Microelements in Citrus

spectrograph reveals presence and amounts of nickel and other trace elements in orange seedlings

A. P. Vanselow

Spectrographic methods revealed that nickel is extremely toxic to citrus plants.

The method is used to determine the presence and quantity of elements of such small amounts that they can not be detected by chemical means.

The spectrograph is a device for vaporizing a substance in an electric arc so that each element—as a gas—gives off its own particular radiations or light. This mixture of radiations is spread out and separated by means of a prism and lenses into a spectrum and is photographed on a film. Each element present radiates its own particular light. Thus, sodium gives off two very narrow bands of yellow light, potassium a few red and blue lines, barium a strong line in the green region, and strontium a strong line of red light. Most of the elements in the sample can be positively identified, many of them even when present in extremely small amounts. Some elements, such as sulfur, carbon, nitrogen, oxygen, and the halogens are not detected by the spectrographic technique used in this laboratory.

The intensity of the light given off by an element indicates the amount of that element present—the greater the percenage of that element the stronger will be its lines in the spectrum.

In the course of the analysis of citrus leaves by the spectrograph, several things became apparent. For some elements—such as copper, manganese, and zinc—it has been possible to establish roughly the percentages of these elements in leaves associated with a deficiency, but it is unknown what percentage of these elements constitutes an excess. In addition, citrus leaves contain elements whose function—if any—is unknown. Examples are aluminum, barium, cobalt, chromium, lead, nickel, silver, and strontium. Preliminary greenhouse experiments were set up to determine the toxicity of these elements to citrus. As an example of the type of exploratory greenhouse studies, results with the element nickel are given. This exploratory work will be followed by field tests to determine effects of these elements on tree behavior and fruit quality.

Sweet orange seedlings—C.E.S. No. 355—were grown for about 11 months in 2-gallon stoneware crocks filled with uniform amounts of the soil to which various amounts of nickel had been added.

Soil from the Citrus Experiment Station was used because its nickel content is low and leaf samples from this immediate area do not usually show detectable amounts of nickel.

The nickel was added to the soil in the exchangeable form—in combination with the clay particles—and not as soluble salt. Elements held in the exchangeable form are readily available to the plant but not subject to quick removal by leaching. A sufficient amount of soil was leached with a solution of nickel chloride almost to the point of saturation. The excess nickel chloride was removed by leaching with distilled water until the soil was free of soluble chlorides. The soil was dried and its nickel content determined by analysis. This nickel-saturated soil was added to enough of the original soil to give three pots of 22 pounds of soil for each of four concentrations of nickel, namely, 25, 75, 150, and 300 ppm—parts per million—of air-dry soil. A set of three pots to which no nickel was added was included as checks.

Sweet orange seedlings were germinated and grown in flats until about four inches tall. The most uniform seedlings were transplanted, three to each pot of soil and the pots were then watered with distilled water. During the 11 months of their growth the plants were always irrigated with distilled water, and care was taken to avoid excess water and leaching. All pots received two applications of .5 gram each of nitrogen as ammonium nitrate.

After 11 months of growth the plants were harvested. Each plant was divided into seven parts: youngest cycle of leaves,

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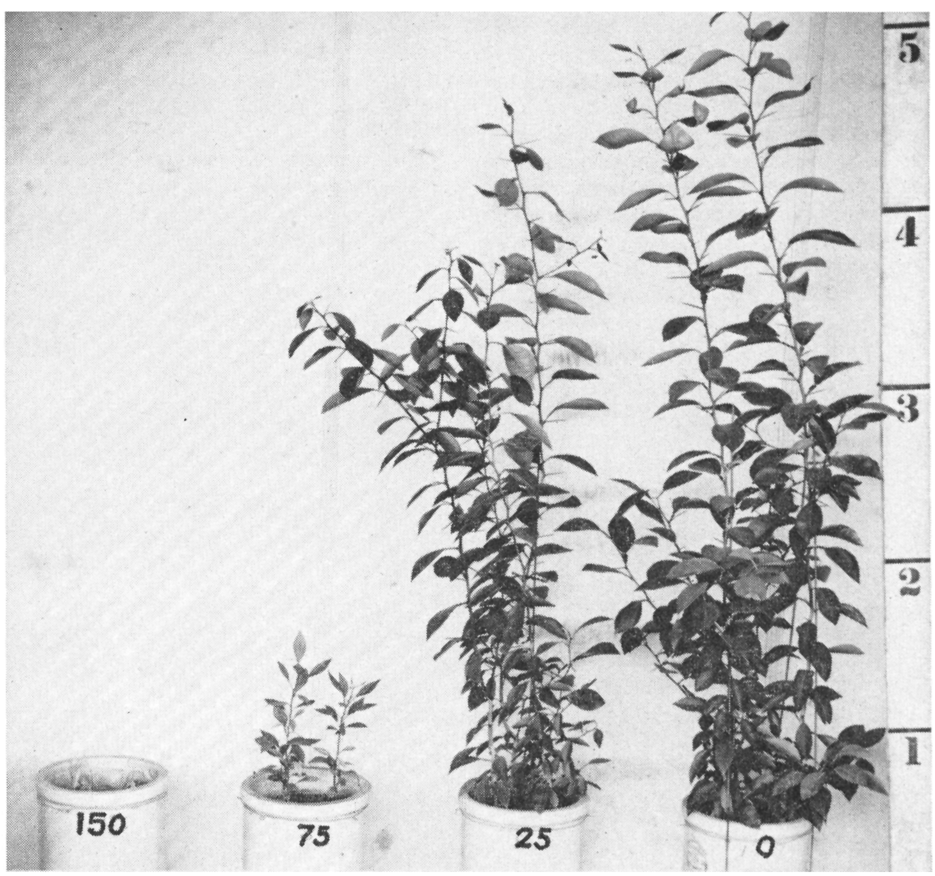
Comparative size of sweet orange seedlings grown at different concentrations of nickel in the soil. Numbers on the crocks indicate ppm of nickel added to the soil. The vertical marker indicates feet.



STRAWBERRY

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ticillium wilt. This holds true in most strawberry areas in California, but not in all because of strain variations in the fungus.

Infected tomato, potato, cotton and nightshade weed—*Solanum sarachoides*—are most commonly responsible for soil contamination with Verticillium. Land once infested with this fungus remains so for long periods of time, and rotations with other crops have not in general reduced the infestation significantly.

Black Root Rot

Black root rot is caused—at least in part—by a complex of soil organisms. Several different fungi, the root lesion nematode and possibly bacteria, in combination, appear to cause the roots to die.

Usually plants affected by black root rot decline sharply in their second fruiting year, rarely producing a satisfactory second year crop and almost never a third. In certain instances the plants decline rapidly during the first growing year, particularly if strawberries were grown previously on the land.

Isolations from black root rot plants have yielded many fungi. Probably significant are *Pyrenochaeta* (*Phoma*) *terrestris*—not reported previously from strawberry and known to produce a root rot of onion—*Phoma* sp. (possibly *P. radicis*) *Rhizoctonia solani*, *Pythium ultimum Stemphylium* sp. probably *S. radicinum*, *Fusarium oxysporum F. solani*, *Cylindrocarpon* spp. and several others, some of which are believed to be new to science.

In addition to the above fungi which grow readily in culture, microscopic examination of cleared sectioned roots revealed a great abundance of the endophytic fungus, *Rhizophogus*. Its presumed beneficial role in the nutrition of strawberry is strongly questioned.

Anatomical studies have yielded valuable information on the structure and potential longevity of the strawberry root system. The large, fleshy roots which arise from the crown are perennial in nature. In their first year they should be white until they develop vascular and cork cambiums. Healthy roots late in the first year and thereafter, add wood to the central xylem cylinder and cork to the outer bark tissues. Three layers should be distinctly visible in two years and older healthy strawberry roots, cut in cross section: *1*, the central cylinder of wood which is white; *2*, the inner bark which surrounds the wood and has the appearance of mother-of-pearl; and, *3*, the outer bark which is light to dark brown in color. If the central cylinder of wood is surrounded only by a loose punky dead bark, the root is diseased—black root rot—and the plant is on the decline. Specific information as to the natural longevity of the small lateral roots is not yet available.

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Harold E. Thomas, Director, Strawberry Institute of California; L. E. Gould, Junior Technologist, Shell Chemical Corp.; and E. C. Koch, Farm Advisor, Santa Cruz County, co-operated in the study.

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mature leaves, stem bark, stem wood, root bark, root wood, and fine roots. All parts were thoroughly cleaned, dried, and the separate portions of each plant were weighed. Similar parts of the nine plants from each treatment were combined for analysis, making seven samples to be analyzed for each of the five treatments.

The seedlings in the soil containing 300 ppm of added nickel died immediately after planting. Those planted in the soil having 150 ppm of added nickel made no new growth and died soon after planting. Plants in the soil to which 75 ppm of nickel had been added, made some growth but after 11 months their total dry weight was only approximately one tenth that of the control plants. The leaves on these plants showed some mottling which resembled that caused by a zinc deficiency. They had a lower top to root weight ratio than the controls. No root injuries were apparent. The plants grown in the soil containing 25 ppm of nickel were normal in appearance but of somewhat reduced size compared to the controls.

Similar experiments with copper additions to the soil indicate that nickel is considerably more toxic to sweet orange seedlings than copper.

The leaf samples were analyzed spectrographically. The results showed that the available nickel in the soil is readily taken up by the plants and can be detected easily in the leaves.

The presence of toxic amounts of nickel appears to lower the uptake of copper by the plant but not to the extent of producing a deficiency. The amounts of chromium found in the leaves are somewhat but not significantly increased. The amount of manganese in the leaves is not altered except when large amounts of nickel are present.

Only about 30% depression in growth was caused by the 25 ppm of nickel in the soil during this first year of growth. The ultimate effect on the mature tree is not yet known.

In only a few samples of leaves from citrus orchards has nickel been found in amounts that might be regarded with suspicion. One of these trees—containing 8 ppm of nickel—came from some trees which had received an extremely large application of sulfur to the soil. In this case the pH of the top foot of soil had been lowered to 3.3. These leaves also contained an excessive amount of manganese but it is difficult to say whether the manganese was dangerously high.

The southern California soils that have been analyzed for minor components have a nickel content of from 15 to 30 ppm. Two soils fall outside this range: the soil from the Citrus Experiment Station contains only 8 ppm, and a soil from Tulare County exceeds 100 ppm of nickel. The nickel present in the average soil will normally be in the form of very insoluble compounds, but if the soil is acidified to too high a degree the nickel will be made soluble and available to the plant. Besides nickel, other elements such as copper, manganese, and zinc may be rendered soluble in toxic concentrations by excessive soil acidification.

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WEED

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The alkyl 2,4-D esters of the lower alcohols are volatile and hazardous to sensitive crops. In their place a number of low volatile esters are on the market. Two of these are the butyoxyethanol ester and the propylene glycol butyl ether ester. These esters are superior to the salts and to the lower alkyl esters in controlling perennials. They approach the acid in this property.

Trials have proved repeatedly that the low volatile esters are effective wherever used on perennials.

Successful use of soil sterilants and translocated herbicides involves complex processes and requires detailed knowledge of the systems that function. Whereas contact spraying of annuals is relatively simple, use of these more involved methods requires understanding of soil-water relations, soil-plant interrelations, plant physiology and plant biochemistry.

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