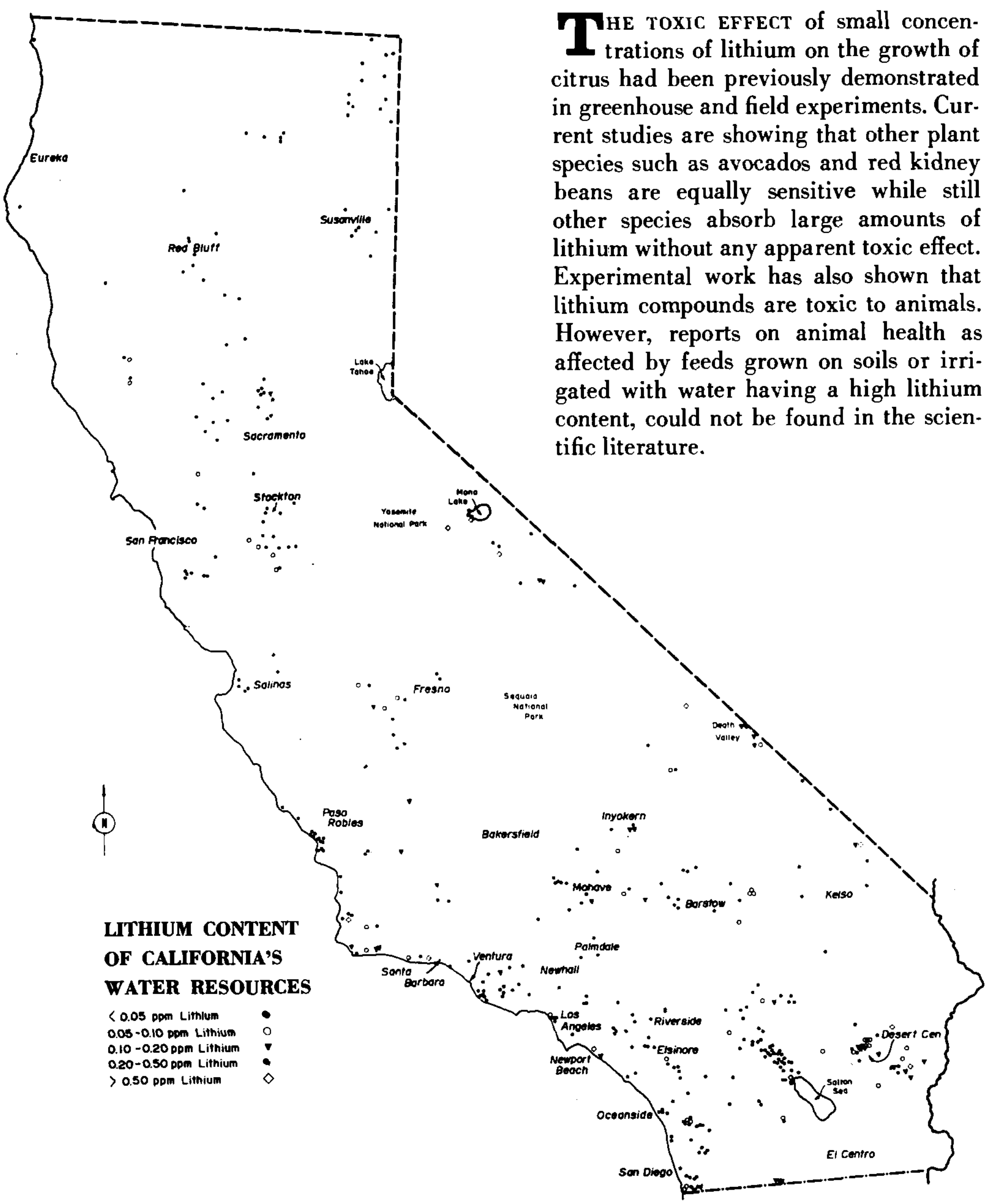
GORDON R. BRADFORD

LITHIUM
in California's Water Resources

Of 400 samples representative of water resources in California, 25% were found to contain toxic levels of lithium, capable of adversely affecting the growth of citrus and other crops. Water samples with a high lithium content were usually associated with low magnesium and/or a high sodium percentage. Because of the natural occurrences of toxic levels of lithium in irrigation water, as well as possible contamination from industrial uses of lithium compounds, agencies responsible for maintaining water quality standards should also include analysis for lithium along with their routine sampling.

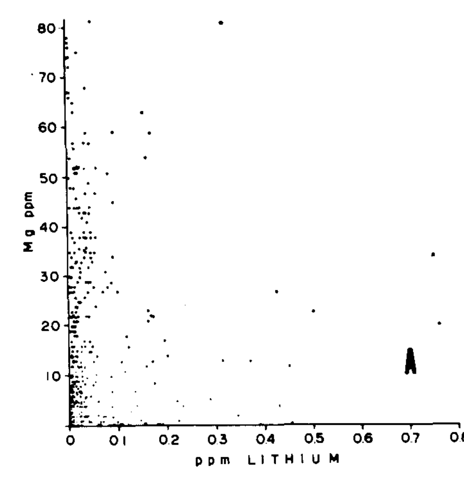


THE TOXIC EFFECT of small concentrations of lithium on the growth of citrus had been previously demonstrated in greenhouse and field experiments. Current studies are showing that other plant species such as avocados and red kidney beans are equally sensitive while still other species absorb large amounts of lithium without any apparent toxic effect. Experimental work has also shown that lithium compounds are toxic to animals. However, reports on animal health as affected by feeds grown on soils or irrigated with water having a high lithium content, could not be found in the scientific literature.

Lithium toxicity to citrus has been reported from the use of irrigation water containing 0.05 to 0.10 parts per million of lithium. This possibility of excess concentrations of lithium in irrigation water led to a survey of agricultural waters in California. The California State Department of Water Resources supplied most of the 400 well water samples and a few surface water samples. The remaining samples were collected by the author and representatives of the United States Geological Survey. Since there are several thousand wells scattered throughout the State, the 400 samples were selected to represent most of the principal drainage basins and agricultural areas of California rather than all the wells. The samples were analyzed by first separating and concentrating lithium with synthetic ion-exchange resin columns and then determining lithium on a flame photometer.

The map shows the lithium content of water samples from different locations in the State. Concentrations ranged from < 0.05 ppm to > 0.50 ppm. Approximately 75 per cent of the samples contained less than 0.05 ppm lithium, and would not be significant as a source of lithium toxic to sensitive plants—except

RELATIONSHIP OF LITHIUM CONTENT OF WATER SAMPLES AND MAGNESIUM



perhaps under conditions allowing the accumulation of lithium and other salts in the root zone. Approximately 11 per cent of the samples contained from 0.05 to 0.10 ppm lithium, and on the basis of limited field observations may be expected to exert a toxic effect on the growth of citrus and other lithium-sensitive plants. From 0.10 to 0.20 ppm lithium was found in approximately 8.5% of the samples and from 0.20 to 0.50 ppm in 3% and over 0.5 ppm in 2.5% of the samples.

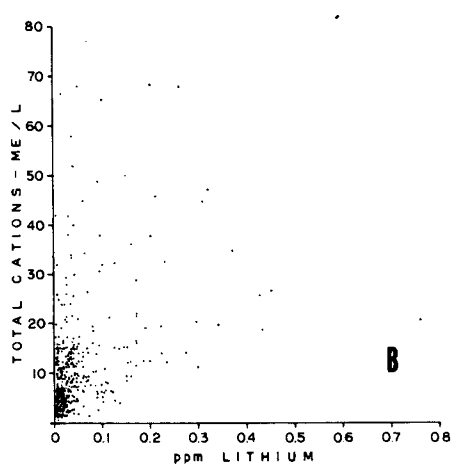
Samples containing more than 0.05 ppm lithium are listed in the table with detailed locations and lithium content. Areas on the map where the lithium content from several wells is abnormally high (greater than 0.10 ppm) include: the Otay area south of San Diego, the Jucumba area near the Mexican border, the coastal area north of San Diego, the Ventura and Santa Barbara area and northward along the coast toward Santa Maria, the Mendota area west of Fresno, the Gloster area south of Mojave, the Tuolumne Meadows area of Yosemite, the Chuckwalla Valley or Desert Center area, the Death Valley area and northwest to the Mono Lake area, and other areas represented by fewer sampling sites.

Graphs A, B, C and D show the relationship between the lithium content of the water samples and four other constituents commonly determined in a water analysis—magnesium, total cations, potassium and sodium. High lithium tends to be associated with low magnesium, according to graph A. Graph B shows that about 20 per cent of the samples contained lithium in excess of 0.05 ppm —even though they would have been considered as acceptable irrigation waters

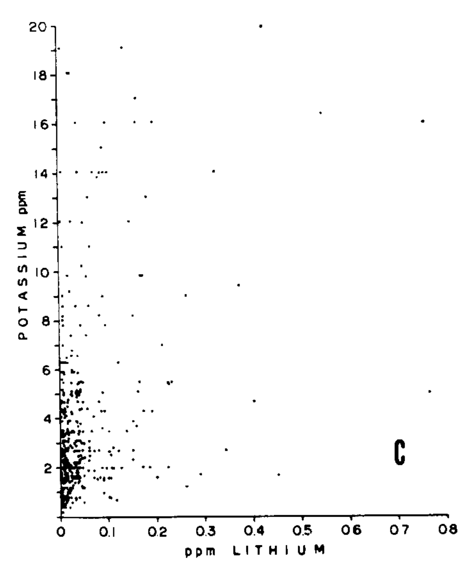
SITE LOCATIONS OF SAMPLES HAVING A LITHIUM CONTENT OF 0.05 PPM OR GREATER

COUNTY	LOCATION Range/Township-Section	LITHIUM ppm
Fresno	14S/13E—12H	0.05
″	14S/14E—11N	0.26
″	15S/17E—10R	0.05
″	16S/15E—8N	0.16
″	16S/16E—9N	0.09
Imperial	9S/17E—4J	0.07
Inyo	15S/44E—36K	1.60
″	27N/4E—25E	0.19
″	26N/5E—34L	0.18
″	25N/6E—18D	0.08
″	25N/5E—14M	0.14
″	27N/4E—27B	0.16
″	27N/4E—26B	0.16
″	6S/33E—6 (Owens River)	0.14
″	21S/43E—25C	0.09
Kern	25S/19E—7P	0.10
″	11N/8W—30F	0.08
″	11N/BW—2N	0.06
″	27S/40E—15L	0.17
″	10N/11W—8E	0.13
Lake	13N/9W—16D	0.06
″	15N/9W—6F	0.05
Los Angeles	2S/15W—22E	0.05
″	Santa Clara River	0.18
Mono	1N/26E—5 Mono Lake	10.50
″	3S/29E—31 Hot Springs, Long Valley	2.25
Orange	5S/7W—8P	0.34
″	6S/10W—18P	0.16
″	5S/11W—20G Oil Well Brine	3.00
Placer	12N/6E—9C	0.29
″	13N/6E—33C	0.12
Riverside	8S/9E—4D	0.06
″	3S/3E—33	0.07
″	5S/15E—13F	0.23
″	6S/21E—36R	0.17
″	3S/18E—11A	1.10
″	4S/16E—29R	0.09
″	4S/16E—30D	0.07
″	4S/16E—32M	0.10
″	4S/17E—6C	0.20
″	5S/15E—12N	0.12
″	5S/15E—12R	0.09
″	5S/15E—13B	0.22
″	5S/15E—13F	0.15
″	5S/15E—22R	0.43
″	5S/15E—27B	0.45
″	5S/12E—29E	0.05
″	Salton Sea Water	2.60
″	5S/16E—5B1	0.06
″	5S/16E—5B	0.09
″	5S/16E—6N	0.09
″	5S/16E—7N	0.10
″	5S/16E—8G	0.16
Riverside	5S/16E—22N	0.40
″	5S/17E—33N	0.12
″	6S/19E—25P	0.50
″	7S/18E—11N	0.37
″	7S/18E—11R	0.17
″	7S/20E—4R	0.75
″	7S/19E—4R	0.31
″	8S/20E—10D	0.16
″	5S/20E—16M	0.09
″	7S/20E—18H	0.18
″	4S/16E—32M	0.11
″	6S/4E—16H	0.09
San Bernardino	15½N/15E—21L	0.15
″	15½N/15E—23P Oil Well Brine	0.54
″	11N/5E—15G	0.07
″	8N/4E—8C	0.06
″	10N/6W—5E	0.11
″	11N/5E—16J	0.06
″	14N/9E—36B	0.32
″	11S/5E—15G	0.08
″	1N/6E—35C	0.09
″	1N/7E—35D	0.10
San Diego	19S/2W—5Q	0.10
″	18S/2W—32H	0.06
″	18S/2W—35L	0.09
″	14S/4W—12H	0.23
″	16S/3W—22G	0.20
″	17S/2W—27P	0.06
″	18S/8E—8J	0.12
″	18S/8E—7J	0.10
″	12S/2W—20G	0.07
″	12S/2W—20K	0.06
″	12S/8E—10N	0.09
″	18S/1W—34N	0.22
″	18S/1W—34F	0.13
″	19S/1W—3E	0.19
San Joaquin	3S/5E—24F	0.06
″	2S/4E—36P	0.06
San Luis Obispo	30S/18E—1D	0.17
″	11N/26W—2G	0.10
Santa Barbara	4N/34W—4N	0.42
″	5N/32W—33H	0.11
″	5N/32W—35F	0.16
″	4N/29W—10J	0.06
″	5N/33W—32D	0.07
″	4N/27W—Arroyo Burro	3.46
″	7N/33W—20K	0.06
″	8N/34W—17K	1.94
Solano	5N/2W—34P	0.05
Stanislaus	5S/7E—35C	0.08
″	4S/7E—17K	0.08
Tuolumne	1S/4E—4 Lambert Soda Spring	0.76

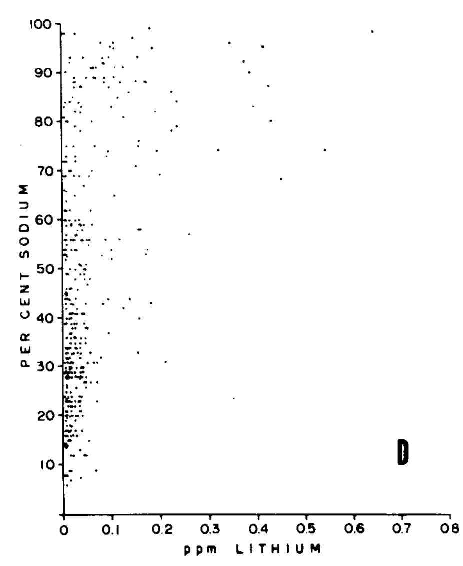
RELATIONSHIP OF LITHIUM CONTENT OF WATER SAMPLES AND TOTAL CATIONS

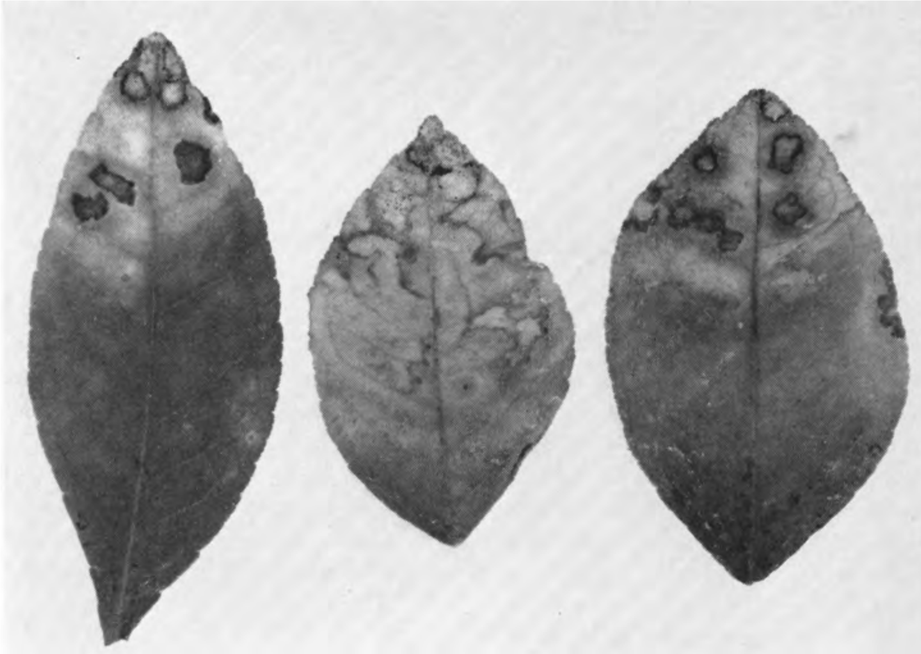


RELATIONSHIP OF LITHIUM CONTENT OF WATER SAMPLES AND POTASSIUM



RELATIONSHIP OF LITHIUM CONTENT OF WATER SAMPLES AND SODIUM





Severe lithium toxicity pattern on field-grown citrus leaves from Chuckwalla Valley (Desert Center area), with lithium accumulation of about 40 ppm on a dry-weight basis from irrigation water containing 0.12 ppm lithium.

from the standpoint of total salt concentration (< 22 ME/L), as reported by the U.S. Salinity Laboratory at Riverside. Graph C shows no relationship between lithium and potassium but low lithium is associated with a low sodium percentage in graph D. About 10% of the samples with a satisfactory sodium level (< 60% Na) for irrigation of citrus, contained potentially undesirable levels of lithium for citrus growth.

Since there are few wells in the Imperial Valley south of the Salton Sea, four samples of leachate from drain tiles installed in an Imperial Valley citrus orchard were analyzed for lithium. They contained about 0.3 ppm lithium. This represents a concentration 10 times the lithium content of Colorado River water which was used for irrigation. The sodium and chloride ion also increased 10 times, suggesting that the lithium ion remains in solution under these conditions and is concentrated by water loss through evaporation and transpiration. The citrus growing under these conditions adsorbed deleterious amounts of lithium. This particular occurrence of lithium toxicity illustrates a problem resulting from the use of a large quantity of irrigation water having a relatively low lithium content (0.03 ppm), but involving a heavy soil with impeded drainage.

Although the lithium content of the Colorado River water is low by comparison with many of the well waters sampled in this study, it is about 10 times greater than the lithium content of the water analyzed from 15 major rivers in the United States and Canada by the U. S. Geological Survey. Because there is considerable variation in lithium content of well waters from adjacent areas such as the Coachella and Chuckwalla valleys, it is conceivable that a major portion of the lithium content of certain river waters may originate from a few limited numbers of tributaries or springs.

As agriculture, industry, and population expand into the arid and semiarid areas of the world there is increased demand on all available water supplies. The increasing use of lithium compounds in industry and defense activities is a potential source of artificial contamination of water supplies in addition to the natural contamination occurring through underground geological processes. This report emphasizes the need for routine analysis of water samples for lithium by agencies responsible for maintaining water quality standards.

Gordon R. Bradford is Associate Specialist with the Department of Soils and Plant Nutrition, Citrus Research Center, University of California, Riverside. David L. Shatto, Assistant Public Health Chemist with the State Department of Water Resources Laboratory at Riverside, made available analytical data, maps, etc., which assisted in the preparation of this report.

SUGAR IN

Limited by High Temp and High Levels of Soi in Kern County Tests

G. V. FERRY · F. J. HILl

Rapid root growth, stimulated by a plentiful supply of soil nitrogen and high summer temperatures, held the sugar content of beet roots down to 15% or lower during July and August in a 1961 field experiment in Kern County. Enough fertilizer nitrogen should be applied to promote early top growth and prevent any deficiency before mid-May. However, a nitrogen deficiency period of from eight to ten weeks before harvest is essential for maximum sugar production from the roots.

Sugar beet crops in the lower San Joaquin Valley usually produce excellent root yields but with low sucrose concentrations. High temperatures experienced in this area during the summer months are not conducive to sugar accumulation in beet roots. Research has shown that a period of nitrogen deficiency prior to harvest is very effective in raising the sugar content of roots.

A field experiment was conducted on the N. L. Ritchey farm in Kern County to determine the duration of the nitrogen deficiency period before harvest for maximum sugar production in this area. Sugar beets were planted in early January, 1961, in Hesperia fine sandy loam. Three rates of nitrogen (80, 160 and 320 lbs/acre) and a control plot were compared in four replications. Each plot was large enough to permit harvesting subplots of two 50-foot-long rows at each of five harvest dates. Petiole samples were collected from the plots at regular intervals throughout the season.