Coastal valley test

Orchard B, a mile south of Camarillo, was located in a coastal valley with relative humidities usually higher, and summer temperatures moderated by oceanic influences—both factors important in this area, because of the high salinity hazard of the irrigation water in use.

The average composition of the irrigation water in ppm was HCO_3, 366; Cl, 277; NO_3, 68; SO_4, 706; Ca, 250; Mg, 92; Na, 216; and K, 8. Boron averaged 0.53 ppm and lithium averaged 0.032 ppm. The soil is an unclassified sandy loam in the surface 6 inches and becomes more sandy with depth. In some localized areas, however, sandy clay was found at depths of 30 to 36 inches. While the surface soil was only slightly calcareous, below 6 inches the soil becomes more calcareous and at four feet was highly calcareous. The parent material was sedimentary sandstone alluvium.

Orchard B

Orchard B consists of 55 acres of 10-year-old selections of Frost, Allen, and Brewer Eurekas on rootstocks of sweet orange and rough lemon. These combinations were planted in six blocks of approximately the same acreage. Four pounds of urea were applied annually per tree. Most of the urea was distributed in split applications in the irrigation water: 1 lb per tree was applied in January, February, June, and September. Zinc, manganese, and copper sprays were applied each year.

Orchard B was tilled once annually, in early spring, and had three broad-basin furrows. This orchard was under a program of "alternate-middle irrigation." Each middle received water every second month. When both middles were irrigated simultaneously, severe iron chlorosis developed in this calcareous soil. Under the alternate-middle program, only transient chlorosis was noted in winter and early spring. At each irrigation, approximately 27 acres received water at a rate of 9 acre-inches per acre. The estimated annual amount of irrigation water received by the orchard was 36 acre-inches per acre. Rainfall at this location during the years since planting was below normal but averaged about 12 inches per year. Rainfall was usually received in amounts sufficient to wet this sandy soil through the top 2 ft of soil.

Analysis of the soil for soluble salts indicated that the tree furrows were essentially no more saline than the irrigation water. Soluble salts tended to increase in the middles and also with soil depth. In the small localized areas where sandy clay lenses were found, soluble salts in the soil were quite high, and stunted trees showed considerable leaf burn and excess patterns of chloride, sulfur, and boron in leaves of stunted trees (table 3).

Average per-acre yield, however, for the 55 acres was 1818 field boxes per acre in 1964, as compared with about 625 field boxes per acre for the 1962 and 1963 harvests. It was not possible to obtain records regarding different rootstock-scion combinations, but observation of comparatively young trees showed no marked differences in size.

The successful use to date of irrigation water with a high salinity hazard as well as high chloride content appeared to be a combination of several factors. First, the major portion of the orchard has excellent internal drainage. This was expected since the soil, with a few exceptions, was coarse textured to a considerable depth. In addition, copious amounts of water were used at each irrigation. Leaching of salts out of the root zone at each irrigation was achieved. Alternate middle irrigation in this calcareous soil was a practice which reduced the hazards of iron chlorosis. Also, roots appeared to extract moisture mainly beneath tree furrows where maximum leaching occurred. This has been noted in the past.

Chloride injury

Previous investigators reported the injury from chloride damage appears more severe under conditions of high temperature and rapid evaporation than in cool, moist climates. This is related, in part at least, to differences in transpiration rates, which in turn affect the rates of accumulation of toxic salts in vegetative parts of the plant. It has also been reported in previous experiments that a somewhat larger quantity of mineral salts accumulates in plants under conditions favoring high transpiration than where transpiration rates are low. It is highly doubtful that the irrigation water used at orchard B could be used successfully except under a combination of factors as noted above.

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Harry Forbes of Camulos Ranch and Clint Hutchins of Camarillo assisted with this study.

Foliar In

FOLIAR ABSORPTION of salts from irrigation waters during sprinkler applications can result in accumulation of sufficient sodium and chloride ions to cause leaf burn and defoliation—as directly related to high temperatures, low humidity and water quality. An additional important factor in the accumulation of specific salts in leaves from irrigation waters is that more sodium and chloride are accumulated under intermittent type sprinkling than under continuous sprinkling. Intermittent sprinkling permits evaporation from leaf surfaces, thereby concentrating the salts in water films remaining on the leaves.

Ventura study

This report, of a study conducted in Ventura County, shows that excessive amounts of boron may also be absorbed by citrus leaves from sprinkler-applied water. The study was made to evaluate factors causing poorer tree conditions under sprinkler irrigation, compared with tree conditions in the adjacent, furrow-irrigated, block.

Several trees were selected from different areas in the furrow- and sprinkler-irrigated blocks of the Valencia orange orchard. Following fruit set in early summer, fruiting and nonfruiting terminals were tagged for future leaf sampling and analyses. In addition to leaf samples, irrigation water samples and soil samples were analyzed. Soil suction and fruit growth measurements were also made.

Soil, water

Analyses of soil samples taken at different soil depths are shown in table 1. At all of the soil depths, the chloride and exchangeable sodium percentage levels are well within the ranges that are considered satisfactory for citrus. The electrical conductivity and boron levels also are not excessive but for some depths, the values approach the upper safe limits.

Analyses of constituents in the irrigation water at different times of the year showed a range of 600 to 900 ppm total soluble solids (table 2). The salts in the water were primarily calcium and sulfate. Chloride levels were low. Sodium levels were marginal (for sprinkler use) at some

Absorption of Boron Sprinkler-Irrigated Citrus

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of the sampling dates. The boron content of the irrigation water was relatively low except for two summer samplings made in August 1959 and September 1960. Even on those dates, however, levels did not exceed 0.5 ppm—the suggested upper limit of boron in irrigation water for citrus.

Leaf analysis

Leaf analyses data presented in this paper are from nonfruiting terminals. Boron from tree leaves in the sprinkler-irrigated block was in the high range (200–250 ppm, see graph) and some leaves showed symptoms of boron toxicity. Boron in the leaves of the furrow-irrigated trees remained in a satisfactory range of 50 to 200 ppm. This indicates that the higher boron content of leaves in the sprinkled block, as compared with leaves in the furrow-irrigated block, was a result of foliar absorption of boron from the irrigation water. As shown in the graph, leaves in both blocks had less than 150 ppm boron in August. By October, there was significantly more boron in the leaves of sprinkler-irrigated trees as compared with furrow-irrigated trees. There was a trend for leaves of the same age to increase in boron in the late summer and also the next spring. Boron increased rapidly in the leaves of sprinkler-irrigated trees which coincided with the increase in boron concentrations in irrigation water during August. The increase in leaf boron from March to May 1960 (in leaves from both blocks) could be related to soil boron becoming more available in the spring, as well as to greater tree activity.

TABLE 1. WATER SOLUBLE SALTS IN SATURATION EXTRACT, AND EXCHANGEABLE SODIUM IN SOILS AT DIFFERENT HORIZONS IN FURROW- AND SPRINKLER-IRRIGATED AREAS, JULY 5, 1960

Location	Soil depth (inches)	Electrical conductivity EC × 10^3 at 25°C	Exchangeable sodium %	Chloride me/l	Boron ppm
Furrow	0–6	2.2	1	1.1	0.5
	6–18	1.3	2	0.9	0.4
	18–24	2.4	2	0.8	0.6
	24–30	2.8	2	0.7	0.6..
Sprinkler	0–6	1.3	1	0.8	0.4
	6–18	1.4	1	1.3	0.4
	18–24	2.1	1	1.2	0.4
	24–30	1.6	1	1.1	0.4

TABLE 2. CONSTITUENTS OF IRRIGATION WATER USED ON THE FURROW- AND SPRINKLER-IRRIGATED BLOCKS

Sampling Date	EC × 10^6 at 25°C	Milliequivalents per liter						B
		Ca	Mg	Na	Cl	SO_4	HCO_3	ppm
Nov. 1958	1060	7.1	2.4	1.7	1.1	5.6	4.1	0.15
Aug. 1959	1160	6.3	2.8	2.9	1.4	6.6	3.8	0.45
Dec. 1959	1094	6.6	2.5	2.0	1.0	5.8	4.0	0.05
Feb. 1960	992	5.3	2.6	2.3	0.8	5.5	3.8	0.10
Mar. 1960	1000	6.9	2.0	1.6	0.9	6.3	2.8	0.15
May 1960	1050	7.5	2.5	0.5	1.2	6.7	3.8	0.15
June 1960	912	8.3	2.1	1.4	0.6	6.7	4.0	0.10
Sept. 1960	1420	9.0	2.8	2.2	1.3	7.6	4.6	0.30

Comparisons of sodium and chloride in leaves from the furrow- and sprinkler-irrigated blocks show three to four times more in the sprinkler-irrigated block than in the furrow-irrigated block (table 3). Sodium was near or slightly above the excess level of 0.25%, for most of the year on the sprinkler-irrigated block. In the furrow-irrigated block, sodium was in the satisfactory range. Chloride in leaves was not excessive in either irrigation block.

Results of this study indicate that foliar absorption of boron from sprinkler-applied irrigation water can cause excessive amounts of this element to accumulate in the leaves of citrus. Such absorption would be expected to occur when the water is sprinkled onto the leaves under high evaporation conditions. The study also shows that such absorption can take place when the boron concentration in the irrigation water does not exceed 0.5 ppm—a level that would not be hazardous to furrow-irrigated trees.

Management practices suggested for preventing chloride and sodium damage

TABLE 3. COMPARISON OF SODIUM AND CHLORIDE IN LEAVES FROM FURROW- AND SPRINKLER-IRRIGATED BLOCKS 1959–1960

Month Sampled	Constituent in dry matter of leaf—%			
	Sodium		Chloride	
	Furrow	Sprinkler	Furrow	Sprinkler
Aug.	0.05	0.21	0.05	0.20
Oct.	0.06	0.24	0.08	0.27
Nov.	0.04	0.27	0.08	0.30
Dec.	0.04	0.28	0.07	0.28
Feb.	0.07	0.25	0.10	0.28
Mar.	0.06	0.19	0.09	0.27
May	0.07	0.25	0.10	0.29
June	0.08	0.20	0.12	0.30

during sprinkler irrigation should also be applicable to control boron damage. These suggestions include: (a) sprinkling during late evenings and nights, (b) use of low-angle sprinklers that wet less of the foliage, and (c) increasing speed of sprinkler rotation.

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COMPARISON OF LEAF BORON ACCUMULATION (AUGUST TO JUNE) IN FURROW- AND SPRINKLER-IRRIGATED BLOCKS