Micro-infused Min-jet Iron Using the Tree I.V. for Iron Chlorosis in *Quercus palustris* in the Mid-West

Joseph J. Doccola[1], Peter M. Wild[2], Ron Howell[3], and Eric J. Bristol[4]
[1, 2, 4]Arborjet, Inc. Woburn, MA
[3]Howell's Tree & Landscape Service, Columbus OH

Introduction

Iron chlorosis describes a condition in which a tree's foliage loses its healthy green color and fades to a pale green or yellow hue. If allowed to progress, this condition will result in reduced growth, leaf loss and eventual tree death. Chlorosis is often caused by a deficiency of one or more micro-elements including iron, manganese, boron and/or zinc. In highly alkaline soils (pH >7), such as occur in Midwestern soils, iron, manganese and zinc become bound in soils and unavailable to the tree. Change in soil pH is difficult, and occurs slowly. Tree species vary in tolerance to the low availability of micro-nutrients, but species such as beech, birch, elm, honeylocust, maple and oak tend toward susceptibility, expressed as physiological disease of yellowing of canopy (chlorosis), reduced growth, thinned canopy, dieback, decline and ultimately, death. For Pin oak (*Quercus palustris*), the micronutrients sufficiency range in ppm are: Fe: 45-180, Mn: 218-633, B: 19-122, Cu: 7-38; Zn: 29-88, and Mo: 0.02-1.58 (2014 Plant Analysis Handbook III). Soil amendments that acidify soils, foliar applications or tree injection of micro-nutrients are used to alleviate micro-nutrient deficiency. In this study, we evaluate the canopy change in Pin oak following tree injection with Min-jet Iron.

Methods

In September of 2004, 90 chlorotic Pin oak (*Quercus palustris*) trees in Columbus Ohio were treated with Min-jet Iron via tree injection. Min-jet Iron is a tree injection formulation designed to provide micro-nutrients to trees expressing symptoms of chlorosis. Min-jet Iron provides 7500, 3800, 2000, 1000 and 1000 ppm of Fe, Mn, Zn, B and Cu per 100 milliliters, respectively. Label rates are based on tree diameter and increase with an increase in tree size. For example, 12, 24 and 36 inch DBH trees receive 16, 19 and 29 mLs per inch of diameter, respectively. Therefore, a tree injected with 100 mLs of Min-jet Fe, receives 9 to 67x the sufficiency levels in ppm required of Mn, B, Zn, Cu and Fe. The trees were injected using the Tree I.V and #3 Arborplugs™ (Arborjet, Inc. Woburn, MA). The injection sites were placed low in the tree, into the trunk flare tissues. A 18 volt cordless drill fitted with a clean, sharp 9/32" (7 mm) high helix drill bit was used to drill 5/8" (15 mm) into the sapwood. A set tool and mallet was used to countersink the Arborplug to the sapwood. One injection site was located every 8" (20 cm) of tree circumference. The tree diameters were measured using a diameter tape at 54" (135 cm) above the ground level and DBH in inches was recorded. Inch DBH was multiplied by the milliliters of Min-jet Iron to be applied in the study. The calculated dose was measured and poured into the Tree I.V. service bottle. The I.V. was then pumped to 35 PSI and each of four injector needles was opened to purge air from the lines, prior to injection. The trees were randomly assigned a treatment rate of 0, 15, 20, 30, 45, 60, 90 milliliters per inch DBH of Min-jet Iron. Prior to injection, all 90 trees were rated on a scale of 1 to 8 based on the severity of chlorosis and defoliation, where a rating of 1 is a healthy tree and 8 is a dead tree. Prior to injection, trees were photographed and rated. Form this initial assessment a photographic severity range was created (Figure 3.) This tool helped the evaluators to make the accurate qualitative canopy assessments.

Table 1: Min-jet Iron treatment rates and number of pin oak treated.

Treatment	# of Trees
Control	13

15mL	16
20mL	13
30mL	38
45mL	5
60mL	4
90mL	1
	90

All 90 trees were assessed in June 2005 and rated again using a scale from 1 to 8. The change of each tree was calculated and these improvements of canopy were statistical tested to prove significance. One-way ANOVA tests were conducted on treatment rates (ex. 15ml, 20ml etc.), then separated by tree size and treatment rate (ex. 12-23" 15mL, 12-23" 20mL etc.)

Results

Untreated trees and all treatments were compared using one-way ANOVA test resulting in a p value of 0.014 indicating statistical significance. For further investigation, a 2 sample t-test was performed to compare the control trees to the 15, 20, 30, 45, and 60mL rates and p values recovered were 0.069, 0.032, 0.004, 0.023, and 0.005 respectively.

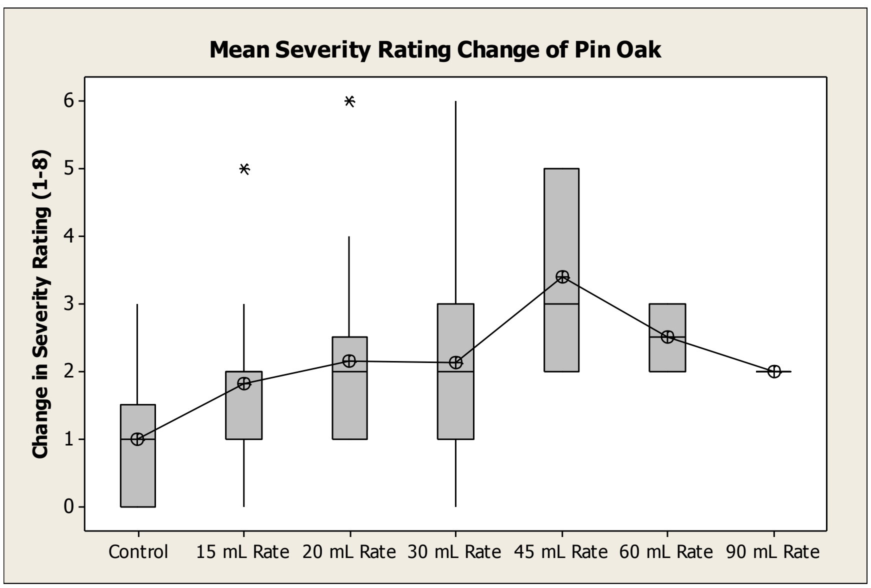

Figure 1: Mean severity rating changes in Pin Oak micro-infused with Min-jet Iron. A scale of 1 to 8 was used. Increases in numeric value indicate a better recovery from chlorosis was observed. In this analysis, change in the severity of chlorosis is associated with an increase in the dosage applied to the trees.

Table 2: Mean severity rating change in pin oak treated with Min-jet Iron using the Tree I.V. Lettered superscripts indicate means that are statistically different or similar.

Treatment	# of Trees	Mean Rating Change
Control	13	1.000^{a}
15mL	16	1.813^{ab}
20mL	13	2.154^{b}
30mL	38	2.132^{b}
45mL	5	3.400^{b}
60mL	4	2.500^{b}
90mL	1	2.000^{b}

	90	

The treatments are significantly different from the control trees at 20 milliliters and higher. No significant differences were observed among the different treatment rates (e.g., 20mL rate compared to 45mL rate).

Treatment rates were further separated into tree size classifications including <12”, 12-23”, 24-35”, and 36”+. The following tables indicate statistical significance for each treatment class. Statistical significance between treatment classes is indicated using lettered superscripts on the mean severity change values (e.g., [a] is statistically the same as [a], but not statistically the same as [b]).

Table 3a: Mean severity change for tree size classification (<12”), and treatment rates (0, 15, and 30mL).

Treatment Class	# of Trees	Mean Severity Change
<12" Control	2	1.000 [a]
<12" 15mL	4	2.250 [ab]
<12" 30mL	2	3.500 [b]

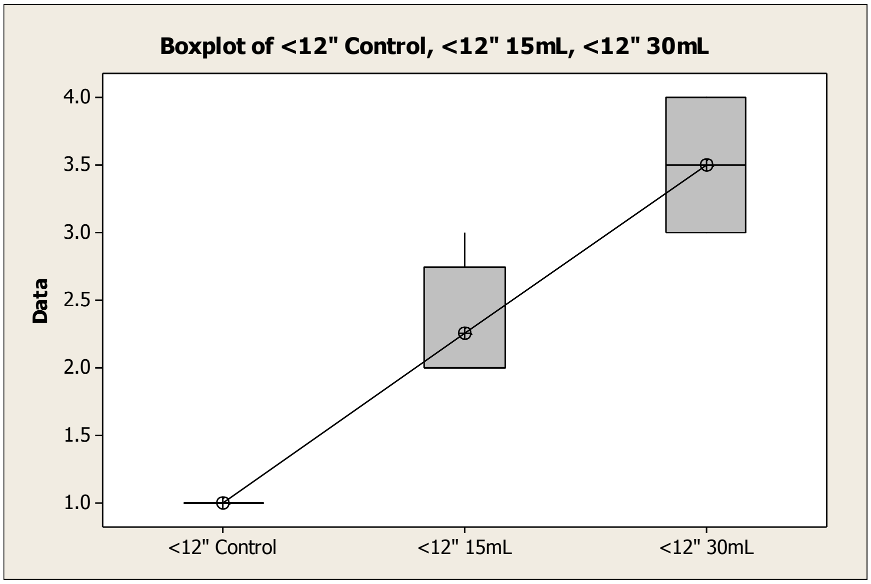

Figure 2a: Boxplot of severity changes for tree size classification (<12"), and treatment rates (0, 15, and 30mL). Figure derived from one-way ANOVA statistical results using Mini-tab.

Table 3b: Mean severity change for tree size classification (12"-23"), and treatment rates (0, 15, 20, 30, 60 and 90mL).

Treatment Class	# of Trees	Mean Severity Change
12-23" Control	3	1.333 [a]
12-23" 15mL	2	2.000 [a]
12-23" 20mL	12	2.167 [a]
12-23" 30mL	26	2.115 [a]
12-23" 60mL	3	2.667 [a]
12-23" 90mL	1	2.000 [a]

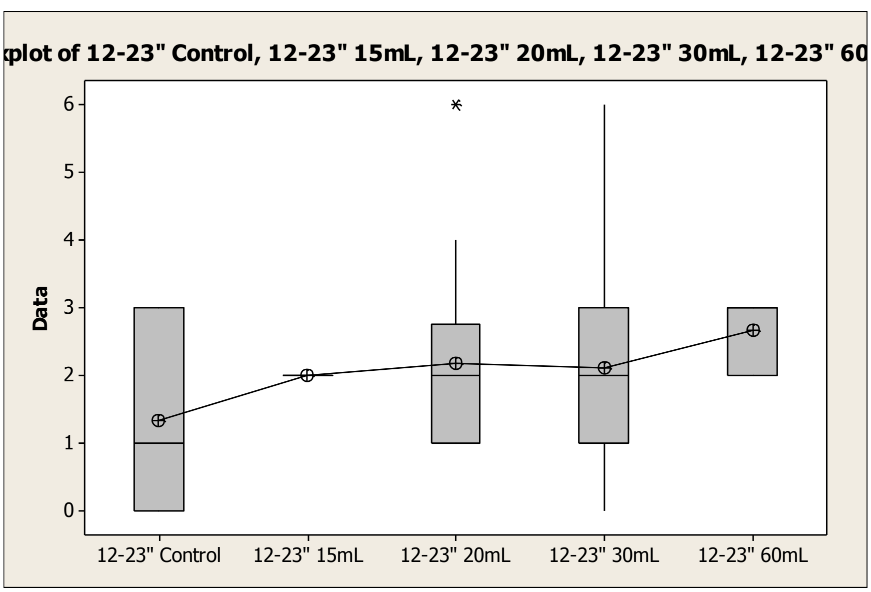

Figure 2b: Boxplot of severity changes for tree size classification (12"-23"), and treatment rates (0, 15, 20, 30, 60 and 90mL). Figure derived from one-way ANOVA statistical results using Mini-tab.

Table 3c: Mean severity change for tree size classification (24"-35"), and treatment rates (0, 15, 30, and 45mL).

Treatment Class	# of Trees	Mean Severity Change
24-35" Control	2	1.000 [a]
24-35" 15mL	8	1.250 [a]
24-35" 30mL	6	1.833 [b]
24-35" 45mL	5	3.400 [c]

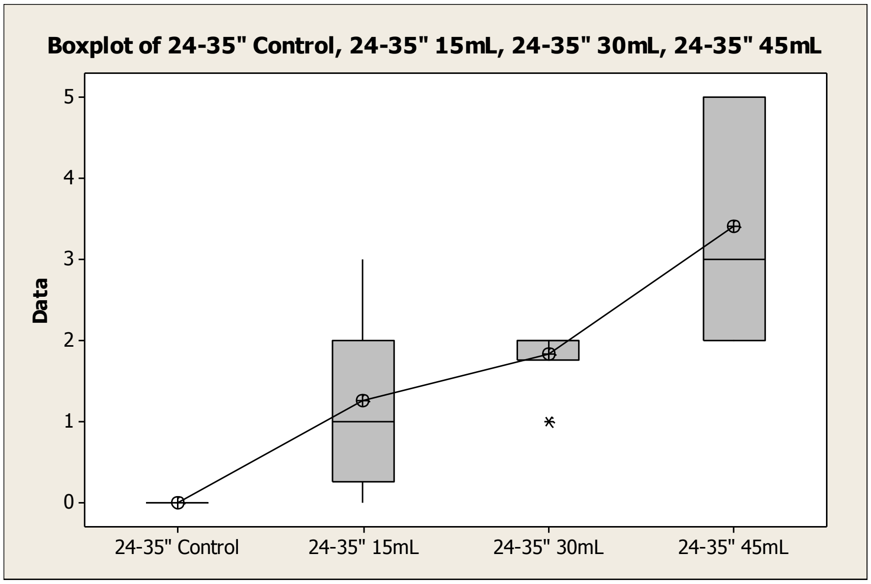

Figure 2c: Boxplot of severity changes for tree size classification (24”-35”), and treatment rates (0, 15, 30, and 45mL). Figure derived from one-way ANOVA statistical results using Mini-tab.

Table 3d: Mean severity change for tree size classification (36”+), and treatment rates (0 and 30mL).

Treatment Class	# of Trees	Mean Severity Change
36"+ Control	6	1.167 [a]
36"+ 30mL	1	1.000 [a]

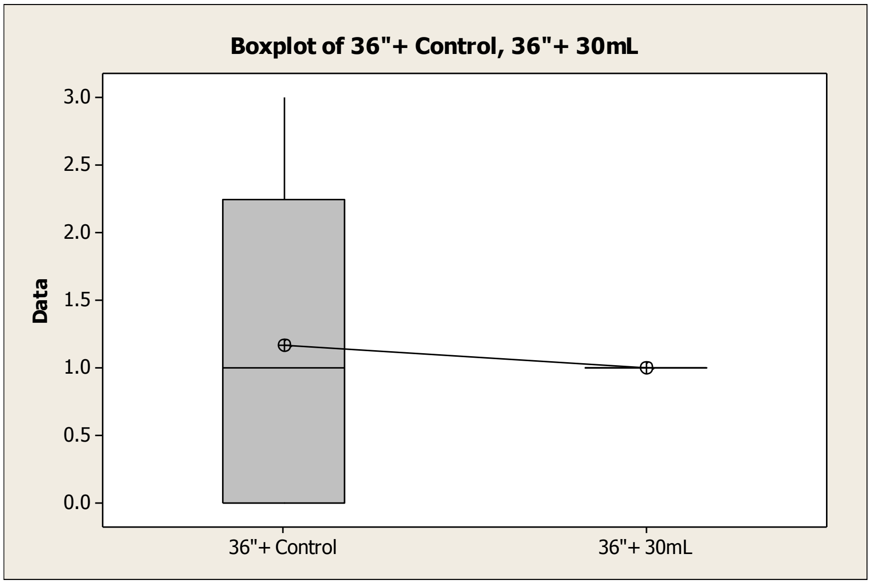

Figure 2d: Boxplot of severity changes for tree size classification (36"+), and treatment rates (0 and 30mL). Figure derived from one-way ANOVA statistical results using Mini-tab.

Discussion

When grouping tree sizes by treatment rates, treatments are considered to be equally effective compared with the control. There was no significant difference when rates were increased higher than 20mL per inch DBH; however, 15 mL was not statistically different than the controls, therefore a rate of 20 mL or greater, is recommended.

There was differential severity rating changes within the tree size classifications and Min-jet Iron applications at various rates. The tree size class of <12"DBH is presented in Table 3a and Figure 2a. These indicate there is a significant difference between the control and 30mL rate application for <12"DBH pin oak. The 15mL/DBH" rate is not statistically different than the <12"DBH control pin oak. This indicates <12"DBH pin oak may require between 15mL and 30mL rate to be effective.

The tree size class of 12-23"DBH is presented in Table 3b and Figure 2b. These indicate there is no significant difference between the control and all treatment rate applications for 12-23"DBH pin oak. There was a mean increase in the severity rating change from 15mL rate and higher that indicates there is a treatment effect, however with the sample population being small there is not a statistical difference.

The tree size class of 24-35"DBH is presented in Table 3c and Figure 2c. These indicate there is a significant difference between the control and the 30 mL and 45 mL rate application for 24-35"DBH pin oak. The 15mL/DBH" rate is not statistically different than the 24-35"DBH control pin oak. There is also a statistical difference in the Min-jet Iron treatment rates indicating the 45mL rate is recommended over the 30 mL rate. This indicates 24-35"DBH pin oak may require between 30 mL and 45 mL rate to be show optimal results.

The tree size class of 36"+DBH is presented in Table 3d and Figure 2d. These indicate there is no significant difference between the control and the 30 mL treatment rate application for 12-23"DBH pin oak. The sample population is too small to provide any accurate information from this tree size classification. Further work can be done in the 36"+DBH tree size class to find an accurate recommended application rate for Min-jet Iron.

Conclusions

Min-jet Iron shows significant results (canopy greening) for pin oak suffering from interveinal chlorosis. The overall recommended treatment rate of Min-jet Iron for pin oak in any tree size class is 20mL/DBH". The 20mL/DBH" rate is the lowest micro-infused rate showing improvement over the control.

When examining the tree size class recommendations, the rates increase as tree size increases. The tree size class of <12"DBH indicates a 15mL to 30mL rate will provide significant results. The tree size class of 12-23"DBH indicates no definite rate class to provide significant results, however the 60mL rate showed the highest mean change. The tree size class of 24-35"DBH indicates a 30mL to 45mL rate will provide significant results. The tree size class of 36"+DBH indicates no definite rate class to provide significant results, as an insufficient number of trees were treated in this study.

Based on these results for the rates, product, method, and tree species tested, the application rates for <12", 12-23", 24-35", and 36"+ should be 20mL, 30mL, 40mL, and 50mL rates respectively. With 20mL as the base rate this gives us a 1x, 1.5x, 2x, and 2.5x rate pattern for tree size classifications.

Further Investigation

The results above can be used to provide a base knowledge of effective liquid fertilizer rates. Other fertilizers can be examined at these rates, and other genera can be tested. The level of Iron in Min-jet Iron can be compared with the content of iron in leaves, and correlated to help target the active micronutrient levels required for developing other effective fertilizers. The 36"+DBH tree size class can be examined at the 50mL or higher rates to further define the requirements. The original proposal of the study can be readdressed to include humates and/or paclobutrazol treatments to compare to Min-jet Iron alone. In 2006, reassessment of the pin oak can be conducted to determine the possibility of residual effect.