Almond orchard above, left, was set up for sprinkler irrigation, with herbicides used down the tree row, and centers mowed. Orchard to right was flood-irrigated with borders on the tree row, and no herbicides used.

Phytotoxicity, and irrigation effects in orchard weed control with herbicides

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PHYTOTOXIC RESPONSES of fruit trees to soil-persistent herbicides have been observed to vary considerably from orchard to orchard, and both sprinkler and flood irrigation have been associated with more injury in sandy soils than has furrow irrigation. The series of orchard irrigation-herbicide studies reported here were conducted from 1963 to 1968 to obtain further information on these problems. Five field experiments comparing furrow with flood irrigation and different levels of sprinkler irrigation were conducted at four different locations—three in Fresno County and one at Riverside. Trees ranged from one year to 20 years in age. All but two trials were conducted on first- or second-year peaches, plums, and almonds. The soils varied in content of organic matter from 0.6 to 2.1 per cent. The sand ranged from 40 to 67 per cent, silt from 24 to 39 per cent, and the clay from 9 to 20 per cent. The herbicides tested included simazine (Princep), diuron (Karmex), terbacil (Sinbar), dichlobenil (Casoron), and fluometuron (Cotoran).

Herbicides were applied at the suggested rates and also at up to four times this rate in most trials so the effects of herbicides under different irrigation regimes could be evaluated.

Heavy rates, and irrigation

In the first test year (1963), 20-year-old bearing Elberta peach trees were severely injured after applications of high rates of simazine and diuron in the late spring followed by flood-irrigation of 20 acre-inches in two months (table 1). Rates of simazine above 4 lbs per acre were excessively toxic, causing severe chlorosis and burn on the foliage of most of the trees. As little as three pounds caused considerable chlorosis and simazine damage pattern. With simazine, the veins remained green and the inner veinal areas turned yellow. Increasing the herbicide rate resulted in more yellowing of the margins and increased burn. No simazine residue was found in the fruit up to highest rates (i.e., 16 lbs per acre).

Diuron was more erratic in phytotoxicity and caused symptoms of an in-

TABLE 1. EFFECT OF SPRING-APPLIED SIMAZINE AND DIURON ON THE FOLIAR CONDITION OF 20-YEAR-OLD ELBERTA PEACH TREES GROWING IN SANDY SOIL* WITH HEAVY BASIN (FLOOD) IRRIGATION†

Herbicide	Rate	Date Applied§		Average
		5-6-63	6-4-63	
	lb/A	Av. rating‡	Av. rating	
Simazine 80W	4	3.0	3.0	3.0
Simazine 80W	8	5.0	6.5	5.8
Simazine 80W	16	8.5	7.0	7.8
Diuron 80W	4	1.0	1.0	1.0
Diuron 80W	8	1.5	8.0	4.7
Diuron 80W	16	8.5	5.0	6.8
Check	0	0	0	0

* Organic matter 0.6%, sand 67.2%, silt 24.0% and clay 8.8%.

† Trees irrigated with 4 A" on 5-8-63, 5-20-63, and 6 A" on 6-5-63 and 7-10-63 for a total of 20 A".

‡ Average of rating made 7-17-63 where 0 = no effect, 3 = definite pattern of chlorosis, 5 = chlorosis with marginal burn, and 10 = all foliage burned brown and dead.

§ Herbicides were applied to single tree plots, four replications per treatment, half of the replications were treated 5-6-63, and half on 6-4-63.

TABLE 2. THE EFFECT OF IRRIGATION ON WEED CONTROL AND PHYTOTOXICITY OF FOUR HERBICIDES TO YOUNG LOVELL PEACH ROOTSTOCKS

Herbicides§	Rate	Average*					
		Weed Control†				Phytotoxicity‡	
		1 month		3 months		3 months	
		Flood	Furrow	Flood	Furrow	Flood	Furrow
	lb/A						
Simazine 80W	2	9.0	9.2	10.0	10.0	0.7	0
Simazine 80W	4	8.0	9.2	10.0	10.0	1.2	0
Terbacil 80W	1	10.0	10.0	10.0	9.5	0.2	0
Terbacil 80W	2	10.0	10.0	10.0	9.7	1.0	0
Terbacil 80W	4	10.0	10.0	10.0	10.0	1.2	0.3
Fluometuron 80W	2	9.7	10.0	9.5	9.5	3.0	1.5
Fluometuron 80W	4	10.0	10.0	10.0	9.5	7.0	3.0
Check	0	0.7	2.5	2.7	6.0	0	0

* Average of four trees per replication times 4 replications.

† Weed control was rated using 0 = no control and 10 = 100% annual weed control.

‡ Phytotoxicity rating using 0 = no effect, 3 = chlorosis pattern, 5 = chlorosis plus marginal burn, 10 = all leaves burned or defoliated.

§ Herbicide applied to loose soil March 3, 1967. (Organic matter 2.1%, sand 49.6%, silt 32.6% and clay 16.8%).

tensity similar to simazine but with a different pattern. Usually the leaves affected by diuron were of a light green with the veins turning chlorotic early, followed by a blotchy burning of the margin.

Furrow vs. flood

In a second trial at the Kearney Field Station, the herbicides were applied during the early spring and caused considerably less injury the following spring than in the first test, even with flood irrigation. With furrow irrigation, very little injury was observed up to, and including, 8-lb-per-acre rates. In the furrow plots the water was not allowed to cover the treated area, whereas in the flood basin irrigation, water was applied over the treated area, and apparently carried the herbicide into the root zone, causing typical simazine and diuron injury at the higher rates. Symptoms were considerably less intense with winter-applied herbicides than with summer-applied, as shown by the results of the drastic treatment in the first test. The rainfall after February was insufficient to cause leaching of the herbicide into the root zone. By the time irrigation had been begun in the flood basin, enough of the herbicide had apparently dissipated, thus minimizing the amount of simazine or diuron that reached the root zone of the peach trees; hence less damage was observed in the second test than in the first test.

Third test

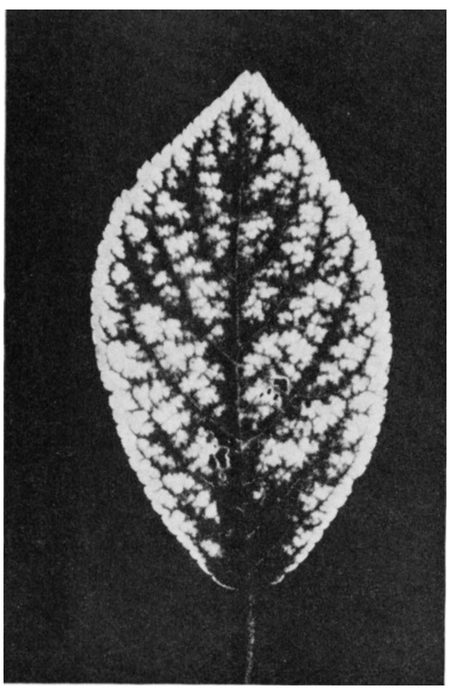
In a third test conducted on a considerably different soil with young (one-year-old) peach trees, excellent weed control was observed from all the herbicide treatments. Fluometuron showed considerably more injury than equivalent rates of simazine or terbacil under flood irrigation. Less injury from fluomenturon was observed under furrow irrigation; however, even here the ratings were above those of simazine or terbacil. The phytotoxicity from simazine—although slight on this soil—was greater under flood irrigation than under furrow. These data were consistent with the earlier two experiments on older trees. The phytotoxicity symptoms from terbacil were comparable in intensity to those of simazine.

Terbacil caused a severe chlorosis with the veins turning yellow down to the small veinlets, causing a lacy pattern of yellow veins. Under the same soil conditions, considerably more injury was observed on young trees than on older trees. However, even the high rates of simazine (4 lbs per acre) caused only slight symptoms. These results again illustrate the large differences brought about by factors relating apparently to location, soil type and to level of organic matter. Simazine and terbacil showed phytotoxicity symptoms under both flood and furrow irrigation (table 3); simazine proved to be slightly more toxic than terbacil on a pound-for-pound basis.

All herbicides tested showed very little evidence of injury under furrow irriga-

Photo shows a raised bed along the tree row for furrow irrigation in a deciduous orchard.

Phytotoxicity symptoms on the foliage of prune trees from root uptake of simazine applied at high rates.



tion; this suggests that under furrow irrigation less herbicide reached the roots of the young growing trees, since only 1 acre-inch of irrigation water was applied by sprinkler immediately after herbicide application (plus 0.76 acre-inch of rainfall). The furrow-irrigated trees got no more water than the treated beds, whereas flood-irrigated areas received 15 acre-inches (a total of 16.76 acre-inches) on top of the herbicide.

Phytotoxicity

A close relationship was noted between the degree of early phytotoxicity symptoms and length of the sprinkler irrigation; the most severe injury occurred at the higher simazine rates and under heavy irrigation (table 4). Few phytotoxicity symptoms were observed under light irrigation. Severe injury resulted at 2 lbs per acre of simazine under medium and heavy irrigation. Strong phytotoxicity symptoms were observed at the 1-lb-per-acre rate under heavy irrigation. The symptoms were apparent about a month after the trees had begun to leaf, and the symptoms reached a maximum in 2 to 3 months, at which time the new growth had begun to recover. By the end of the growing season, the trees showed much less phytotoxicity than they had earlier. Although the foliar injury was severe under heavy irrigation and higher rates of simazine, there was no effect on tree growth.

Conclusions

A number of tests in several locations have proven the importance of irrigation methods on the response of fruit trees to herbicides. Although many pre-emergence herbicides are quite insoluble, some detrimental herbicidal effects have been demonstrated under flood and sprinkler irrigation that have not been seen with furrow irrigation.

The soils in these experiments were sandy and for the most part were low in organic matter where herbicide-irrigation differences would be expected. A considerable degree of foliar injury from root uptake was recorded in these trials. Some deviations from these results have been observed in commercial practice; nonetheless, these studies clearly point out that a raised bed with furrow irrigation is safer than general flood and sprinkler irrigation.

Resistance of trees to herbicides in most California soils is largely one of vertical position of the herbicides in the soil. The soil acts as a buffer between the herbicide and the tree roots. Any cultural practice which incorporates the herbicide into the soil tends to increase injury in the tree by placing the herbicide closer to the tree roots. Sprinkler and flood irrigation move salts and herbicides into the soil. Furrow and bed irrigation move the salt laterally and up to the highest point on the bed.

These studies illustrate the effect of the movement of herbicides downward on tree health and on tree foliage. These results further emphasize the importance of water management in orchards when using soil-persistent herbicides.

TABLE 4. EFFECT OF IRRIGATION ON THE PHYTOTOXICITY OF SIMAZINE TO PEACH AND PLUM VARIETIES AS OBSERVED ON FOLIAGE, 1–4 MONTHS AFTER APPLICATION

Herbicide	Rate	Average* 2 Months		
		S-37[a]	Nem.[b]	Plum[c]
	lb/A			
Light Irrig.				
Simazine 80W	½	0	0.4	0
Simazine 80W	1	0.7	1.5	1.6
Simazine 80W	2	0	1.6	1.4
Check	–	0.1	0	0
Mod. Irrig.				
Simazine 80W	½	0.9	0.5	0.7
Simazine 80W	1	1.1	1.0	3.0
Simazine 80W	2	3.1	2.8	4.5
Check	–	0	0	0
Heavy Irrig.				
Simazine 80W	½	1.2	0.4	1.4
Simazine 80W	1	1.9	2.7	3.9
Simazine 80W	2	3.2	8.0	5:0
Check	–	0	0	0

* Average rate of 4 replications per treatment where 0 = no effect, 3 = definite pattern, 10 = all foliage dead.
[a] S-37 peach rootstock
[b] Nemagard rootstock
[c] Marianna plum rootstock

TABLE 3. THE EFFECT OF FLOOD AND FURROW IRRIGATION ON THE PHYTOTOXICITY OF HERBICIDES ON YOUNG PEACH AND ALMOND TREES

Herbicide	Rate	Average*							
		Flood					Furrow		
		Fortuna Peach	Starn Peach	Red Top Peach	Peerless Almond	Ave.	Cling Peach	Texas Almond	Ave.
	lb/A								
Simazine 80W	1	2.7	1.7	2.7	0.7	1.9	—	—	—
Simazine 80W	2	5.3	3.7	4.3	2.3	3.9	1.0	3.3	2.2
Terbacil 80W	2	3.3	2.3	3.0	1.3	2.5	—	—	—
Terbacil 80W	4	4.3	2.0	4.3	4.7	3.8	2.7	2.0	2.4
Dichlobenil 4G	4	2.7	2.0	3.0	2.0	2.4	—	—	—
Dichlobenil 4G	16	5.0	5.3	5.0	5.0	5.1	1.3	0	0.6
Check	—	2.3	3.7	2.0	0.7	2.2	1.0	0	0.5

* Average of three replications per treatment where 0 = no effects, 3 = definite pattern, 5 = chlorosis plus marginal burn, 10 = all leaves burned or defoliated.

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