Total Nutrition for Trees
and
A Technique for Solving Chlorosis Problems

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Nutrition of trees with limited root systems or those planted in small spaces where soils are alkaline has perplexed scientists for years. Calcium or other bases that raise the soil pH and reduce the availability of micronutrients may be inherent in the soil or the result of residues from construction or the slow accumulation of minerals in the irrigation water or a combination of factors. The end result is poor plant growth.

Years of work in Florida where micronutrient deficiencies are rampant led me to conduct a huge and complex experiment in 1980 that resulted in Micromax® micronutrient fertilizer. The product is a unique combination of the correct sulfate forms of iron, manganese, copper and zinc plus sodium borate and sodium molybdate. It has been very effective in eliminating micronutrient deficiencies and accelerating growth of plants grown in containers. Since about 1990 Micromax® has been the #1 selling micronutrient fertilizer in the world. The product was designed to be used in containers, but it seemed that it should aid plants in the field as well. I did a number of studies where Micromax was placed in holes in the soil around chlorotic trees. The treatment was not effective and excavation later revealed the micronutrients had reacted with the calcium in the soil and had become insoluble.

My focus then shifted to sulfur treatments of the soil surface. An assortment of experiments in Oklahoma showed that if enough sulfur was applied, the surface of the soil could be affected, thus lowering the pH and increasing micronutrient availability. The quantity of sulfur required varies with the soil type and level of calcium and other bases in the soil. In some cases, several applications were necessary over a period of two years or more in order to make a change in soil pH without damaging the grass or groundcover growing on the soil surface. The desirable thing about the sulfur treatment was the general increase in availability of all the micronutrients and not just iron, plus the long lasting effects that address the cause of chlorosis, not just the symptom.

The research that led to Micromax micronutrient fertilizer showed that the balance or proportion among the six micronutrient elements is very specific. If one element is out of balance with the others, chlorosis occurs even though all others may be near the correct level. Numerous experiences with what appeared to be iron chlorosis were not "cured" by applying iron. In fact, on some occasions the "chlorosis" became more severe after applying iron because it was really manganese deficiency. The additional iron made the ratio of iron to manganese wider and, in effect, increased the severity of the manganese deficiency. Work in Michigan has shown that at least some of the chlorosis of trees is manganese deficiency. In areas of the southwest, zinc deficiency may cause chlorosis.

One spring day in 1986, and with another review of the many factors involved in the chlorosis problem, a possible solution came to mind. Adding all of the micronutrients in the correct proportions to the soil seemed the "best" answer, but how? A combination of sulfur effects and Micromax micronutrients in the same hole might be the answer.

On May 4, 1986, eight chlorotic pin oaks were located. They ranged from mild chlorosis to severe chlorosis with some twig death. The trees ranged in size from five to eight inches DBH. The technique chosen was to auger holes two inches in diameter and about 10 inches deep in the soil with eight holes per tree. The first four holes were drilled about three feet out from the stem at the four points of the compass. The other four holes were drilled about five feet out from the stem and centered between the first holes. The objective was to contact most of the roots extending radially from the main stem.

In the bottom of the holes was placed ½ pound of Micromax® micronutrients, then ½ pound of granular elemental sulfur (92%), then the hole was filled with approximately one pound Osmocote 24-4-10 (Micromax® and Osmocote are products of the Scotts Co).

When the holes were drilled around the most chlorotic tree, a layer of lime rock sand and mortar remnants was encountered about five to six inches below the surface. This debris had been covered with sandy loam topsoil. Beneath the debris was a heavy clay. The other seven trees were all growing in heavy clay soils with pH ranging from 7.2 to 7.8. Only an occasional root was found when drilling the holes.

A check of the trees on May 25, 1986 showed an improvement in foliage color. Leaf color continued to improve during the growing season. The spring flush of growth in 1987 was a dark green for all trees except the specimen with the most severe chlorosis and growing conditions. A check of the trees in September 1987 revealed all to have a good green color and a strong bud set for the following spring. The next time the trees were evaluated in detail was June of 1990. All of the trees were dark green and attractive, even the one on the terrible site. A check with the homeowners confirmed that only broadcast N, P, K fertilizer had been applied to the turf. Further investigation was done with the tree on the most severe site. Soil samples from just outside the fertilizer hole contained many fine roots. Analysis of this soil showed a pH of 5.1 and 88 ppm iron and 120 ppm manganese, whereas originally the pH was 7.8 and iron and manganese availability were 4.0 and 8.1, respectively. Ten years after the initial treatment and with no further treatments other than normal N, P, K fertilization all of the trees remained a rich dark green and were growing well.

This technique provides a long term slow-release system of micronutrients and sulfur in a zone in and around each hole (see drawing). The sequence of events is probably as follows: 1) the holes are drilled and the micronutrients, sulfur, and fertilizer are placed around the tree. 2) With the first wetting, the Micromax micronutrients form a hard mass and small amounts of sulfur and N, P, K are released from the Osmocote into the soil immediately surrounding the hole. 3) With each successive rain or watering, a small amount of N, P, K and sulfur is released. The sulfur dissolved by the water forms a very dilute sulfuric acid, which dissolves a small portion of the micronutrients. The micronutrients and sulfur slowly lower the pH of the soil surrounding each hole. 4) New root growth in and around each hole aids in the absorptive capacity of the tree. This is encouraged by the N, P, K as well as the sulfur and micronutrients and the improved aeration. 5) Over a period of time, a zone of soil around each hole is modified to be lower in pH and rich in micronutrients in approximately the correct proportions. Note: substitutes for Micromax have worked poorly or not at all and Osmocote 18-6-12 has been the best performer in supplying the slow release N,P,K.

A plant does not require all roots to be in soil with optimum nutrient conditions for good growth. An array of studies have been done where one or more roots of a plant are in a soil or medium with favorable conditions of nutrient availability, plant growth is enhanced and the problem of the deficient nutrient is reduced or eliminated. In *Methods of Studying Root Systems* W. Bohm lists an array of techniques and over 1000 references on the subject.

The number of holes per tree should be approximately one per inch of stem diameter. A series of rings of holes starting about three feet out from the stem appears better than only a single ring further out (see drawing). Longevity of the treatment was more than 10 years on my study sites, but would be expected to vary with the severity of the conditions. This technique is an effective treatment for chlorotic trees on alkaline soils or trees where the root system has been damaged or reduced, with no risk to the health of the tree and with a cordless drill and two inch bulb planter type auger, is relatively easy to install.