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# A STUDY OF CHLOROSIS IN WOODY ORNAMENTAL PLANTS IN OKLAHOMA

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# A Study of Chlorosis in Woody Ornamental Plants in Oklahoma

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Chlorosis, an "anemic" condition of ornamental plants, is a common problem of nurserymen and homeowners in Oklahoma and the Southwest. The problem has increased under drought conditions of the past few years. This yellowing of the normally green foliage may progress from a pale green color to a definite yellow coloration, followed by death of the leaf tips and edges and then the entire leaf. This leads to reduced vigor, slow growth and eventual death of the affected plant.

The Oklahoma Agricultural Experiment Station has been studying this problem during the past three years. The problem is being attacked in three ways: (1) testing the response of plants to iron-containing materials, (2) testing methods of applying materials, and (3) determining the effect of soil treatments designed to increase soil acidity. This publication reports results of the study to date.

## Previous and Preliminary Studies

Previous studies have indicated that deficiencies of iron, boron, calcium, copper, magnesium, manganese, zinc and other materials cause yellowing of plant foliage. Lack of available iron, particularly, has been noted as a cause of chlorosis.

An experiment to determine the relative amounts of iron in chlorotic and in green healthy foliage substantiated earlier research indicating that the amount of actual iron present in the foliage may not be directly related to foliage chlorosis, but that the important factor is that the iron be in an assimilative form. For example, a spectographic analysis of a sample of five leaves each from twenty plants of Japanese Flowering Quince, (Chaenomeles lagenaria) that were severely chlorotic (rated 1.5, see rating scale page 3) contained almost as much iron (Fe 0.008%) as a similar sample of green (rated 5.0) healthy foliage (Fe 0.009%).

## Tests with Iron-Containing Products

Preliminary investigations in 1954 using chelated iron, zinc, manganese and other materials indicated that lack of iron in a form capable of being assimilated was the chief cause of chlorosis on ornamental plants in Oklahoma. Therefore, emphasis was placed upon this phase of the investigation.

## Methods

As the study progressed, several iron-containing products, including chelated and non-chelated iron, were supplied to plants, and comparisons were made to determine which substances produced the best results. The products used are listed below. For reference purposes, the materials tested will hereafter be designated by their alphabetical key.

a Sodium ferric ethylenediamine tetra-actate (Sequestrene NaFe (Chel 153)-Geigy Agr. Chemicals, N. Y.) (1)

b Monosodium hydrogen ferric diethylenetriamine penta-acetate (Chel 330 - Geigy Agr. Chemicals, N. Y.) (1)

c An iron complex of the sodium salt of ethylenediamine tetra-acetic acid (Iron Tetrine - Glyco Products Co., Empire State Bldg. N. Y. ) (1)

d A 10% aqueous solution of "C" (Ferralkine LS - Glyco Products Co., Empire State Bldg. N. Y. ) (1) (2)

e An iron sodium salt of ethanol ethylenediamine tri-acetic acid (Versenol Iron Chelate - Dow Chemical Co., Midland, Michigan) (1)

f Ferrous sulfate

g Ferric ammonium sulfate

h Ferrous ammonium sulfate

i Ferric nitrate

j Ferric ammonium citrate

k Iron malanate (Nu-Iron-Tennessee Corp., College Park, Georgia)

All plants used in the tests were known to be subject to iron chlorosis, and both evergreen and deciduous types were used. The plants treated included:

Quercus palustris -- Pin Oak
Chaenomeles lagenaria -- Japanese Flowering Quince
Spiraea thunbergi -- Thunberg Spirea
Taxodium distichum -- Common Baldcypress
Abelia grandiflora -- Glossy Abelia
Euonymus kiautschovicus -- Spreading Euonymus
Euonymus fortunei erecta -- Euonymus
Euonymus japonica -- Evergreen Euonymus
Juniperus procumbens -- Japanese Garden Juniper
Juniperus sp. H. V. -- Armstrong Juniper
Juniperus sabina H. V. -- VonEhron Juniper

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(1) Chelated iron products
(2) Manufacture discontinued

A rating scale was arbitrarily established to designate the degree of yellowing (chlorosis) of the plants under observation as follows:

Color Rating Scale

| | Rating |
|---|---|
| Severely chlorotic, to the point of necrosis (dead tissue) | 1 |
| Severely chlorotic | 2 |
| Moderately chlorotic | 3 |
| Slightly chlorotic (leaf tips and interveinal areas) | 4 |
| No chlorosis. Healthy green foliage | 5 |

Results

Several tests with a number of plant materials indicated the value of chelated iron treatments. A typical example was a block of stunted, severely chlorotic Euonymus (Euonymus fortunei erecta) growing in a Dale silty loam soil. The iron-containing materials were placed in two-inch furrows on one side of the row, covered, and watered by irrigation. Results are shown in Table I.

Table I. --Response of Euonymus (Euonymus fortunei erecta) to Iron-containing Materials

| Treatment [1] | Av. Height | Foliage Color [2] | Cost of Treatment per Plant |
|---|---|---|---|
| | Prior to Treatment | | |
| | 2.60 inches | 1.5 | --- |
| | 56 Days After Treatment | | |
| Check (no treatment) | 3.77 inches | 1.5 | --- |
| Ferric nitrate | 3.30 inches | 2.0 | 2.0¢ |
| Ferrous sulfate | 3.30 inches | 2.0 | 2.0¢ |
| Ferrous Ammonium sulfate | 3.90 inches | 2.0 | 1.5¢ |
| Chelate A | 4.00 inches | 3.5 | 0.46¢ |
| Ferric Ammonium sulfate | 4.13 inches | 2.0 | 0.52¢ |
| Chelate E | 6.37 inches | 5.0 | 0.46¢ |
| Chelate D | 6.43 inches | 5.0 | 0.095¢ |
| Ferric Ammonium citrate | 6.70 inches | 3.5 | 0.66¢ |
| Chelate B | 6.70 inches | 5.0 | 0.46¢ |

Growth data show that very excellent results were obtained with Chelates B, D, and E and with ferric ammonium citrate. Foliage color also was rated excellent for Chelates B, D, and E, but lacking for ferric ammonium citrate. Chelate D was the most economical and produced excellent color as well as growth.

(1) Treatment was 1.9 grams per plant. Three replications. (453.59 grams for pound)

(2) 1 = Severe chlorosis, some necrosis ranging to 5 = Dark green foliage

## METHODS OF APPLYING MATERIALS

### Methods

Three methods of applying materials were compared. They included (1) soil applications, (2) foliage sprays, and (3) direct applications into the trunks of trees (see Figure 1). The soil applications were made in furrows, 2 to 3 inches deep, along the row of small nursery stock (liners), or around the drip line of trees. Foliage sprays were made with a compressed air sprayer using a solution of 6.5 percent concentration. Mauget feeders [1] were used to introduce solutions directly into the xylem (conducting) tissue of the trunk.

Pin Oaks (Quercus palustris) were used to study the different methods of application. The trees tested were uniform in size (10 to 12 feet high and 1 1/2 to 2 inches in diameter) and growing in a Kirkland silt loam soil over a clay subsoil. The soil pH averaged about 7.0. The treatments were randomized and replicated three times.

### Results

Trunk applications produced the maximum improvement in the shortest length of time. Foliage applications ranked second in speed of correction, but the improvements were due, in part, to the fact that repeated applications were necessary because rain washed off the material into the soil. Soil applications required longer than the other materials to reach the foliage and improve the color. Later observations, however, indicated that soil applications produced a more complete and lasting effect.

### Chemical Treatment of Soil

Tests of the soil in which chlorotic trees and shrubs were growing indicated the pH to be 6.9 to 7.8 in most cases. Soils whose pH was 5.9 or lower usually produced plants with healthy green foliage. This agrees with other research work that shows iron to be available to plants in soils which are relatively acid.

### Methods

Two methods were used to test the feasibility of reducing the soil pH to a point where iron might become available to the plants. (1) Sulfur was composted with chicken manure at the ratio of 1 pound sulfur to 15 pounds of manure. This mixture was applied at the rate of 250 pounds of sulfur per acre. It was put on as top dressing and worked into the soil. (2) Sulfuric acid was applied as a weak water solution (4 ml sulfuric acid in 496 ml of water per plant) in a furrow or in pots.

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(1)Mauget Co. 3361 Union Pacific Ave., Los Angeles 23, Calif.

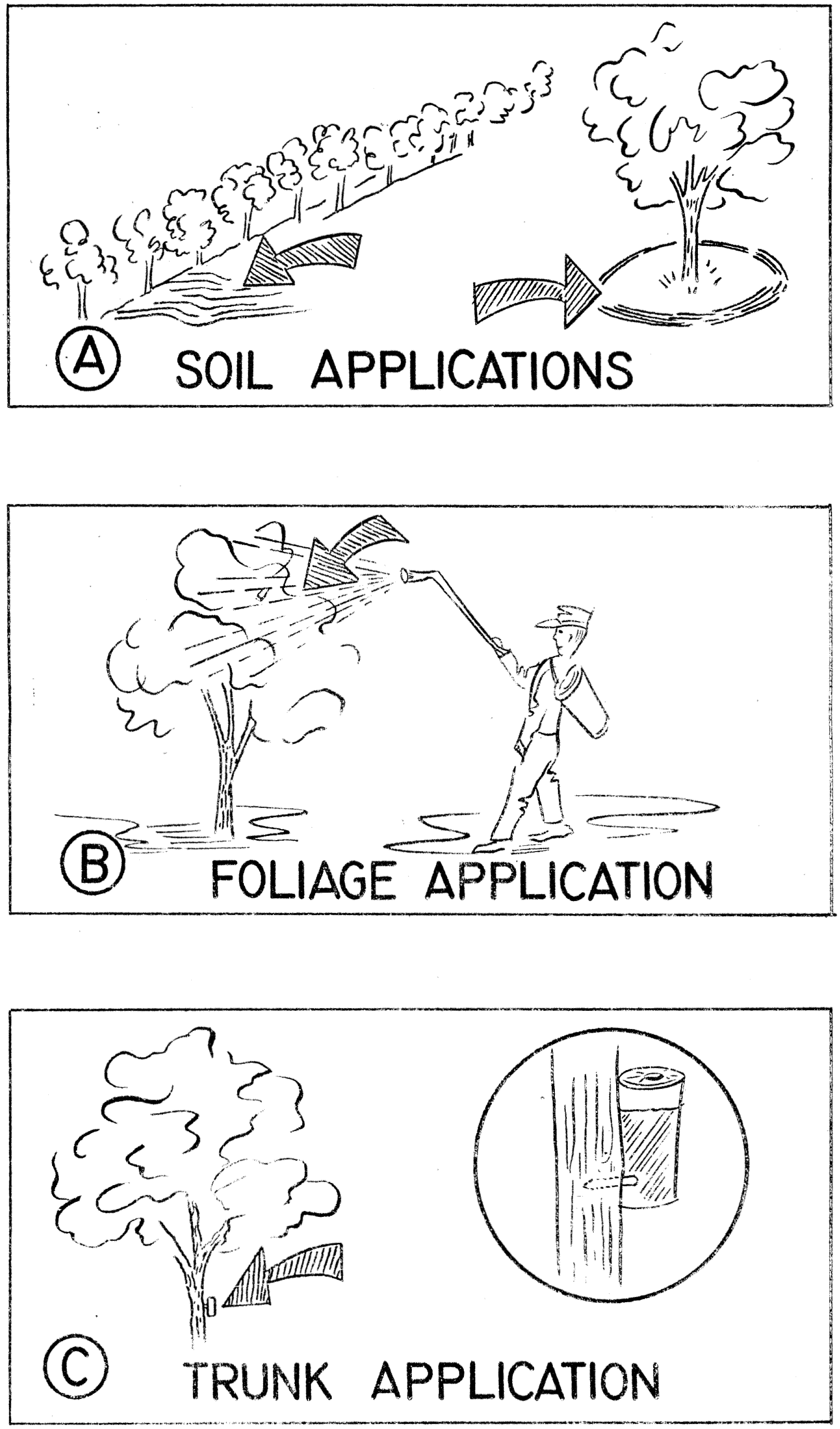
A SOIL APPLICATIONS
B FOLIAGE APPLICATION
C TRUNK APPLICATION

FIG. 1

## Results

Neither treatment produced any improvement the first year when used outdoors, with little rain and no irrigation. Potted chlorotic plants grown in the same Dale silty clay laom soil in the greenhouse reacted differently with an adequate soil moisture supply. The acid treatment of 500 ml of solution (4ml $H_2SO_4$ in 496 ml $H_2O$) lowered the pH of a 40-pound soil sample from 7.7 to 6.2 within four weeks and improved the foliage color of Glossy Abelia 3 points (2.0 to 5.0). The sulfur compost produced 1 point of improvement the first year as compared to 3 for chelate B and 2 for ferrous sulfate.

The sulfur compost reaction was the same on potted Pin Oaks. In both cases, however, the second year showed an increased improvement (2.0).

## SUMMARY

The Experiment Station has been working on chlorosis investigations since the summer of 1954. It has been established that:

(1) Usually chlorosis of ornamental trees and shrubs in Oklahoma is due to lack of iron in a form the plants can assimilate and that this condition is intensified by drought.

(2) Many Oklahoma soils contain sufficient iron (only small amounts are required by most plants to produce healthy green foliage) but that it does not reach the plant leaf in an assimilative form.

(3) The needs of a number of plants can be more readily supplied by several of the new chelated iron products than by iron sulfate.

(4) Treatments to lower the soil pH to a slightly acid state also result in the production of healthy green foliage on a variety of plants grown in certain soils under adequate soil moisture conditions.

(5) Only temporary improvement can be expected from applications of materials supplying iron as foliage sprays.

(6) Trees such as Pin Oaks suffering from iron chlorosis can be most readily treated by direct applications of chelated iron solutions not to exceed 2 grams of the chelated iron per liter of water. Stronger concentrations proved injurious to the foliage. Two 35 ml capacity Mauget feeders on opposite sides of a 2-inch trunk will suffice.

(7) If not in serious condition, soil applications at the rate of 1/2 pound per tree (2-inch trunk) of the chelated iron materials mentioned should be adequate treatment. Small liners (4" - 6") respond to only 2 grams per plant.

In most cases the soil application method is the most practical of the three methods tested. Soil moisture conditions must be satisfactory, neither dry nor saturated, but moist enough to get the material into solution. Five chelated iron products proved useful in treating iron chlorosis of ornamental plants (including many not specifically mentioned in the examples given).

Of the non-chelated materials, ferric ammonium citrate proved to be better than ferrous sulfate which has long been used as a corrective for iron chlorosis.

The application of these materials should be accompanied by good cultural practices and optimum soil moisture, neither too dry nor too wet.