The possibility of lithium hazard to crops merits attention and further study in all irrigated regions; but for the present, there is no real basis for alarm.

TOXICITY of Lithium

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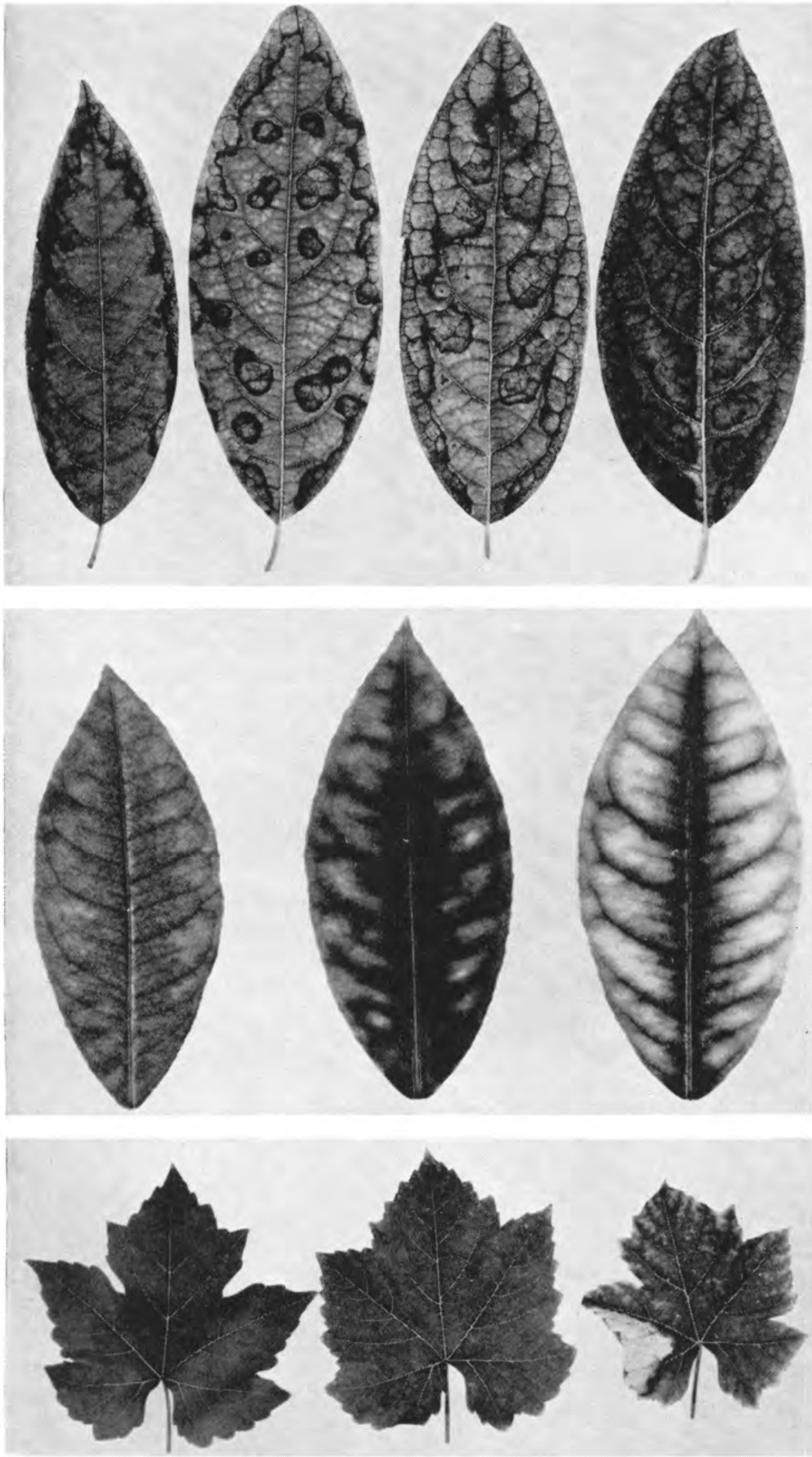

Leaf symptoms of lithium toxicity in avocados (top photo), citrus (center) and grapes (below).

COMPETITION FOR WATER in California between rapidly expanding industrial-urban activities and agriculture undoubtedly will lead to usage of waters of varying quality. Although standard criteria for water quality are at hand, they do not usually include a consideration of lithium—which may pose a hazard to certain plants. Lithium content may vary widely. For example, a previous report established the presence of lithium in a number of well-water sources, varying in concentrations from 0.05 ppm to 0.50 ppm lithium. Lithium injury in some citrus orchards had been associated with irrigation waters containing concentrations of 0.10 ppm lithium or higher. With information on lithium hazard to economic plants limited thus far to a few citrus orchards, diagnostic criteria are needed, and the effects of lithium on other crops should be studied.

This report evaluates lithium hazards to dwarf red kidney beans, soybeans, red beets, sweet corn, tomatoes, cotton, Dallis grass, Rhodes grass, sour orange seedlings, avocado seedlings, and grape cuttings. Injury symptoms and plant tissue analyses were studied in greenhouse experiments under controlled levels of lithium. Soil cultures were treated with increasing amounts of lithium sulfate sufficient in each case to produce a range of injury symptoms. An individual plant container held 30 lbs of soil (Fallbrook series, surface sample) uniformly treated with peat moss and a 10–10–10 fertilizer. Deionized water was used for irrigating. Avocado and sour orange were transplanted as seedlings as were rooted cuttings of grapes. Rapidly growing plants were seeded directly in the soil pots. After two months of growth the plants were harvested, and roots, leaves and petioles were separately analyzed for lithium.

Although several lithium rates were used, table 1 summarizes results of lithium rates producing mild toxicity symptoms. Corresponding plant tissue analyses are also given. On the basis of the minimum lithium rate producing a significant growth depression or leaf injury symptoms, the test plants were classified.

to Plants

TOLERANCE TO LITHIUM

Very sensitive	Sensitive	Slightly sensitive	Tolerant
Avocado	Grape	Cotton	Rhodesgrass
Soybean	Red kidney bean	Dallisgrass	Sweet corn
Sour orange	Tomato	Red beet	

The above-tolerance classes closely parallel tolerance of plants to sodium. Therefore, plants known to be readily injured by low amounts of sodium (deciduous trees, citrus, avocados, red beans, for example) also would be expected to be sensitive to lithium. Beets, cotton, sweet corn, alfalfa, barley, rice and other sodium-tolerant crops would be relatively tolerant to lithium.

Uptake by plants will generally follow addition of lithium to the soil. Different plant species vary markedly, however, in their uptake of lithium. Usually, plants observed to be lithium-tolerant, such as cotton, red beets, and Rhodes grass, accumulate larger amounts of lithium.

Sand culture experiments were conducted with beans, tomatoes and sour orange seedlings with a range of lithium levels in the irrigating solution sufficient to produce injury. The results are given in table 2. Although isolated citrus orchards in California and Arizona exhibit what appears to be lithium injury associated with irrigation waters containing 0.05 to 0.10 ppm lithium, injury was not observed with the plants in the sand cultures at such low substrate concentrations. Lithium concentrations of 5 ppm were required for injury in the sand culture study—an increase of 100 to 200 times higher than that found in irrigation waters used in the affected citrus orchards. Apparently, considerable accumulation of lithium must occur in the root zone before injury can be expected, but information is lacking on how to predict when a toxic condition will develop. In suspected cases of injury, leaf analysis should be made.

The combination of specific leaf symptoms and plant tissue analysis is a convenient and necessary criterion for evaluating plant nutrition—including lithium content and injury. Lithium toxicity symptoms are not distinct and are difficult to recognize; however, lithium-injured broad-leaf plants generally exhibit necrosis along the leaf margins, subsequent interveinal chlorosis and leaf abscission. The photograph illustrates some of these characteristics found with sour orange, avocado and grape plants.

Table 3 summarizes lithium concentrations found in different plant species cultured under controlled levels of lithium. Three ranges of lithium content are given, one for plants unaffected by lithium, a second for plants with high lithium content, possibly to the point where some growth retardation occurs yet without specific leaf symptoms: and a third, for plants obviously injured by lithium.

The leaf analysis and plant response data reported from these controlled greenhouse tests indicate the possibility of lithium injury to other sensitive crops, especially under management conditions favoring accumulation of lithium in the root zone. In addition, criteria for evaluation are suggested. The level to which lithium must accumulate in the root zone before becoming injurious is not known at present, although considerable amounts apparently are necessary before injury occurs. Additional studies are needed to determine the characteristics of lithium accumulations in soils irrigated with lithium-bearing water in order to relate such accumulation characteristics to plant nutrition. Contents of lithium in irrigation waters ranging from 0.10 to 0.50 ppm do not directly suggest an immediate toxicity.

In instances of suspected lithium injury, plant tissue analysis as well as water analysis for lithium and other salt components (sodium, chloride, sulphate, boron, etc.) are needed in order to establish the cause or causes of plant injury. For example, some lithium-bearing waters contain sufficient sodium, boron, and other salts to pose a hazard, perhaps more serious than that attributed to lithium.

TABLE 1, TOLERANCE OF PLANTS TO SOIL ADDITIONS OF LITHIUM SULFATE

Plant tested	Li range tested	Li rate producing 25% growth depression	Lithium content in tissue at 25% growth depression		
			Blade	Petiole	Root
	ppm	ppm	ppm	ppm	ppm
Avocado	0–6	6	120	400	60
Soybean	0–20	7	40	40	80
Sour Orange	0–6	8	180	ND*	50
Grape	0–16	12	300	450	400
Tomato	0–40	12	ND*	380	100
Red kidney bean	0–20	12	140	140	520
Cotton	0–40	25	1100	350	250
Dallisgrass	0–20	25	340		180
Red beet	0–80	35	5500	2200	90
Rhodesgrass	0–60	65	2400		205
Sweet corn	0–120	70	160	340 (midrib)	180

* No determination.

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TABLE 2, GROWTH AND LITHIUM CONTENT OF RED KIDNEY BEANS, TOMATOES, AND SOUR ORANGE SEEDLINGS IN RELATION TO MAINTAINED CONCENTRATIONS OF LITHIUM IN SAND CULTURES (MEAN OF 4 REPLICATIONS)

Plant species	Li in sand culture	Shoot weight	Li in leaf tissue	Leaf injury symptom
	ppm	gm	ppm	
Red kidney bean	0	2.1	1.3	None
	5	1.8	72	Slight chlorosis
	10	1.5	166	Chlorosis
	20	0.7	510	Chlorosis, leaf burn and abscission
Tomato	0	36	5	None
	5	28	219	None
	10	12	316	None
	20	1.0	1692	None
Sour orange	0	25	1.5	None
	2	23	10	None
	4	16	245	Slight mottle
	6	27	300	Mottle and some leaf abscission

TABLE 3, PLANT TISSUE CONCENTRATIONS USEFUL FOR DIAGNOSIS OF LITHIUM HAZARD

Plant species	Tissue analyzed	Lithium concentration (dry matter)		
		Normal	High*	Toxic
		ppm	ppm	ppm
Avocado	petiole	<5	25–75	100–450
Red kidney beans	petiole	<5	25–50	100–400
Soybeans	petiole	<5	25–50	100–300
Red beets	petiole	<10	2000	2500–4000
Sweet corn	midrib	<5	50–300	350–500
Sour orange seedlings	leaf	<5	50–75	100–300
Cotton	petiole	<5	100–300	500–2000
Dallisgrass	blade	<5	60–300	300–500
Rhodesgrass	blade	<10	500–2500	2500–3000
Thompson seedless grapes	petiole	<5	100–200	300–600

*No symptoms