The major difference was in the iron content of juice. In 1957, fruit juice from iron-deficient trees contained 83% as much iron as from high-iron trees. In the 1960 crop, the figure was 57%. Other differences found to be statistically significant in the 1960 crop were: low-iron fruits were 46.5% rind, compared with 44.3% in high-iron fruits; and low-iron fruit juice contained 12.8% sugar compared with 13.5%. Flavor and texture were not obviously affected. Color was less intense in iron-deficient fruits.

Measurements of trunk circumference made annually at the same point on each trunk showed that by 1961 the rate of trunk growth in the low-iron trees was about half that of the high-iron trees. Thus, both fruit yield and tree growth were affected by iron deficiencies in the same range.

Application of results

Obvious differences between solution cultures and soils indicate a need for caution in applying results from one type of culture to the other. One important difference is that in the field, chlorosis is often more severe on one side or in particular limbs than over the tree as a whole. This is assumed to be caused in part by the condition of the particular roots connected to the affected part of the tree. In solution culture, all roots are in about the same environment and iron deficiency tends to affect the whole tree uniformly. Thus, the leaf-analyses and fruit-production figures in this experiment indicate the effects of iron nutrition on the entire tree. In trees that are not uniform in this respect, fruit production varies from one limb to another according to their respective levels of iron nutrition. The fruit deficit, therefore, depends on what fraction of the tree is deficient in iron.

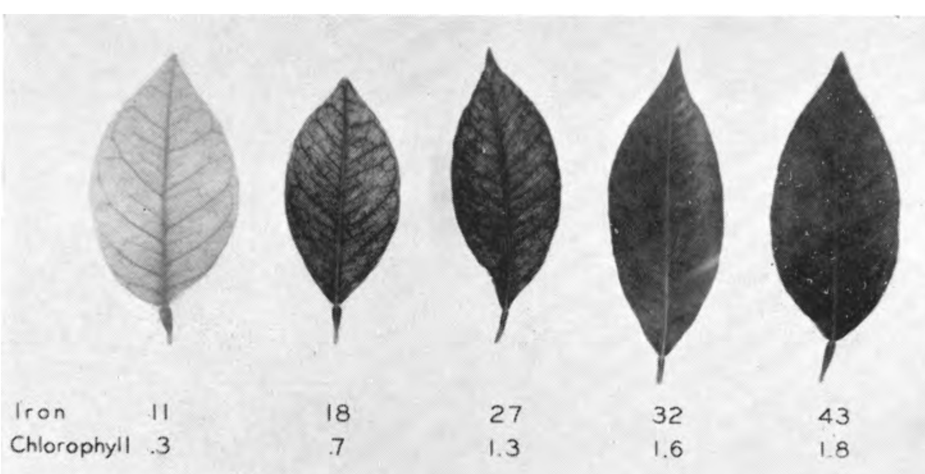
Use of 30 ppm iron in standard leaves as a critical concentration value for fruit production in navel orange trees does not seem to have any obvious source of error, although experience may show that the figure should be revised slightly upward or downward. The main concern is to be sure it is not misinterpreted. The important point is that leaves that are moderately chlorotic during the period of expansion usually become less chlorotic with age. Spring-cycle leaves that are chlorotic in May or June may be almost uniformly green by September. However, chlorotic summer-cycle leaves may be present on the tree in September and subsequently turn green. If the standard reported here is to be used, judgment should be based on appearance and chemical analysis of spring-cycle leaves in the September condition.

Twig dieback resulting from iron deficit can also be useful in the field as an indicator that tree productivity is reduced. When new leaves are so chlorotic that they never lose the yellow coloration between veins, they commonly drop by midsummer, leaving bare, green twigs that soon die. Fruit-bearing wood is thus lost from the tree.

E. F. Wallihan is Associate Professor of Soil Science and Associate Chemist in the Citrus Research Center and Agricultural Experiment Station, M. J. Garber is Professor of Biometry and Biometrician, Biometrical Laboratory, University of California, Riverside.

J. R. Hammond, Wilma L. Printy, D. S. Rayner and R. G. Sharpless also assisted in the conduct of this experiment.

(5) Orange leaves showing degrees of chlorosis pattern associated with various iron concentrations in leaves. Iron concentrations in parts per million of dry weight. Chlorophyll concentrations in milligrams per gram of fresh weight.



A. H. LANGE
C. ELMORE
D. BAYER
E. STILWELL
L. BUSCHMANN
N. ROSS
B. FISCHER

Studies

WEED COSTS for the state's 110,000 acres of almond orchards totaled $1,160,000 in 1964, according to estimates by the California State Chamber of Commerce Weed Control Committee. In the same year, a survey by the Agricultural Extension Service indicated that 88% of almond orchard weeds were annuals and 12% perennials. Most of the cost of control has been for machinery and hand labor necessary to control the weeds in the tree row. Continued disking has also frequently been injurious to both roots and trunks of young trees.

Several Chemicals

Although several chemicals offer a potential for this type of weed control in almonds, there have been problems in the state over the years because of their toxicity to almond trees. Studies by the University of California since 1959 have shown that a number of herbicides will give economical annual weed control, at rates of 2 to 4 lbs per acre under most orchard conditions. The problem has been essentially one of safety to several tree species. A summary of the phytotoxicity work up to 1963 shows that simazine and diuron were considerably safer than atrazine, but in some trials, simazine at rates up to 4 lbs per acre showed injury to almonds. Atrazine was

Untreated check plot in almond orchard photo to left shows weed growth, in contrast to clean strip down tree rows in photo to right, resulting from use of pre-emergence herbicides.

of PHYTOTOXICITY in the use of herbicides for controlling annual weeds in almond orchards

generally injurious to most fruit trees at rates as low as 2 lbs per acre.

There have been some important changes in the herbicides registered by USDA for use in almond orchards during the past two years. One is the deletion of 2,4-D which, at one time, was registered for dormant applications in most tree fruits; it was reregistered in 1965 for apples and pears. Data has been developed for the reregistration of 2,4-D in almonds, stone fruits, and walnuts. Although simazine is registered for several of the species in the genus *Prunus*, it is currently not on any manufacturer's label for almonds because of phytotoxicity. Diuron is not yet registered for almonds. DNBP and PCP (seldom used in California orchards) are both registered for use in almonds for knockdown of standing weeds. Weed oil is registered and is used extensively but causes handling and storage problems, requires repeat applications, and is hazardous to young trees.

A summary of 10 statewide uniform trials showed a similar pattern of injury from trial to trial with simazine and diuron (table 1). Most of the injury occurred on Mission variety trees, but in some trials other varieties also showed symptoms. Considerably more injury resulted to almond trees in four locations on

Phytotoxic injury to almond leaves, left photo, resulted from applications of simazine at 8 lbs per acre. Injury visible in photo to right resulted from applications of diuron at 4 lbs per acre.

TABLE 1. A SUMMARY OF PHYTOTOXICITY TO ALMOND TREES FROM 1963–66 FROM 10 UNIFORM TRIALS FOR ANNUAL WEED CONTROL WITH SIMAZINE AND DIURON

County location of orchards*	Tree age†	No. years treated	Soil characteristics				Type irrig.	Phytotoxicity‡	
			Org. matter	Sand	Silt	Clay		Simazine	Diuron
			%	%	%	%			
Butte	4	1	6.1	42.0	40.0	18.0	Sprinkler	–	–
Contra Costa	20+	2	5.6	21.6	54.0	24.4	Sprinkler	–	–
Contra Costa	20+	2	3.2	25.4	51.0	23.6	Furrow	–	–
Contra Costa	20+	2	2.7	81.8	14.0	3.6	Sprinkler	–	–
San Joaquin	7	3	2.1	81.2	14.0	4.8	Sprinkler	–	–
Sutter	4	3	2.1	47.2	30.0	22.8	Flood	+	+
Stanislaus	4	3	1.6	65.4	27.8	6.8	Flood	+	+
Fresno§	5	1	1.4	54.4	37.6	8.0	Furrow	+	+
Fresno	10	2	1.4	54.4	37.6	8.0	Furrow	–	–
Stanislaus	2	2	1.2	80.0	14.0	6.0	Flood	+	+

* Special Note: Varieties tested included Mission, Nonpareil, and Ne Plus in Butte County; mixed varieties in Contra Costa; Nonpareil and Merced in San Joaquin; Nonpareil, Ne Plus, and Mission in Sutter; Nonpareil, Mission, and Merced in Stanislaus; and Nonpareil, Davey, and Mission in Fresno County.
† Approximite tree age at time of first application.
‡ + = phytotoxicity at herbicidal rates, i.e., ratings of 3 or above on a scale of 0–10 where 0 = no observable effect, 5 = severe chlorosis and marginal burn of foliage, 10 = all leaves dead. – = 0 to 3 rating.
§ Some irrigation broke over the treated beds between trees.

sandy soils with low organic matter. In the University of California trials on heavier soils, there was no injury even at the high rate of 8 lbs per acre. Commercial applications have shown injury on heavy as well as on light soils at herbicidal rates. In about one out of eight observations, toxicity was observed on almonds at the 4-lb-per-acre rate, and some symptoms occurred from simazine even at 2 lbs per acre. Since at least 2 lbs per acre are usually necessary for weed control in most soils, simazine and diuron offer a very narrow safety margin. A year of heavy rainfall, overirrigation of the treated area, a slight overdosage, or the build-up of other factors detrimental to tree health could (and did) reduce the margin of safety. These levels are too hazardous.

This orchard work, and research with herbicides in general, has shown that a number of factors in the soil can influence weed control and crop sensitivity. Sandy soils, low in organic matter and clay content, are often associated with tree injury from soil-persistent herbicides. Unfortunately, a recent survey (table 2) showed that 50% of our almond orchard soils come under this classification. (Pears, however, are predominantly on heavier soils which could explain their relative resistance to simazine and diuron injury. See CALIFORNIA AGRICULTURE March 1967.)

Young almond trees that have been uninjured even by high rates of simazine and diuron have been in soils that are deep. More injury has occurred on shallow than on deep soils because roots growing close to the surface in a shallow soil are more apt to be damaged. Half of our almond orchards are on shallow soils, further reducing the margin of safety.

Work with rootstocks showed that almonds growing on peach roots are considerably more resistant to herbicides than those on plum roots. Fortunately, the greatest percentage of almond trees in the state are on peach stock.

TABLE 2. SUMMARY OF 1964–1965 CALIFORNIA ORCHARD SURVEY BY FARM ADVISORS, CALIFORNIA AGRICULTURAL EXTENSION SERVICE

PERCENTAGE OF CALIFORNIA ORCHARD CROPS GROWN ON SANDY AND CLAY SOILS

Orchard crop	Sandy	Clay
	%	%
Almonds	60	41
Pears	27	73
Walnuts	52	48

PERCENTAGE OF CALIFORNIA ORCHARD CROPS GROWN ON SHALLOW AND DEEP SOILS

Orchard crop	Shallow	Deep
	%	%
Almonds	50	50
Pears	12	88
Walnuts	29	71

While this summary may represent a somewhat conservative picture in light of many experimental orchard trials over the years where there was no indication of toxicity from the use of simazine in almonds, it clearly points out the hazards involved as well as the difficulties of making general recommendations for simazine and diuron for almond orchards.

Arthur H. Lange is Extension Weed Control Specialist, Riverside; Clyde Elmore is Extension Weed Technologist, Davis; David E. Bayer is Lecturer and Assistant Botanist, Davis; Edwin K. Stilwell is Farm Advisor, Contra Costa County; Leonard L. Buschmann is Farm Advisor, Sutter County; Norman W. Ross is Farm Advisor, Stanislaus County; and Bill B. Fischer is Farm Advisor, Fresno County.

Assistance with these studies was also obtained from Clem Meith, Farm Advisor, Butte County; and Don Rough, Farm Advisor, San Joaquin County. The Geigy Chemical Co. contributed financial support to the project.

Vegetative

COTTONS DERIVED FROM the species *Gossypium hirsutum* such as the Acala varieties, and from *G. barbadense* such as Sea Island and Tanguis varieties —or hybrids between the two species—have been found easy to propagate vegetatively by cuttings. There are obvious advantages in certain disease studies to conducting experiments with genetically uniform or clonal lines of cotton. There may also be advantages to the seed industry. For example, a plant selected as a basic seed parent for superior yield and quality could be increased many fold by cuttings and an abundant seed crop realized—sufficient to reduce the time between initial selection, and release of the seed to growers by perhaps one seed generation.

Maintain plants

Also, when tests determine the value of specific cotton plants to the industry as seed or breeding parents, these could be maintained by cuttings year after year—or until replaced by superior lines. With vegetatively propagated cottons, field performance of basic lines could be evaluated in several different geographical areas. Cottons rooted by cuttings do not have the tap root system characteristic of those grown conventionally from seed, and thus may perform atypically in the field, but there is a tendency in rooted cottons for one or more roots to grow considerably faster than others, as if the plant might reconstruct the tap root. Atypical performance in the field, if it occurred, would not affect the genetic composition of the seed.

The incorporation of Verticillium wilt resistance into Acala cottons from the species *G. barbadense*, with clonal cottons for instance, would allow back-crossing to the same individuals year after year, in