NUTRIENT TREATMENTS FOR SUGAR MAPLE DECLINE[1]

by Roger Funk and Ward Peterson

Abstract. Preliminary and ongoing research have shown that soil treatments with high nitrogen fertilizer can significantly improve leaf color of sugar maples (*Acer saccharum*) symptomatic of maple decline. Manganese treatments were less often effective.

The nutrient level in chlorotic leaves was lower than in healthy leaves for all of the elements tested exept sodium and aluminum. The high level of sodium found in chlorotic leaves may implicate salt (sodium chloride) in maple decline.

Maple decline, also known as maple dieback and maple blight, is more a description of symptoms than a specific malady. These symptoms include chlorotic and scorched leaves that are often sparse and smaller than normal, premature fall coloration and leaf drop, and twig and branch dieback initially involving the upper crown.

Several factors have been shown to trigger or contribute to maple decline, and others have been suggested. Hepting (1971) categorizes five different declines, two of which are involved in the general decline that occurs in the Northeast, Midwest and parts of Canada. Among the reported factors are road salts (Rich, 1971; Pirone, 1972), high pH-manganese deficiency complex (Kielbaso, 1976), nitrogen deficiency (Jacobs, 1931; Mader, 1969), drought (Hibben, 1962) and other adverse environmental conditions (Griffin, 1965). Diseases such as root rots and cankers are believed to be secondary in nature and further contribute to the decline.

PRELIMINARY RESEARCH

Preliminary research was initiated in 1975 and completed in 1977 to determine the effectiveness of trunk treatments, foliar sprays and soil fertilization in improving the condition of declining sugar maples (*Acer saccharum*).

Trunk treatments consisted of ten different nutrients applied separately and in various combinations. Two grams of the nutrient salts were either implanted in gelatin capsules or injected on a four-inch spacing near the base of affected trees.

The same nutrient salts were used as foliar sprays by dissolving one teaspoon in a gallon of water (combination sprays contained one teaspoon of each nutrient salt) and spraying the leaves of selected branches until runoff. The nutrient sources for the trunk and foliar treatments are given in Table 1.

Table 1. Nutrient sources for trunk and foliar treatments in preliminary tests

Nutrient	*nutrient source*	*Elemental*
nitrogen	urea	8.5%
potassium	potassium sulfate	15.0%
phosphorus	mono-sodium phosphate	21.0%
calcium	calcium acetate & calcium chloride	9.5%
magnesium	magnesium sulfate	4.0%
manganese	manganese sulfate	3.4%
iron	ferrous sulfate	2.2%
zinc	zinc sulfate	1.3%
copper	copper sulfate	0.9%
boron	boric acid	0.6%

The soil fertilization treatment consisted of high nitrogen, complete fertilizer applied to the root area within the dripline at the rate of 6# N/1000 square feet.

Results from the preliminary study were varied and inconsistent, possibly due to variabilities in test sites, timing of treatments and degree of decline.

Soil fertilization elicited the most consistent responses as evidenced by darker green leaves, increased growth and no further dieback (Figure 1, 2, 3). Trunk and foliar treatments containing manganese also improved leaf color, but results were less frequent and less uniform than from soil fertilization (Figure 4). Manganese treatments that contained nitrogen were more effective than manganese alone. None of the other nutrient salts

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elicited a visible response during the three-year study.

CURRENT RESEARCH

More extensive research with soil fertilization and trunk-applied manganese was planned in the City of Grand Rapids, Michigan. With the help of the City personnel, several streets were identified with declining sugar maples. The maples were divided into two studies:

(1) manganese treatments applied to the trunk of selected trees.

(2) manganese treatments applied to individual branches within selected trees.

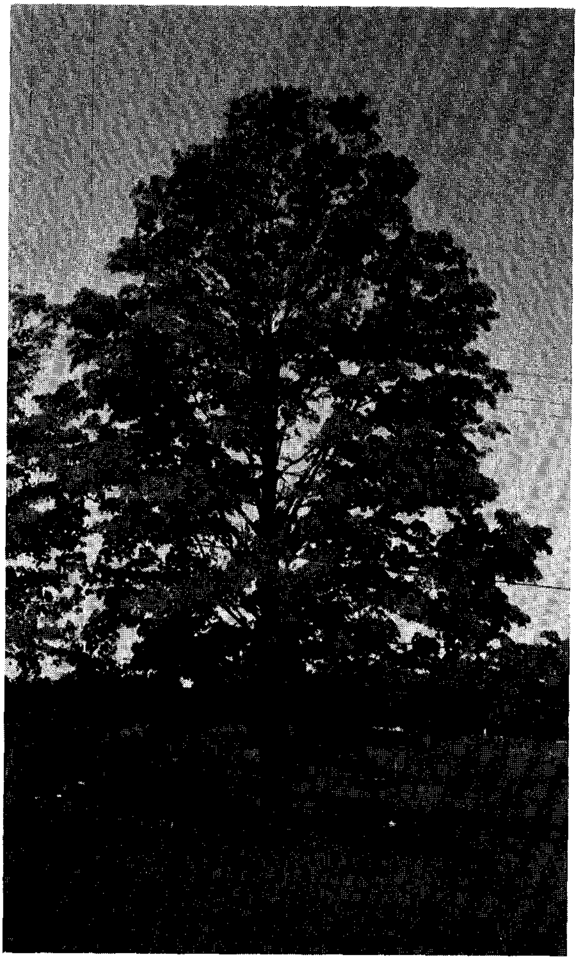

Figure 1. Year one. Sugar maple displaying initial symptoms of maple decline.

The trees in both studies were treated on May 10 and 11, 1979, with five different manganese treatments, soil fertilization, and manganese treatments plus soil fertilization. At the time of treatment, the leaves were either in the tight bud or initial expansion stage.

Trunk and branch treatments

1. Liquid injection

For Treatment No. 1, Mauget capsules were filled with 2 grams manganese sulfate monohydrate dissolved in 4 ml. distilled water.

For Treatment No. 2, Mauget capsules were filled with 1.6 grams manganese sulfate monohydrate and 0.4 grams of soluble 30-10-10 fertilizer dissolved in 4 ml. distilled water.

For Treatment No. 3, Mauget capsules were filled with 2 ml. manganese nitrate dissolved in 4 ml. distilled water.

The Mauget capsules were installed about four inches apart in a spiral pattern near the base of the tree or limb.

2. Dry implantation

Capsules were prepared for dry implantation by filling No. 000 gelatin capsules with a total of 2 grams of material.

For Treatment No. 4, the capsules contained 2 grams of manganese sulfate monohydrate.

For Treatment No. 5, the capsules contained 1.6 grams of manganese sulfate monohydrate and 0.4 grams of 30-10-10 fertilizer. The capsules were placed about four inches apart in a spiral pattern near the base of the tree or limb.

Trunk and branch treatments plus soil fertilization

Treatment No. 6 = Treatment No. 1 + Treatment No. 11 (soil fertilization)

Treatment No. 7 = Treatment No. 2 + Treatment No. 11

Treatment No. 8 = Treatment No. 3 + Treatment No. 11

Treatment No. 9 = Treatment No. 4 + Treatment No. 11

Treatment No. 10 = Treatment No. 5 + Treatment No. 11

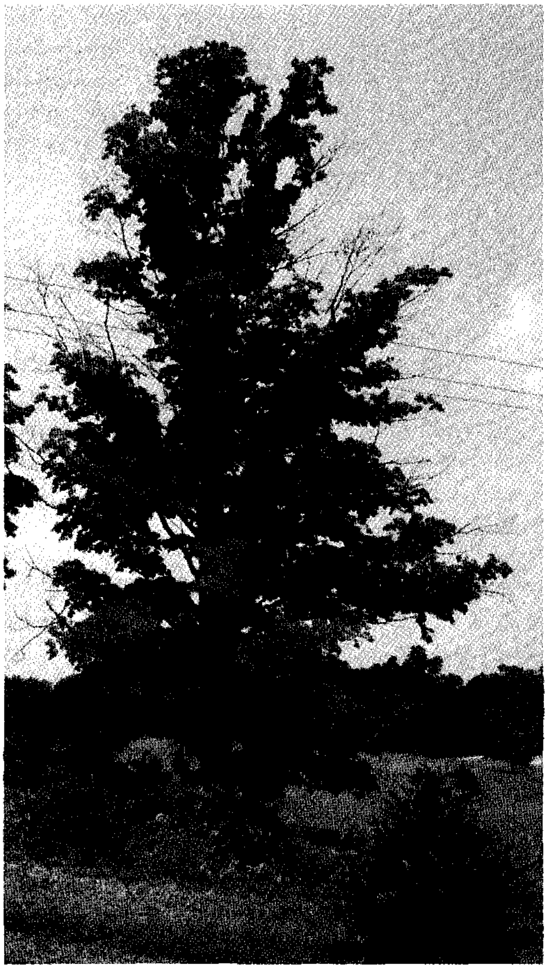

Figure 2. Year two. Advanced symptoms of maple decline. Tree fertilized with high nitrogen, complete fertilizer.

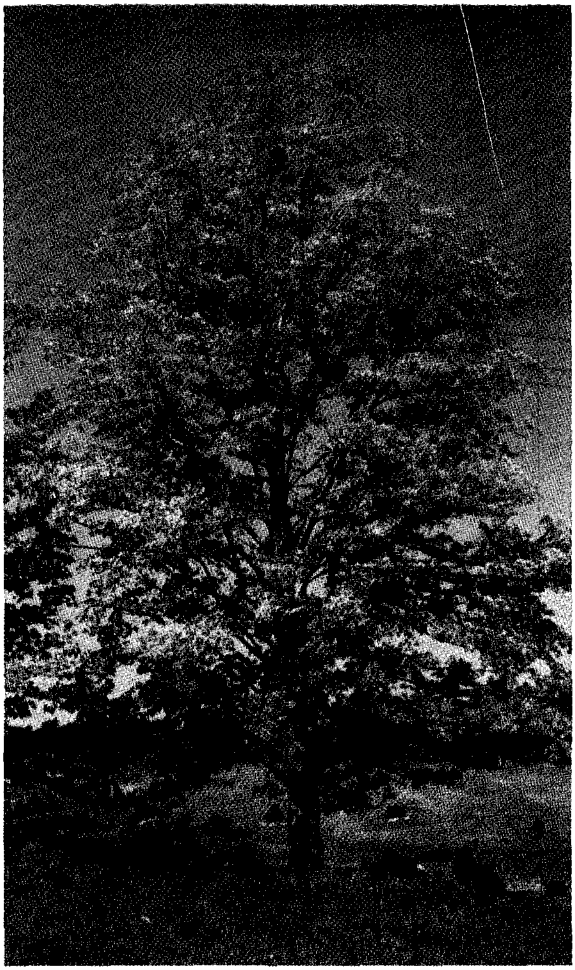

Figure 3. Year four. Two years after initial fertilization, sugar maple has lush, green foliage, good growth and no further dieback.

Soil Treatments

For Treatment No. 11, forty pounds of Arbor-Green (30-10-7) were suspended in 100 gallons of water. Injections into the root zone with a probe were spaced three feet apart, and ½ gallon of the mixture was applied at each injection point. This technique applied 6 pounds of nitrogen from ureaformaldehyde; two pounds of phosphorus (P_2O_5) and 1.4 pounds of potassium (K_2O) from monopotassium phosphate; and 50 gallons of water per 1000 square feet of root area within the dripline.

The water control (Treatment No. 12) was injected at the same rate of water using the same technique as in Treatment No. 11.

RESULTS

The trees were evaluated on July 24, 1979, which was 74 days after treatment. The trees and branches were rated on a scale of 1 to 10 (with 1 representing a dark green color and 10 representing a very chlorotic leaf), and compared to the 1978 ratings. The difference between the color value for the two years is referred to as color improvement (see Table 2).

In determining the estimated standard deviation of the difference of the two sample means, the assumption was made that the samples were not independent since the same trees or branches were observed before and after treatment (Clark, 1979).

Tree trunk study

Two of the manganese treatments resulted in a color improvement but only Treatment No. 4 was significantly different at an acceptable level of confidence. The leaves on some branches were dark green although the response within the canopy was irregular.

All of the manganese plus soil fertilization treatments were significantly different at an 80% or greater level of confidence, and responses were fairly uniform throughout the canopy.

Soil fertilization alone elicited as great a color improvement as manganese plus soil fertilization and was significantly different at a 95% level of confidence.

Branch study

None of the manganese treatments alone elicited a response when implanted or injected into individual branches.

All of the treatments which contained soil fertilization elicited a color improvement significant at a 90% or greater level of confidence.

Soil fertilization alone elicited as great a response as soil fertilization plus manganese treatments.

The water-treated trees in both the tree trunk and branch studies did not visibly improve in color.

Nutrient study

At the time the leaves were evaluated for color, samples were taken from each tree for tissue analysis. Leaves from both the tree and branch study were analyzed with the assistance of Dr. Elton Smith, extension horticulturist for Ohio State University. The data were grouped according to color evaluation regardless of the treatment. Unfortunately, the samples were not analyzed for nitrogen but a definite pattern was established for the other elements. The information for leaf samples rated as 1 and 2 was combined under *Healthy*, and for 9 and 10 under *Chlorotic*, in

Figure 4. Manganese trunk injection elicited irregular response.

Table 3. In testing for a significant difference between the *healthy* and *chlorotic* samples, it was assumed that the population variances are unknown and unequal and that the samples are independently drawn (Wonnacott, 1977).

In the tree trunk study, the nutrient level for the *chlorotic* leaves was lower than in the *healthy* leaves for all of the elements except copper, sodium and aluminum.

The level of copper was not significantly different. The level of sodium and aluminum was actually greater in the *chlorotic* leaves.

The difference in nutrient level between the *chlorotic* and *healthy* leaves was significant at an 80% or greater level of confidence for all of the elements except potassium and copper (unchanged).

In the branch study, the same pattern developed. The nutrient level for all of the elements was lower in the *chlorotic* leaves than the *healthy* leaves except for sodium and aluminum. The level for both of these elements was, again, higher in the *chlorotic* leaves.

The differences in the nutrient level for the *chlorotic* and *healthy* leaves were not as significant as in the Tree Trunk Study for most of the elements.

Table 2. Average color improvement to trunk- and branch-applied manganese treatments and soil-applied fertilizer.

Treatment number	No. of trees	Average Leaf Color rating 1978	Average Leaf Color rating 1979	Color improvement	Significant difference level of confidence
Trunk Study					
1	3	3.6	3.6	0.0	—
2	5	6.0	5.4	0.6	65%
3	4	N/A	N/A	N/A	N/A
4	3	4.3	4.0	0.3	90%
5	3	5.0	4.6	0.3	60%
6	3	6.6	5.0	1.6	75%
7	4	4.0	2.0	2.0	80%
8	4	5.2	3.2	2.0	85%
9	4	6.0	5.6	0.3	90%
10	4	6.7	5.0	1.7	75%
11	3	6.3	4.3	2.0	95%
12	3	2.3	2.3	0.0	—
Branch Study					
1	3	6	6.0	0.0	—
2	3	6	6.0	0.0	—
3	3	6	6.0	0.0	—
4	3	6	6.0	0.0	—
5	3	6	6.0	0.0	—
6	3	7	3.3	3.3	95%
7	3	7	3.0	4.0	90%
8	3	7	3.6	3.3	95%
9	3	7	3.6	3.3	95%
10	3	7	3.6	3.3	95%
11	3	7	3.6	3.3	95%
12	3	7	7.0	0.0	—

*Color rating on a scale of 1 to 10, with 1 representing dark green leaves and 10 representing chlorotic, undersized, and scorched leaves.
N/A = Not available

DISCUSSION

Although maple decline has become a serious problem only within the past decade, references to declining maples occur over a period of at least 50 years. In 1931, Homer Jacobs, former vice president of research for The Davey Tree Expert Company and currently horticulture consultant for Holden Arboretum, reported dramatic improvements in declining maples following proper soil fertilization. Our preliminary and ongoing research supports his conclusions.

Initial research conducted in 1975-77 indicated that soil fertilization with high nitrogen fertilizer and trunk or foliar treatments with manganese were often effective in improving the color and growth of sugar maples symptomatic of maple decline. Further research has shown significant and fairly consistent results from high nitrogen fertilizer applied to the soil and occasional results from trunk-applied manganese. In general, response to soil fertilization was fairly uniform throughout the canopy, whereas, manganese response was irregular although often more dramatic than that from soil fertilization. The fact that the manganese sometimes elicited a response without soil fertilization suggests the possibility of more than one problem masquerading under the same symptoms as suggested by Kielbaso (1976).

The nutrient level was lower in *chlorotic* leaves than in *healthy* leaves for all of the elements listed except sodium and aluminum. The extremely high sodium level found in *chlorotic* leaves lends support to the thought that salt (sodium chloride) is involved in sugar maple decline along highways.

Perhaps more definitive conclusions can be

Table 3. Average nutrient level (ppm) of *healthy* (color rating 1 and 2) and *chlorotic* (color rating 9 and 10) sugar maple leaves.

	Trunk Study				Branch Study			
Element (ppm)	*Healthy (13)**	*Chlorotic (5)**	*Difference in nutrient level*	*Significant difference level of confidence*	*Healthy (5)**	*Chlorotic (5)**	*Difference in nutrient level*	*Significant difference level of confidence*
phosphorus	1653.	1152.9	500.1	95 %	1746.8	1574.	172.8	70%
potassium	4689.	4268.4	421.	75 %	9002.8	6260.4	2742.1	99%
calcium	13341.	7807.8	5533.2	97.5%	10269.	8743.	1526.	75%
magnesium	2006.	1316.8	689.2	97.5%	1340.	1107.2	232.8	80%
sodium	13.2	362.6	-349.3	90 %	12.1	487.1	-475.	80%
manganese	96.5	29.3	67.1	99 %	148.1	117.2	30.8	60%
iron	166.4	52.6	113.7	80 %	49.5	48.4	1.0	60%
boron	59.	35.1	23.8	99 %	58.0	38.2	19.7	95%
copper	2.6	2.7	-0.0	0 %	3.5	2.2	1.2	85%
zinc	15.8	12.8	2.9	85 %	12.6	9.7	2.8	97%
aluminum	25.5	38.4	-12.9	90 %	28.1	29.5	-1.4	75%
strontium	18	12.6	5.3	90 %	9.8	5.9	3.9	90%
barium	11.6	5.9	5.6	97.5%	5.4	4.4	1.0	80%

*Number in parenthesis indicates number of samples.

drawn as the research continues and the sample size increases.

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