Each pin oak showed the typical chlorotic symptoms of iron deficiency chlorosis. The silver maples showed leaf chlorosis symptoms similar to those of the pin oaks. Soil pH in the area ranged from 7.5 to 7.8 and had an average of 7.6 (n = 5). Foliage analyses of iron and other nutrients were not conducted in this study, because a previous study (1) involving trees in the same area found no correlation between foliage color and any of the nutrients N, P, K, Fe, Mn, Zn, Mg, Cu, Ca, and S. The absence of a correlation between foliage color and iron content in the foliage has been reported and discussed earlier (5, 8). The explanation for the absence is that healthy and chlorotic leaves do not differ in the amount of total iron, but do differ in the amount of iron present in a form that is usable by the plant.

Initial foliage color ratings for treatments in 1986 were made on August 23, 1985 for silver maple and August 21 and 30, 1985 for pin oak. For treatments in 1987 (only on silver maple), initial color ratings were made June 24, 1987. Treatments in 1986 were applied from April 23 to May 30. Treatments in 1987 were applied from June 24 to July 8. The application of commercial products was timed to follow manufacturer guidelines. After-treatment color ratings for treatments in 1986 were made on August 26 and

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27, 1986, and August 26 and September 2, 1987. After-treatment color ratings for treatments in 1987 were made on September 2, 1987. The color ratings were based on a 10-point scale as used in an earlier study by Harrell et al. (1) using color plates in the Munsell Book of Color (6) as color references. A rating of 10 corresponded to the darkest green observed in healthy trees. A rating of 1 corresponded to the most chlorotic and necrotic condition observed. If a single color rating did not adequately describe the colors present in a tree, two or three color ratings were assigned, and a weighted average was calculated by multiplying each color by the proportion in which it was present in the tree. Color changes occurring after treatment were determined by substracting the initial average color rating from the after-treatment rating. Differences in color change among treatments were determined using the nonparametric Friedman's method for randomized blocks (3). The treatments and species tested were:

Iron NutriBoosters: ArborSystems, Inc., Omaha, NE. Trunk injection of a liquid formulation of ferric ammonium citrate applied at the rate of one Iron NutriBooster (0.18 g Fe) per four inches (10 cm) of trunk circumference (label rate); used on silver maple and pin oak.

Medicap FE: Creative Sales Inc., Fremont, NE. Trunk implants of ferric ammonium citrate powder applied at the rate of one Medicap FE (0.22 g Fe) per three- to four-inch (7.5- to 10-cm) spacing around the trunk (label rate); used on pin oak.

Medi-Ject: Fischbach Tree-Lawn Service, Lincoln, NE. Trunk injection of ferrous sulfate solution applied at the rate of 0.2-0.4 oz. of $FeSO_4$ (1.2-2.4 g Fe) per inch (2.5 cm) of trunk diameter (label rate); used on pin oak.

Arbotect 20-S: Merck & Co., Inc., Rahway, NJ. Trunk injection of the fungicide thiabendazole at the rate of 2.4 fl. oz. (71 ml) of Arbotect per inch (2.5 cm) of trunk diameter (label rate) using ArborSystems' Tree I.V. MicroTip applicator; used on silver maple to determine whether the chlorosis problem was caused by a microorganism that would respond to this treatment.

Manganese sulfate injection: Manganese sulfate applied as a trunk-injected solution using a Tree I.V. applicator at the rate of 0.05 oz. (1.4 g) of $MnSO_4$ per inch (2.5 cm) of trunk diameter; used on silver maple because manganese sulfate has been reported as effective on silver maple in Ohio (11). (The rate used in Ohio was approximately 0.04 oz. (1.2 g) $MnSO_4$ per inch (2.5 cm) of trunk diameter applied as implants. The Ohio rate and method of application was not effective when used previously in Nebraska (1).)

N-P-K injection: A trunk-injected fertilizer solution containing 14% available nitrogen, 4% available phosphoric acid, and 4% soluble potash applied through a Tree I.V. applicator at the rate of 0.03 fl. oz. (0.8 ml, 0.8 g) of solution per inch (2.5 cm) of trunk diameter; used on silver maple to determine whether an N-P-K fertilizer would correct the chlorosis problem.

Control: No treatment.

Results and Discussion

Pin oak. Iron NutriBoosters corrected the chlorosis of pin oak through two growing seasons in a manner equal to that of Medi-Ject and Medicap FE (Table 1). The results of the Medi-Ject and Medicap FE treatments are consistent with those reported previously (1).

Silver maple. Iron NutriBoosters improved the foliage color of silver maple in the first growing season when applied in May (Table 2) and when applied in June and July (Table 3). The color change in the second year was not statistically different from the control (Table 2). The Arbotect

Table 1. Foliage color change of pin oak following treatments in April and May, 1986.

Treatment (n = 12)	*Initial color at 8/85*	*Color change[1] at 8/86*	*8/87*
Medi-Ject (Ferrous sulfate injection)	5.4	3.4a[2]	3.3a
Iron NutriBoosters (Ferric ammonium citrate injection)	5.5	3.2a	2.6a
Medicap FE (Ferric ammonium citrate implants)	5.4	2.7a	2.3a
Control (No treatment)	5.5	-0.5b	-0.6b

[1]Color change = final color − initial color
[2]Color change values in the same column followed by different letters are significantly different from each other (P .05) using Friedman's method for randomized blocks.

Table 2. Foliage color change of silver maple following treatments in May, 1986.

Treatment (n = 4)	*Initial color at 8/85*	*Color change[1] at 8/86*	*9/87*
Iron NutriBoosters (Ferric ammonium citrate injection)	6.2	1.7a[2]	1.4a
N-P-K injection	6.2	0.8b	1.0a
Manganese sulfate injection	5.9	0.7b	0.6a
Arbotect 20-S (Thiabendazole fungicide injection)	6.2	0.5b	0.6a
Control	6.4	0.2b	-0.2a

[1]Color change = final color − initial color
[2]Color change values in the same column followed by different letters are significantly different from each other ($p < .05$) using Friedman's method for randomized blocks.

Table 3. Foliage color change of silver maple following treatments in June and July, 1987.

Treatment (n = 5)	*Initial color at 6/87*	*Color change[1] at 9/87*
Iron NutriBoosters (Ferric ammonium citrate injection)	6.3	1.1a[2]
Control	6.4	-0.2b

[1]Color change = final color − initial color
[2]Color change values followed by different letters are significantly different from each other (p .05) using Friedman's method for randomized blocks.

20-S, manganese sulfate, and N-P-K injections did not improve foliage color in either year (Table 2). In the previous study (1), no treatments, including Medi-Ject, Medicap FE, Medicap MD, Medicap MN, Stemix, Stemix HV, Stemix + Zinc Stemix, Fungisol, and manganese sulfate trunk injections, and soil treatments using manganese sulfate, FeHEDTA, and aeration were effective in correcting the chlorosis condition. The results of these two studies suggest that the chlorosis of silver maple in Nebraska is caused at least in part by a deficiency of iron. Since the improvement in color of silver maple after an iron treatment was not as large as that of pin oak, other nutrients may be deficient as well, but tests have not yet identified these deficiencies.

Many products are available for treating chlorosis in trees. The evaluations in this study and the one reported previously (1) have identified Medi-Ject, Iron NutriBoosters, and Medicap FE as effective trunk injection and implant products for correcting iron chlorosis of pin oak. In our tests in Nebraska, only Iron NutriBoosters have corrected the chlorosis of silver maple to any significant degree.

Acknowledgments

This study was supported by the Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, and the City of Omaha, Nebraska. Iron NutriBoosters, Tree I.V., and MicroTip are trademarks of ArborSystems, Inc., Omaha, NE. Medicap FE, Medicap MD, and Medicap MN are trademarks of Creative Sales, Inc., Fremont, NE. Medi-Ject is a trademark of Fischbach Tree-Lawn Service, Lincoln, NE. Stemix and Fungisol are trademarks of J.J. Mauget Co., Burbank, CA. Iron Sul is a trademark of Duvall Sales Corporation, Houston, TX. Arbotect is a trademark of Merck and Co., Inc., Rahway, NJ.

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