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# IRON CHELATES FOR CHLOROTIC AVOCADO TREES

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In the 1952 California Avocado Society Yearbook we reported that the new chemicals, iron chelates, may be a possible method for controlling lime-induced chlorosis in avocado trees (2). Since that time a number of laboratory, glasshouse, and exploratory field studies have been conducted concerning the use of these chemicals. Several significant developments have occurred since that time, and as they relate to avocado will be briefly outlined in this report.

The iron chelate of EDTA did not give the spectacular results in the calcareous soils of the Western United States that it gave in correcting iron chlorosis of citrus on the acid sandy soils in Florida. Two reasons for this were the instability of iron EDTA in calcareous soils and also the ability of clay to bind EDTA on its surface. These two factors resulted in the requirement of from 5 to 20 times as much chelate to correct lime-induced chlorosis in trees in California as in Florida. The calcium carbonate and clay contents of western soils resulted in difficulty in moving chelates into the soil by irrigation application. Partly for this reason this method of control of lime-induced chlorosis is far too costly for use other than for ornamental plants.

Since 1952 the chemical industries have synthesized many new chelating agents in the hope that one might be developed that will economically control lime-induced chlorosis on calcareous soils by soil application. Several of these compounds have been evaluated in the Department of Subtropical Horticulture at the University of California at Los Angeles. The first new compounds tested that were designed to be extremely stable in calcareous soils were found to be more readily fixed on the soil clay than was EDTA (1, 3). However, a new compound, Chel 138 or EDDHA (ethylene-diamine di [ohydroxyphenyl acetic acid]), has been under study since December of 1954. The iron chelate of this compound not only has the ability to remain soluble in calcareous soils but also has the extremely desirable characteristic of not becoming fixed on the clay fraction of the soil, at least at alkaline pH values. The material appears to be relatively nontoxic to plants. The tests to date indicate that from 1 to 5 pounds of iron per acre chelated with this material may result in effective control of lime-induced chlorosis on avocado and many other crops, but not including citrus in California. This amounts to from 10 to 50 pounds of the chelate per acre. These application rates become more nearly economical for orchard application than those necessary with EDTA and other similar chemicals. The synthesis of this particular chemical compound is perhaps the most significant development in the iron chelate field to date.

In 1956 other new but less expensive compounds, including analogs of EDDHA, were available for study. No new compounds were found to be superior to EDDHA, although

one, with the code number RA 157, proved to be almost as good. Relative manufacturing costs will determine which of these compounds will be preferred for soil use. Both are undergoing pilot plant studies for cost evaluation.

Lime-induced chlorosis can make fruit trees unthrifty or can even kill them. The avocado tree on the bottom is essentially dead. The cause was lime-induced chlorosis. The avocado tree on the top is in the same orchard but this one received ten pounds of an iron chelate by soil application. After three months the tree became green. Newer chelates are effective at much lower application rates but are still in the experimental stage.

Most of the work at the University of California at Los Angeles concerning iron chelates has been done in the glasshouse and laboratory for the purpose of learning the basic behavior of these chemicals, both in soil and in the plant. In addition to these studies, a planting of avocados in La Habra Heights on the property of E. W. Driver has been used to test the laboratory findings under field conditions. The orchard is 35 years old with trees on Mexican seedling roots. Approximately 200 trees in this orchard have been severely iron chlorotic for several years. Some of the trees have died from the chlorosis. The soil is Hacienda loam which contains 32% calcium carbonate. How much the irrigation procedures contributed to the development of the chlorosis is not known. The grower has used liberal amounts of sulphur in recent years in an attempt to correct the situation, but this has been ineffective. Tests have indicated that only a thin layer of the surface soil has been acidified by the sulphur. The iron chelate treatments were started in the orchard in the summer of 1953, when 1 and 5 pounds of iron EDTA and smaller amounts of other iron chelates were applied to separate trees and washed into the soil with irrigation water. An injection of 625 mg. iron as HEEDTA (1, 3) was made into one of the trees.

It has been our experience in this orchard that treatment responses have not been evident from soil applications for from 3 to 6 months following the application. The 5-pound EDTA applications gave a slight response and the smaller soil applications gave none. The injected iron resulted in considerable leaf burn on one branch of the tree, but subsequent new growth came out green. Later in 1953 a 10-pound application of iron EDTA was made under one tree and later an application of 10 pounds of iron DTPA was made to another tree. In the spring of 1954 both these trees had become green and have remained green until the present date (1957). The DTPA response has been more complete than the EDTA responses.

In the summer of 1954 several additional trees were injected with from 200 to 350 mg. iron as EDTA and also others with an equivalent amount of manganese EDTA, both singly and in combination with iron. Within one month the iron-injected trees were considerably greener than untreated trees. There was no response to manganese. The iron injections were made by boring a series of holes around the trunk of the tree, usually five or six, and inserting glass tubing that had been bent and pointed into the holes and filling each of them with about 10 ml. of the iron solution. In the summer of 1956 these injected trees were still in considerably better condition than the untreated trees, and in some responses were as good as those that had received soil application. About one half hour's time per tree was necessary to install the injectors. These treatments resulted in the trees becoming somewhat unsightly because of the exudation of sap through the holes and the development of molds on the exuded sap.

In the fall of 1954 several trees were treated separately with 10 and 15 pounds of iron EDTA and iron DTPA each. Immediately after this application there was a three-inch rainfall. Within three months each of these trees was normally green and has continued thus until the present time.

In February of 1955 enough of the new iron chelate (Chel 138) was available to supply one pound to one tree in this orchard by soil application. In May of 1955 sufficient was available to apply one pound separately to each of several other trees. By July there were sufficient responses from these one-pound applications to indicate that the

possibilities are extremely good that one pound per tree of this material, which contains 10.7% iron, might be an effective control of lime-induced chlorosis on mature avocado trees. This is equivalent to about four pounds of iron per acre. How much less than one pound per tree would be effective is not yet known by field test, but laboratory tests indicate that smaller rates could be effective — such as one-half or less of this amount (4). In 1956, 27 trees were treated with three metal chelating agents at three application rates with three trees for each treatment. EDDHA and RA 157 proved equally effective except for the lowest rate, which was equivalent to about two pounds of iron an acre, where EDDHA was superior.

How long the responses from any soil treatment will last is unknown, although many of the trees in this particular orchard that have been made green continue to be green even after two years or more from the original application. With other species of plants we have observed that repeated applications are necessary to maintain green color. This particular avocado orchard, however, several years ago was green and an adverse condition resulted in the almost complete development of lime-induced chlorosis. It is possible that once the trees are made green again they will have the ability to maintain themselves and obtain their iron from the regular soil sources without additional amendment applications. It could be that faulty irrigation practices several years ago induced the condition, and once the trees have been made green again with proper irrigation they might be maintained green.

It is evident that avocados are one of the easiest of plant materials to correct iron chlorosis by the use of metal chelating agents by soil application. This has been so easy to accomplish that spray application experiments have been relatively neglected. In the Driver orchard where we conducted experiments, soil application was economically feasible in that trees were kept from dying and those treated in 1954 and 1955 were producing good crops of fruit in 1956. Nontreated trees were not and, as mentioned, some had died. Spray applications would be less expensive because of economy of material. Intensive studies are being made on spray applications at the present time, with major emphasis on chemicals to be included with the sprays that increase leaf permeability to the chelates. As yet we do not know that spray applications can be as effective as soil applications.

The status of both spray and soil applications of metal chelates has been covered in considerable detail in the July, 1957, issue of Soil Science, which is devoted entirely to metal chelates in plant nutrition, and in a symposium presented before the Western Society of Soil Science in 1956. Copies of the latter can be obtained without charge from Geigy Agricultural Chemicals, 5542 East Ashcroft, Fresno, California. Both Dow Chemical Company and Geigy Agricultural Chemicals have partially financed the chelate studies at U.C.L.A. and their help is acknowledged.

## SUMMARY

The continued development of more promising chemicals that have the ability to chelate iron makes the correction of lime-induced chlorosis by these means extremely promising. An agent, EDDHA, has been developed that is extremely stable in calcareous soils, is little toxic, and will not become fixed on the clay fraction of soils.

One pound per tree of this material chelated with iron has given promising results with 35-year-old chlorotic trees. Less would probably suffice. This material is not yet commercially available (1957). Ten pounds of other iron chelates per tree have given excellent results, but these application rates are uneconomical. Other new chelating agents are being investigated for soil use and studies are being conducted on spray use.

## LITERATURE CITED


1. Lunt, O. R., Hemaidan, N., and Wallace, A. 1956 Reactions of some polyamine polyacetate iron chelates in various soils. Proc. Soil Sci. Soc. Amer. 20:172-175.
2. North, C. P., and Wallace, A. 1952 Lime-induced chlorosis in avocado and a possible method of control. Calif. Avocado Soc. Yearbook 37: 177-186.
3. Wallace, A., et al. 1955 Comparisons of five chelating agents in soils, in nutrient solutions, and in plant responses. Soil Sci. 80: 101-108.
4. Wallace, A., and North, C. P. 1956 Soybean pot tests as an index of soil application rates of iron chelates to correct lime-induced chlorosis in avocado trees. Symposium on the Use of Metal Chelates in Plant Nutrition. Pp. 48-50. Ed. By Arthur Wallace.