would like to entertain our Society. It will, however, be the policy of this Society to select its meeting place the succeeding meeting, only one year ahead. I mention this so that no one will become exercised about the 1938 meeting until the session in Ocala in 1937, where we will celebrate our fiftieth anniversary and Golden Jubilee. We selected our 1937 meeting place at the 1935 meeting in order to provide plenty of time for planning for our Golden Jubilee.

Mr. Poole: Doesn't a tree deposit in its leaves certain materials to be eliminated from the tree?

Answer: Under a condition of excessive mineral absorption, it is possible that these minerals may be eliminated through the leaves. Unquestionably, the falling of old leaves will eliminate certain quantities of these materials since they are generally high in ash content.

Question: Is it true that the analysis of the average leaf would be a true indication of what the leaves had taken up or absorbed?

Answer: Yes. Of course there has been a great deal of work done on total analysis of plants, and a great deal of criticism of the true significance of these data since no differentiation is possible between the active and inactive parts of the total analysis. Personally, I think that an analysis of the sap, along with the total analysis of dried leaves gives a better picture of the condition of the nutrition of the tree.

Question: May I make one comment? Isn't it true that the life of a tree (?) largely depends on the replacement of the leaves, and if there is a shortage of calcium or magnesium, doesn't that cause early dropping of the leaf?

Answer: Personally, the changed condition in the plant itself, as related to the soil, is a little obscrue and often far-fetched. There are many changes within the plant which apparently are independent of soil variations.

Question: Dr. H. says this: that the new growth will rob the older leaves of the calcium, and cause the leaves to drop.

Answer: There are always optimum, maximum and minimum conditions, and of course we should like to maintain the optimum condition, which gives what is known as "tone" to the tree. Often we fall short of that optimum and the results as expressed in the plant are often difficult to determine.

THE YELLOWING OF CITRUS LEAVES

A. F. Camp, Horticulturist in Charge, Citrus Experiment Station
and
Walter Reuther, Laboratory Assistant, Department of Horticulture

Yellowing of citrus leaves may result from a number of different causes and may be characterized in many different ways. Yellowing is not a distinct characteristic of any particular trouble any more than fever in the human organism is an indication of any particular disease. It is not particularly surprising that the disappearance of the green color in leaves, for that is what yellowing really is, should be quite common. The green color is chlorophyll which is an exceedingly complex system involved in the manufacture of carbohydrates and being a delicate and complex system many things may upset it and, in many cases, destroy the chlorophyll entirely.

The disappearance of chlorophyll may arise from several different sources. It may be genetic, as in variegation, and due to a fault in a growing cell so that the progeny of that cell do not produce chlorophyll; it may be due to a deficiency of some kind in the environment as a deficiency of light or of some chemical element required in its makeup; or it may be due to some toxic substance that destroys chlorophyll after it is manufactured or even inhibits its manufacture. Since the ability of a plant to manufacture carbohydrates is the very basis of its life processes anything which hampers or destroys this ability is serious.

The occurrence of variegation in which the

leaves are striped with white or yellow is not unusual in plants and in fact forms the basis for a number of ornamentals such as the variegated Sansevieria or Pittosporum. These arise from the derangement of a single cell resulting in its inability to transfer to succeeding cells the ability to produce chlorophyll. This cell represents a variant from the normal cell and when it occurs in the early stages of the growth of the leaf all of the cells derived from it are devoid of chlorophyll. As a result the yellow areas are usually fan shaped, spreading as they do from an original point. Sometimes this variegation may occur in the development of the embryo and the entire plant may be white, but such plants, though commonly seen in the seedbed, live only a short time due to their inability to nourish themselves. Older trees may commonly show a white stripe on an occasional leaf or an entire tree may be somewhat deranged genetically and almost all of the leaves will show white stripes to some degree. Buds from such a tree would be likely to produce a tree with the same characteristic and might be used for ornamentals, but never for commercial fruit production. The only remedy is to avoid taking budwood from trees which have a tendency to show this characteristic.

Diseases and insects commonly produce a yellowing of leaves, either of the whole leaves or of spots on the leaves. Melanose, scale, and six spotted mites are all common causes of this sort of trouble and most growers are familiar with the manifestations of their attacks. Mechanical injuries also may cause yellowing and wind injury caused a great deal of it this year throughout the central citrus belt. This sort of yellowing is too familiar to justify discussion in detail. It should be remembered, however, that the yellowing indicates a destruction of the manufacturing ability of the leaf and that the growth of the plant is dependent on this.

DEFICIENCIES

A common source of yellowing of citrus leaves is nitrogen starvation. This is commonly evidenced in Florida by a general yellowish green or light green color of the leaf, but it is usual to have the veins of the leaf more yellow than the areas between the veins. This sort of thing is very prominent in some groves in the tropics when trees are suddenly affected by quick acting trunk diseases which kill the bark and the living wood. The veins of the leaves become quite yellow with the areas between the veins green, a condition which could be quite aptly described as "inverted frenching." A few cases of this extreme condition have been observed in this state, but even these are not as pronounced as those commonly seen on the heavier soils in the tropics. More commonly nitrogen shortage is evident as a general yellowing of the leaves, with the veins a shade lighter than the areas between the veins, and the leaf is commonly thinner and more fragile than leaves from trees well supplied with nitrogen.

The so-called "deficiencies of minor elements" have received an enormous amount of attention during the last two or three years and in many of the popular papers generalizations have been freely made in which water or sand culture was applied literally to field work, or work on a specific crop or soil was transferred bodily to another crop or soil. The number of papers dealing with the effect of specific elements on specific crops is comparatively small and it is only from these that recommendations can be made with any degree of safety. This makes the field exceedingly difficult to discuss since the volume of published material might make it appear as though an enormous amount of information had been obtained, whereas only a very small amount of proved information is actually available. To cite a specific typifying the danger of generalizations: Zinc deficiency in citrus is characteristic "frenching," whereas zinc deficiency in tung trees is called bronzing because it produces a typical bronzed condition of the leaves not at all resembling frenching, in pecans zinc deficiency is called rosette and the typical chlorosis found in citrus is not present. On the other hand, a perfectly typical "frenching" of *Crotalaria* exists which does not respond to zinc and is apparently not a zinc deficiency.

Frenching will be discussed first because it is possible to give the diagnostic characteristics with a reasonable degree of accuracy and to be quite specific about some of the recommendations. Frenching of citrus called "mottle leaf" in Cali-

fornia and foliocellosis by Fawcett is characterized by a yellowing between the veins of the leaves with the veins and the adjacent tissues remaining green. Where the trouble is severe the leaves are small in size and narrow and in very severe cases may be almost "strap-like." Multiple buds are common and a bushy, shortened growth is produced giving the tree a sort of bristly appearance. Dying back is severe with the dying starting at the ends of the twigs and working back toward the center of the tree. It is common to find water sprouts with green leaves growing profusely in the center of the tree when all of the foliage on the outer twigs is frenched and limbs are dying back severely. The fruit is reduced in quantity and some large coarse fruit is usually produced near the center of the tree and small hard fruits on the frenched portions of the tree. The fruit in general is coarse and dry, and flat in flavor.

Frenching occurs in California on soils high in lime and in Florida on some East Coast soils which have an excess of lime. On such soils it occurs, apparently, due to the natural soil conditions and might be conveniently classed as "natural frenching" as it is due to naturally occurring conditions. Frenching also occurs in Florida on the lighter soils due to treatment that has been given the grove and might in contrast to "natural frenching" be classed as "induced frenching," having been induced by some treatment given the grove. In the first condition the frenching occurs in irregular areas in the grove and can be correlated with the amount of marl in the soil, while in the latter case it usually occurs uniformly over a whole block of trees and is coincident with the treatment. The treatments that may cause frenching are not always clear. Floyd reported frenching where liming had been excessive and in some experimental groves the history would indicate that liming has been a contributing cause, in other cases this relationship is not evident inasmuch as the frenching is occurring on soils very low in lime.

In studies by Kelley and Cummins of California and subsequently by others a low calcium and high potassium content was found in frenched leaves. Under some conditions this same relationship has been found to exist in Florida, though frequently it is much less clear than their data would indicate. This lack of clarity may be due to the effect of bronzing which frequently occurs in conjunction with frenching and might easily affect either or both the calcium and potassium content. It was first believed that frenching was a calcium deficiency, calcium being unavailable on alkaline soils even though the soils were high in limestone. Later it was interpreted as an iron deficiency. However, field work with iron salts fell down and it was found that the zinc in the salts used in the work was the real remedy. This illustrates again the caution necessary in work with elements which are needed in only small amounts.

It seems fairly well established now that zinc is a specific for frenching, though its exact role is still undetermined. Most of those present are familiar with the recommended methods for utilizing zinc sulfate for this purpose, and for that reason it will not be reviewed here. However, there has been some demand recently for recommendations covering the use of zinc oxide instead of zinc sulfate and some remarks concerning this may be desirable.

Zinc oxide has been used considerably in California as it fits in better with their spray program. We have been using it experimentally, but have not felt the definite need for making recommendations until we were sure of its value and its place in our spray program. This work will not be completed until fall, but the California work has attracted such attention that it is necessary to give some recommendations for its use at the present time.

Zinc oxide first came into prominence in California as a form of zinc that could be used in oil sprays. The fact that oil sprays are little used here during the spring period when zinc sprays give the best results makes it probable that this combination will be little used. However, for those who wish to try it, 2 lbs. of zinc oxide per 100 gallons of oil spray may be used. There is this exception, however, do not add zinc oxide to oil emulsions containing fish oil soap as this causes a coagulation which will stop up your sprayer. Zinc oxide can also be used successfully alone at the rate of 2 lbs. per 100 gallons of water or at the same rate in lime-sulfur and wettable sulfur sprays. Our chief interest in zinc oxide has been

with aim of obtaining zinc sprays with a minimum of residue. For this reason low concentrations are recommended, and it will be a little slower than the zinc sulfate-lime combination previously recommended. Further information on this point will be available before next season as extensive experiments on the effect of the various sprays on scale build up are being checked this season. Until this work is completed zinc oxide should only be used more or less experimentally.

BRONZING

Bronzing of citrus is perhaps the most difficult phase of leaf yellowing to discuss. California workers have very carefully figured the type of yellowing associated with magnesium deficiency in water culture. The diagnostic symptoms are yellow areas on each side of the midrib. There is also a bronze color associated with boron deficiency and this is associated with a pronounced corking of the veins on the upper side of the leaf, deficiencies of potassium and calcium are also figured. These symptoms are not always reliable in the field where something resembling magnesium deficiency is often found, but other characteristics are often associated with it. An overall bronzing is often seen that cannot be accurately classified. Bahrt reported in 1934 that magnesium in various forms produced a favorable response in some cases of bronzing. Bryan and DeBusk reported recently that bronzing is a magnesium deficiency, this conclusion being based on the efficacious effect of dolomitic limestone. Whether this took in all of the symptoms commonly classified as bronzing is not clear. Bahrt's experiments with dolomitic limestone and other forms of magnesium probably cover more types of soil and a much longer period than any other worker's in this field and so far he has not felt like drawing this conclusion. Observations would seem to indicate that applications of dolomitic limestone or other forms of magnesium will correct the condition present in many groves, but possibly not in all.

It should be remembered that these deficiencies are seldom as simple as they seem at first glance. They cannot be classified on an absolute basis because they are usually deficiencies as related to something else. In other words, it is more likely to be an upsetting of a balance rather than an absolute deficiency. Moreover, many of these things are very toxic when the amount present overbalances other elements present in the soil. Corrective treatments have received a lot of attention recently, but are makeshifts and should be used with caution. The ultimate aim should be to balance the entire program so that the need for corrective treatments will not occur.

TOXICITIES

While a typical boron deficiency seems hard to define in the field, boron toxicity is relatively easy to find, particularly around packing houses which have used the borax dip for treating boxed fruit. It has also been observed in the field when borax treated boxes were left under trees through a rainy period. This injury is typified by a yellow to white color of the leaf starting near the tip and later in severe cases involving the whole leaf. This injury is very typical and once seen can usually be distinguished. Many other toxicities exist, too numerous to mention, and more often than not our information is too meager to classify them accurately in the field. Such things are quite easy to identify in water or sand cultures under controlled conditions, but field classification is difficult. Most of them yield to a sensible program of fertilizers and pest control. If you keep in mind the fact that yellow leaves are boarders and not producers and try to keep good green foliage on the trees by means of a sensible program most of these troubles disappear.