additional evidence that they are separate and distinct diseases.

LITERATURE CITED


MOLYBDENUM DEFICIENCY IN CITRUS

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Preliminary investigations indicate that molybdenum deficiency is widespread in Florida citrus. The symptom caused by this deficiency is the well known yellow spot illustrated in Fig. 1. This disease occurs chiefly in Florida and was first described by Floyd (1) in 1908. Since then, numerous attempts have been made to determine its cause. The deficiency appears first as water-soaked areas in leaves in the early spring, and then develops into large interveinal yellow spots with gumming on the lower leaf surface late in the summer. In extreme cases, yellow spot may cause complete defoliation of the trees. Repeated studies (3) failed to demonstrate that it was due to an infectious fungus, bacterium, or virus. Yellow spot has been reported on practically all kinds of citrus but trees on grapefruit rootstock appear to be the most susceptible. The disease has been associated with acid soils and acid producing fertilizers such as ammonium sulfate.

Studies on other plants have indicated that molybdenum deficiency occurs chiefly on acid soils. By the use of radioactive molybdenum (4) it has been shown that this element tends to concentrate between the leaf veins in normal leaves; hence, in deficient leaves it would be expected that a breakdown would occur in the interveinal tissue first. In order to determine whether yellow spot of citrus was related to molybdenum deficiency, various amounts of molybdates were applied to trees as soil treatments and as nutritional sprays. No response to the soil treatments has been observed after two months. Molybdenum sprays, however, caused yellow spot leaves to become green within three to four weeks after the application was made. Some response was obtained from a concentration as low as one gram of sodium molybdate in 100 gallons of dilute lime sulfur spray, when 10 gallons was applied to each tree. This amounts to only 0.1 gram per tree. Complete greening of yellow spot leaves was obtained by spraying or injecting 1 gram of sodium molybdate in one gallon of water per tree. The lowest satisfactory amounts found have been one ounce of sodium molybdate or ammonium molybdate in 100 gallons of dilute lime sulfur spray, when 10 gallons was applied to each tree. Increasing rates up to 8 ounces per 100 gallons did not give marked improvement over the 1 ounce per 100 gallon treatments. Studies made with plants other than citrus indicate that large amounts of molybdenum are required to produce toxicity to the plant itself.

The amount of molybdenum actually needed by the tree is very small. Greenhouse studies (5) have indicated that molybdenum deficiency shows up in citrus when there is between .01 and .02 p.p.m. molybdenum in the dry leaves. Chemical analyses of yellow spot leaves and of leaves from healthy trees growing near by, have indicated that the molybdenum content was below .05 p.p.m. in both cases. The water soluble molybdenum as determined on soil taken from around yellow spot trees and that from healthy trees in the same area indicated it to be below .005 p.p.m.

Methods now in use for molybdenum analysis
are being revised for the determination of even smaller amounts of this element.

Preliminary microscopic examination of leaves having yellow spot shows that three main changes take place. First, gum and oil are deposited in the cell cytoplasm causing the cells to swell and close the air spaces within the leaves. Large deposits of gum are also formed within the intercellular spaces. In some instances there appeared to be a small amount of gum and oil in the nucleus. Second, cork cells are formed on the under sides of the leaves. Third, there is a decomposition of the chlorophyll causing the characteristic yellow spots. Spraying leaves with molybdenum brings about renewed production of chlorophyll and there are many indications that much of the gum is absorbed. The enlarged cells become more nearly normal in size. In some instances the molybdenum treated yellow spot leaves can be identified only by the remaining cork cells.

The work of Davis (2) and others on molybdenum toxicity in cattle in the Everglades is well known. Since large quantities of citrus peel are fed directly to cattle or used for production of processed cattle feed, general recommendations for the use of molybdenum in controlling yellow spot will not be made until it is determined how much molybdenum is retained on sprayed citrus peel after the fruit has gone through the canning plant.

It is not known at the present time in what form molybdenum will be available commercially. Molybdenum is important in producing military equipment, and some compounds may be in limited supply. Sodium molybdate and ammonium molybdate are very soluble and can be put directly into the spray tank. However, molybdic oxide is very in-
soluble in water but dissolves readily in alkaline solutions. For practical purposes molybdc oxide can be dissolved in sodium carbonate solution before putting it into the spray tank.

LITERATURE CITED

BORON NUTRITION IN CITRUS

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INTRODUCTION

Since the spring of 1948 more than a thousand determinations have been made on citrus leaves, fruit, twigs and roots in connection with boron nutritional studies in commercial orchards and at the Citrus Experiment Station. This paper is a part of that work and, following a literature survey, it includes a study of (a) leaf boron levels in commercial orchards on low boron programs, (b) boron symptoms related to leaf and fruit analysis and (c) some observations on boron treated grapefruit at the Citrus Experiment Station. From the available data an attempt has been made to estimate the supply and demand of boron for Florida citrus.

Numerous symptoms are listed for boron in the literature. From the publications of Haas (11), Morris (13), Roy (15) and Camp (5), it is possible to list eight symptoms for leaves, two for flowers, eleven for twigs and three for roots, or altogether a total of 24 symptoms for boron deficiency. Smith and Reuther (16) in their nutrient culture work, recently listed eighteen of these symptoms and added two more. With so many symptoms it may seem surprising that boron deficiency is so hard to identify with certainty in commercial orchards. The reason these symptoms are not as dependable as those for magnesium, manganese or zinc deficiency is because they are not as specific. A few examples will illustrate this point.

Multiple bud formation and dieback, along with gum formation inside the fruit, has been described for copper deficiency (6) as well as for boron (11). Chapman (7) has reported that prolonged nitrogen or iron starvation, potash deficiency or potash excess have all resulted in split corky veins of citrus leaves which was commonly considered a symptom of boron deficiency. A similar condition has been reported by Camp (5) where trees suffered from bronzing due to magnesium and manganese deficiency. Curling or buckling of leaves has been described for potash deficiency (12) as well as for boron. Yellowing along the midrib and lateral veins is a symptom described for boron deficiency, but it is also typical of starvation (6) (3). When such a symptom is associated with low nitrogen uptake the boron level may be even higher than in normal leaves. Workers in California (8) have reported that, with low nitrate availability to support normal growth, boron accumulated in lemon leaves faster than when growth was not retarded.

It is difficult to say which symptom or symptoms described in the literature are likely to be most specific for boron under Florida conditions. The only place where boron deficiency has been studied extensively in commercial orchards is in South Africa. Two of the outstanding symptoms described by Morris for Valencia trees in South Africa (13) were (a) the hard, thick rind, lumpy fruit with gum or translucent spots in the rind and gum deposits around the axis, and (b) translucent spots on the leaves, particularly on young leaves. Roy (15) showed that gumming similar to boron deficiency occurs in the albedo of grapefruit where arsenic sprays are used. Such gumming frequently occurs in arsenated grapefruit in Florida but it is not primarily due to boron deficiency. Translucent spots on citrus leaves associated with boron deficiency in Florida have been reported by Camp and Fudge (6). However, this symptom was not found in any of the orchards examined in this study.

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