

SOIL SCIENCES, U.C. RIVERSIDE

. . . a brief history of research contributions

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IN THE 60-YEAR HISTORY of research in soils and plant nutrition at Riverside, there have been four major, overlapping periods—during which more than 1,200 technical and semi-technical articles have been published. Any substantive account would fill a volume, and only a few major projects can be mentioned here.

The first of the four periods began in 1914, and the main concerns were alkali soils, salinity, water quality, and the phenomena of base exchange. In the second period, roughly 1927–1961, citrus nutrition and the development of related diagnostic techniques were the main areas of study. However, old and new salinity projects were continued, and significant information was developed on special citrus problems—for example, replant, small sizes, and fruit quality.

In the third period beginning in the early 1960s, undergraduate and graduate teaching programs were initiated. Emphasis in the continuing salinity and plant nutritional research was on basic studies of soil chemistry, coupled with physical studies of soil aeration, compaction, irrigation techniques, and methods of monitoring soil moisture.

The fourth period began in the late 1960s and focused on the national and worldwide concern about pollution. Research continued on salinity and plant nutrition, with emphasis on undergraduate and graduate teaching, plus basic chemical and physical studies of soil.

The department had its origin in 1914 with the appointment of Walter Pearson Kelley as Professor of Agricultural Chemistry and Chairman of the Department of Agricultural Chemistry. (Kelley did his graduate work under E. W. Hilgard.) He served in this position until 1938. Assisted by able colleagues E. E. Thomas, A. B. Cummins, S. M. Brown, and A. S. Vanselow, Kelley's distinguished investigations into the nature, formation, and reclamation of alkali soils were widely recognized.

Shortly after coming to Riverside in 1914, Kelley's attention was drawn to

alkali injury on citrus and the prevalence of "mottle leaf." He and his assistants investigated this problem, analyzing thousands of well and surface waters used to irrigate citrus and soils from citrus orchards. This led to a rough classification of irrigation waters as to their suitability for citrus and their soil salinity levels. As a service to growers, hundreds of irrigation waters were analyzed over a period of many years.

It was found that certain waters contained toxic quantities of boron. This led to extensive subsequent research on the subject by the U. S. Department of Agriculture. Nitrate also was found in the waters from a number of locations, and has recently become a subject of great interest to those concerned with soil and water pollution.

In the years following Kelley's appointment, the subject of base exchange in soils began to be investigated with Kelley and colleagues Brown, Cummins, and Vanselow making notable contributions. Where previous alkali reclamation experiments had failed, Kelley and his colleagues were able to reclaim a black alkali soil in the Kearney properties near Fresno by providing for adequate drainage and soil treatments to rid the soil of absorbed sodium. Following this, a white alkali soil in Imperial Valley was reclaimed. These classic experiments and the concomitant soil chemical research enabled Kelley to spell out in detail the major features of alkali soil origin, nature, and reclamation.

Kelley's contributions, nearly all resulting from work at Riverside, brought requests from the American Chemical Society to prepare two monographs, now classics in their field, one on alkali soils and the other on cation exchange in soils.

During the early period, E. E. Thomas of Kelley's staff made a comprehensive study of nematode distribution in citrus soils and showed clearly that their presence in citrus roots was detrimental to growth. This work was published in 1923.

Shortly after the establishment of the Citrus Experiment Station at its present

site (UCR), a 44-acre citrus fertilizer experiment was laid out in 1917 and differential fertilization begun in 1927. The author joined the department staff that year to follow this experiment. During the early 1930s great controversy existed about the need for phosphorus and potassium in citrus fertilization. I spent several years in the first exhaustive study of phosphorus supply and availability in California citrus soils. Though there proved to be great differences in its basic supply and availability, most older citrus orchards, through past use of manures, had accumulated considerable quantities of both. For this reason, none of the past fertilizer experiments with these elements had given positive indications of need.

During this period the author recognized the need to work out better diagnostic methods for determining the fertility requirements of citrus. Techniques were developed in order to grow bearing citrus trees out doors in controlled sand and water cultures. Over some 30 years, controlled nutritional experiments made it possible to determine (1) many of the visual symptoms of nutritional deficiencies and excesses in citrus; (2) the effects of these problems on the inorganic composition of citrus leaves and other plant parts; and (3) the effects of nutritional variables on fruit quality. The author published the first comprehensive table of leaf analysis standards in 1949. Enlarged and expanded by the work of others, leaf and tissue analysis for determining the nutritional status of citrus trees and for guiding fertilizer practices has become a worldwide practice.

In the early 1940s, L. D. Batchelor, then Director of the Citrus Experiment Station, called attention to the poor growth of citrus when replanted on old citrus soils. Suspecting a biological problem, he added microbiologist J. P. Martin to the staff. Martin demonstrated in a series of experiments that a gradual buildup of detrimental fungi, as well as nematodes, occurs in citrus soils and is mainly responsible for the poor growth of citrus subsequently planted. Working with various citrus ranches and other CES departments, Martin showed that, while periods of fallow, crop rotation, use of certain kinds of cover crops, and other management practices were helpful, pre-plant fumigation of old citrus soils, though expensive, was the most spectacular and often the best way to

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or less. Trials were randomized and replicated four times in Tulare County and seven times at U.C. Davis. At the end of a specified period, live sprouts were counted in the pomegranate, plum, and walnut plots. Olive trees were rated on a 1-to-5 value scale based upon the percent of sprouts killed and prunes on a 0-to-3 scale.

Both formulations of NAA killed established sprouts and reduced surviving sprouts below untreated control levels. In all tests, except the pre-treatment "sprout-cut" experiment in plums, the 72-A112 formulation was superior to the 72-A96 formulation.

The addition of latex paint enhanced

NAA performance slightly but was not of major benefit. On olives the untreated trees rated 1.0 (no sprout control) compared to an average 3.8 rating for trees treated with .5% solution of 72-A112 and a 4.5 average rating for trees treated with 1% solution. Olives, pomegranates, plums and walnuts treated with .5% solution of 72-A112 had 20-25% the number of regrowth suckers of untreated trees, while 1% solution applications reduced the number of regrowth suckers to 10% of untreated trees. Sucker regrowth length on prunes varied from 40.8-53.6 cm on untreated trees compared to .3-2.0 cm on 1% solution 72-A112 treated trees.

This progress report indicates that

NAA sprays inhibit and reduce sprout growth in some tree crops and that it has considerable commercial potential. Further investigations on timing, repeated treatments, and rates are warranted. NAA is not registered for this use on these crops, and is not recommended at this time by the University of California.

J. H. LaRue and G. S. Sibbett are Farm Advisors and M. S. Bailey is Field Assistant in Tulare County. L. B. Fitch is Farm Advisor in Sutter County. J. T. Yeager is Extension Pomology Research Associate, U.C., Davis, and M. Gerdt is Pomology Specialist, San Joaquin Valley Research and Extension Center, Parlier.

RESEARCH BRIEFS

Short Reports on Current Research in Agricultural Sciences

BIOLOGICAL CONTROL OF SNAILS

Pilot experiments are in progress to ascertain the feasibility of controlling the brown garden snail, *Helix aspersa*, with another introduced snail species, *Rumina decollata*. Repeated observations in private gardens strongly indicate that *R. decollata* tends to displace *H. aspersa*. *R. decollata* feeds omnivorously but is considerably more reluctant to attack living plant tissue than is *H. aspersa*. Further, *Rumina* attacks and devours *Helix*. The tree-climbing habit of *Helix* is well known, but in California *Rumina* rarely has been seen away from the ground. Testing in citrus groves is planned for 1974-75.—*T. W. Fisher, Dept. of Entomology, Riverside.*

FOLIAR-APPLIED NITROGEN FOR CITRUS FERTILIZATION

FIFTY-SIX "experiment years" of orange, lemon, and grapefruit data show that, pound-for-pound, foliar-applied nitrogen (urea, containing less than 0.25% biuret) was as effective as soil-applied nitrogen (from urea, ammonium nitrate, calcium nitrate, or anhydrous ammonia) for fruit production. However, while one annual soil application supplied adequate

nitrogen, three to six or more foliar sprays annually were required. The total yearly amount of nitrogen applied per tree to the foliage depended upon tree size, foliage density, spray solution concentration, and the number of sprays per year.

Fruit produced per lb of applied nitrogen varied from 97 to 484 lbs. At or near the maximum nutritionally-attainable yield, from 11 to 75% of the applied nitrogen was removed from the orchard in the fruit. The pounds of nitrogen per 1000 lbs of fresh fruit varied from 1.15 to 1.73, and increased with increasing nitrogen rates.—*Tom W. Embleton and Winston W. Jones, Dept. of Plant Sciences, U.C., Riverside.*

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prepare for new citrus plantings on old citrus land.

In response to the change in research emphasis from alkali reclamation and soil chemistry to nutritional research, the department's name changed from Agricultural Chemistry to Soils and Plant Nutrition during the 1940s. Somewhat later a Riverside unit of UC's Division of Irrigation and Soils was consolidated with this department. Sterling J. Richards, a soil physicist concerned with soil moisture, irrigation, and soil physics research, headed the group. He and his colleagues, L. H. Stolzy, J. Letey, and others made strong contributions in irrigation control methods, use of tensiometers for guiding irrigation, use of neutron equipment to measure soil moisture, evaluation of the oxygen status of soils, soil aeration in

relation to crop growth, biological activities, and other problems.

The third period began with the arrival of N. T. Coleman to head the establishment of a full academic and graduate teaching program at Riverside. While salinity, citrus nutrition, soil physics, fluorine air pollution research, and numerous other activities continued, Coleman and his colleagues initiated much new and basic research on clay mineralogy, ion exchange phenomena, and phosphorus and trace element chemistry.

In the fourth period, Coleman moved into campus administration and Dr. P. F. Pratt was appointed chairman. Pratt greatly broadened research in environmental pollution, involving agricultural wastes (especially manure), nitrate movement, underground water contamination, degradation of pesticides, accumulation and fate of trace elements in soils, surveys of trace elements in irrigation water, and a long list of other problems (in addition to teaching). Participants in these studies, and other research, include: F. T. Bingham, G. R. Bradford, A. L. Page, L. J. Lund, W. J. Farmer, D. D. Focht, and their assistants.

A long series of investigations on the iron nutrition of citrus and other plants by E. F. Wallihan and his assistants has elucidated the role of excess soil moisture, oxygen, soil temperature, and other soil variables as affecting iron deficiency. He also developed leaf analysis standards for iron in citrus leaves and other plants.

Homer D. Chapman, Professor and Chemist (Emeritus), was Chairman of the Department of Soils and Plant Nutrition, 1938 to 1961.