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TOXICITY OF THREE 2,4-D FORMULATIONS IN CALIFORNIA SOILS

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TOXICITY OF PHENYL MERCURIC COMPOUNDS IN CALIFORNIA SOILS[1]

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INTRODUCTION

IN THE SPRING of 1947 the Rhode Island Experiment Station announced that phenyl mercuric acetate (soluble), which had been applied to soil as a fungicide, also controlled crabgrass (*Digitaria* sp.) seedlings in lawns (1947).[4] DeFrance (1947) reported good control of crabgrass seedlings from seven applications of the commercial product, sold under the trade name of Tat-C-Lect, made at the rate of one pint of concentrate to 100 gallons of water and applied at the rate of 10 gallons per 1,000 square feet. The commercially recommended dosage is eight ounces per gallon, applied twice, five to seven days apart, at a rate of one gallon per 500 square feet.

Because crabgrass is one of the worst of lawn weeds, the commercial publicity given to its control by the phenyl mercuric compounds was very widespread. To determine the eventual toxicity of spray residues in the soil and the possibilities of ridding the soil of their effects was therefore important.

MATERIALS AND METHODS

Tests were carried out in the greenhouse to study the toxicity, distribution (percolation), and leaching of phenyl mercuric compounds in samples from four California soil series: Yolo, Aiken, Hanford, and Willows. Three compounds were studied in their effects on the soils: phenyl mercuri triethanol ammonium lactate, phenyl mercuric acetate, and phenyl mercuric hydroxide. Kanota oats were used as indicator plants.

Toxicity Tests. The method followed in these tests was first described by Crafts (1935). Several series of cultures were grown in unperforated no. 2 cans. They contained the following concentrations of phenyl mercuric compounds: 0.0, 5.0, 15.0, 40.0, 80.0, 140.0, 220.0, 340.0, 490.0, and 680.0 p.p.m., air dry soil basis.

Because of the somewhat low solubility in water of phenyl mercuric acetate, no cultures using this herbicide above 370.0 p.p.m. were set up. The amounts of chemical were taken from a stock solution, diluted to a total volume sufficient to bring the soil to its field capacity, and added in three increments to obtain more even distribution. The cans were then seeded and the soil brought regularly to its field capacity by weighing. After 30 days, the crop was cut at ground level and its fresh weight recorded. It was then returned to each individual culture. The soil, which had dried out over a period of 30 days, was pulverized, poured back into the cans on top of the dried plant material, moistened to its field capacity, and reseeded to determine any change in toxicity.

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[4] See "Literature Cited" for citations referred to in text by author and date.

The results of the toxicity tests are shown in figures 1 to 5 and in tables 1 and 2.

Distribution Tests. Percolation tests were carried out to determine the distribution of the phenyl mercuric compounds in columns of air dry soil. The apparatus used and the method followed were first described by Crafts (1935). The amounts of herbicide added were equal to those necessary to induce a severe growth inhibition in cultures of the toxicity tests, to half, and to twice this value.

Experimental results are shown in figures 6 to 11 and in tables 3 and 4.

Leaching Tests. The apparatus used in the percolation test was also used here. After the chemical solution had percolated entirely through the soil, measured quantities of water were added to the top of these columns and allowed to leach through the soil. To columns previously receiving herbicides quantitatively equal to twice the amount necessary to inhibit growth in the original toxicity series were added 5.0, 10.0, and 20.0 "surface cms of water" (Crafts, 1949).

Figures 12 to 16 and table 5 summarize the experimental data.

DISCUSSION AND CONCLUSIONS

As can be seen in figure 1, the effect of the three different chemicals used was very similar in Yolo fine sandy loam, the acetate and hydroxide compounds being very slightly less toxic than the triethanol ammonium lactate. These differences, however, are not significant.

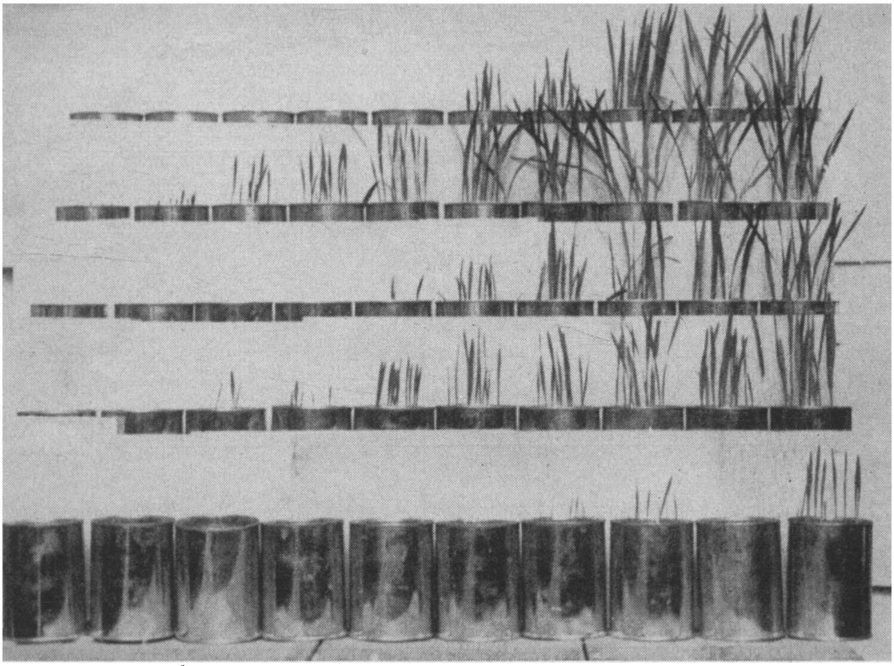
A study of the data on the initial toxicity run indicates that these compounds act as soil sterilants for a range of values going from 220.0 to more than 680.0 p.p.m. in the four soils studied, yet at 220.0 p.p.m., reduction in yield was considerable in all instances.

With the exception of Yolo adobe clay, which Crafts (1949) reported as acting differently from soils of its type, there is an evident relation between toxicity and clay content of the soils, as can be seen in table 6. Within the Yolo group, the toxicity can also be correlated to the fertility level of the soil, if the fresh weight of the checks is taken as an index of that soil characteristic (table 7).

Results of the percolation tests later confirmed this point, as can be seen in figures 6 to 10, where, in all instances, growth inhibition occurred in the top 10 cms of a soil column 85 cms long. It was also determined (fig. 11) that the chemical compound actually accumulated in a much smaller fraction of soil—not more than 5 cm in thickness.

The apparent discrepancy in growth in the 2.5 to 5.0 cm fraction between Yolo clay loam and Yolo fine sandy loam, shown in table 4, is due probably to the fact that 1 inch of air dry soil of a column of the last soil is approximately equivalent to 166 gm, whereas that of the first soil is only 145 gm.

Examination of figures 2 to 5 will show that by the second cropping the chemical had decomposed to such an extent in all instances that little toxicity was left in the soil, even at the highest concentrations (680.0 p.p.m.). It can also be noted that in some instances values higher than the check yields were obtained after decomposition of the chemical in the soil. These values may be



Phenyl mercuri triethanol ammonium lactate toxicity in five California soils. The concentrations used are (from right to left): 0.0, 5.0, 15.0, 40.0, 80.0, 140.0, 220.0, 340.0, 490.0, and 680.0 p.p.m. air dry soil basis. Soils from top to bottom are: Yolo adobe clay; Yolo clay loam; Yolo fine sandy loam; Hanford fine sandy loam; and Egbert loam.

due to a breakdown of the herbicide releasing ammonia—for example, the triethanol ammonium lactate salt was used—and/or may be due to the total available bases in the soil, because those bases, still in the form of undecomposed plant material, utilized in the first crop were not available immediately to the second crop.

Results of the leaching experiments (figures 12 to 16) show that water up to and including 20.0 surface cm was not able to displace the toxicant from the top layer of the soil column where it had accumulated.

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1935. Toxicity of sodium arsenite and sodium chlorate in four California soils. Hilgardia 9:461–97.
1949. Toxicity of 2,4-D in California soils. Hilgardia 19:141–57.
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1947. H_2O soluble mercurials for crabgrass control in turf. The Greenkeeper's Reporter, January–February.

TABLE 1

FRESH WEIGHTS OF KANOTA OATS GROWN IN YOLO FINE SANDY LOAM CONTAINING VARIOUS CONCENTRATIONS OF THREE PHENYL MERCURIC COMPOUNDS
(Values are averages of two replicates)

Concentration of compound in p.p.m. (air dry soil basis)	Phenyl mercuri triethanol ammonium lactate	Phenyl mercuric hydroxide	Phenyl mercuric acetate
	(wt, gm)	*(wt, gm)*	*(wt, gm)*
0.0	9.0	9.0	9.5
5.0	9.5	10.8	10.1
15.0	9.2	10.7	9.9
40.0	8.4	10.3	8.2
80.0	7.2	7.1	7.4
140.0	5.0	4.1	4.2
220.0	0.8	1.3	3.7
340.0	0.0	0.8	0.8

TABLE 2

FRESH WEIGHTS OF KANOTA OATS GROWN IN FOUR CALIFORNIA SOILS CONTAINING VARIOUS CONCENTRATIONS OF PHENYL MERCURI TRIETHANOL AMMONIUM LACTATE
(Values are averages of two replicates)

Concentration of compound in p.p.m. (air dry soil basis)	Soils			
	Yolo fine sandy loam	Yolo clay loam	Yolo adobe clay	Hanford fine sandy loam
	First crop			
	(wt, gm)	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*
0.0	9.0	12.1	6.9	6.0
5.0	9.5	14.3	8.5	6.0
15.0	9.2	13.5	6.8	5.6
40.0	8.4	14.3	6.3	5.5
80.0	7.2	12.3	5.3	5.2
140.0	5.0	10.3	0.5	3.4
220.0	0.8	8.3	0.0	1.2
340.0	0.0	4.8	0.0	0.8
490.0	0.0	3.6	0.0	0.0
680.0	0.0	2.8	0.0	0.0
	Second crop			
	(wt, gm)	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*
0.0	6.8	9.0	3.7	6.3
5.0	5.8	9.1	4.0	5.3
15.0	6.4	9.1	3.8	5.6
40.0	6.9	11.0	4.2	5.6
80.0	8.6	12.1	4.3	6.3
140.0	9.8	12.7	6.2	8.2
220.0	8.9	13.1	5.2	8.8
340.0	8.8	10.1	4.9	8.6
490.0	7.0	10.9	3.6	7.3
680.0	6.0	11.5	2.7	6.8

TABLE 3

FRESH WEIGHTS OF KANOTA OATS GROWN IN FRACTIONS OF COLUMNS OF FIVE CALIFORNIA SOILS IN PERCOLATION TESTS USING PHENYL MERCURIC HYDROXIDE

Depth	Soils					
	Yolo fine sandy loam (p.p.m. added)			Yolo clay loam (p.p.m. added)		
	75	150	300	350	700	1400
(*cm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)
0.0– 8.5	4.3	2.0	2.8	4.1	3.5	1.7
8.5–17.0	5.1	5.0	5.7	11.7	9.0	6.9
17.0–25.5	6.8	5.3	6.1	12.9	12.6	9.5
25.5–34.0	7.8	7.4	7.3	12.7	15.0	12.2
34.0–42.5	11.1	11.1	9.2	13.6	15.0	12.6
42.5–51.0	12.8	11.3	11.2	13.0	15.2	12.1
51.0–59.5	13.8	11.7	11.9	14.0	15.8	14.0
59.5–68.0	11.8	10.4	11.3	16.2	17.2	15.1
68.0–76.5	10.6	9.6	9.4	16.3	15.6	13.8
76.5–85.0	10.4	10.2	9.6	0.0	15.6	14.6
Checks	10.7	10.6	9.6	12.3	13.0	12.4

Depth	Soils								
	Hanford fine sandy loam (p.p.m. added)			Aiken clay loam (p.p.m. added)			Willows adobe clay (p.p.m. added)		
	50	100	200	700	1400	2800	100	200	400
(*cm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)	(*wt, gm*)
0.0– 8.5	8.5	6.2	6.2	3.2	1.1	0.7	2.6	1.8	1.7
8.5–17.0	8.4	8.1	9.0	5.7	5.4	5.9	3.6	3.0	5.3
17.0–25.5	15.6	9.0	9.2	6.9	5.0	5.8	4.0	3.1	5.1
25.5–34.0	15.0	9.2	9.5	5.8	6.2	6.3	4.6	3.8	5.2
34.0–42.5	16.7	13.3	10.4	5.0	5.5	5.1	3.2	3.5	6.2
42.5–51.0	14.0	8.8	8.5	5.0	5.5	5.1	4.2	4.2	5.2
51.0–59.5	14.6	8.7	7.9	3.4	5.6	5.9	3.2	3.7	5.0
59.5–68.0	14.7	8.6	8.7	5.5	5.4	5.9	4.6	4.4	5.3
68.0–76.5	14.3	9.6	9.1	5.2	6.0	6.0	4.0	4.7	5.4
76.5–85.0	13.6	10.8	9.2	5.4	5.3	4.9	5.0	4.0	5.0
Checks	13.1	9.6	10.4	4.0	5.0	5.7	4.2	4.0	5.4

TABLE 4

FRESH WEIGHTS OF KANOTA OATS GROWN IN FRACTIONS OF COLUMNS OF TWO CALIFORNIA SOILS IN PERCOLATION TESTS USING PHENYL MERCURIC ACETATE

Depth	Yolo fine sandy loam (150 p.p.m. added)	Yolo clay loam (700 p.p.m. added)
(*cm*)	(*wt, gm*)	(*wt, gm*)
0.0– 2.5	0.3	0.0
2.5– 5.0	3.2	2.5
5.0– 7.5	4.5	4.9
7.5–10.0	4.4	5.6
10.0–12.5	4.5	5.9
Checks	6.6	6.6

TABLE 5

FRESH WEIGHTS OF KANOTA OATS GROWN IN FRACTIONS OF COLUMNS OF FIVE CALIFORNIA SOILS IN LEACHING TESTS USING PHENYL MERCURIC HYDROXIDE

Depth	Hanford fine sandy loam (columns percolated with 200 p.p.m.)			Yolo fine sandy loam (columns percolated with 300 p.p.m.)			Yolo clay loam (columns percolated with 1400 p.p.m.)			Willows adobe clay (columns percolated with 1400 p.p.m.)			Aiken clay loam (columns percolated with 2800 p.p.m.)	
	Surface water added			Surface water added			Surface water added			Surface water added			Surface water added	
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	5 cm	20 cm
(cm)	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*	*(wt, gm)*
0.0– 8.5	3.9	2.3	4.6	1.6	0.4	3.3	0.1	0.2	2.8	0.6	1.0	1.8	0.1	0.5
8.5–17.0	8.4	9.3	7.0	5.3	5.5	5.5	7.0	8.2	13.3	4.7	3.9	3.1	4.5	5.4
17.0–25.5	10.3	11.4	8.0	7.5	5.1	6.2	7.0	13.3	12.0	5.8	4.9	2.9	4.8	6.1
25.5–34.0	10.2	10.1	9.6	8.6	6.3	5.4	11.3	13.5	13.2	5.0	4.4	2.9	5.0	5.3
34.0–42.5	10.5	11.3	10.0	11.4	7.3	6.2	14.2	15.2	13.4	6.0	5.0	3.0	4.8	5.3
42.5–51.0	9.3	11.5	10.5	11.5	10.3	6.5	16.4	17.1	15.4	4.5	5.0	3.1	4.8	4.7
51.0–59.5	10.1	10.3	11.0	10.7	12.1	6.9	17.2	16.0	11.8	5.6	5.1	3.1	5.2	4.7
59.5–68.0	9.2	9.3	9.0	12.2	11.4	7.8	18.0	16.8	14.1	5.2	5.1	2.5	5.0	5.3
68.0–76.5	10.0	9.1	9.1	12.4	13.1	10.4	15.6	15.1	15.0	5.4	4.4	2.3	5.4	4.8
76.5–85.0	11.6	8.2	9.1	11.0	11.0	11.4	14.3	14.5	12.0	4.7	5.1	2.5	4.6	4.1
Checks	10.0	10.4	9.1	10.6	12.4	8.4	15.1	15.7	13.3	6.3	6.3	5.0	4.4	5.2

TABLE 6

RELATION BETWEEN CLAY CONTENT OF SOILS AND TOXICITY OF PHENYL MERCURI TRIETHANOL AMMONIUM LACTATE

Soil	Clay	No growth at:
	(per cent)	*(p.p.m.)*
Yolo fine sandy loam	14.94	320.0
Hanford fine sandy loam	16.44	490.0
Yolo clay loam	38.28	more than 680.0
Yolo adobe clay	50.8	220.0

TABLE 7

RELATION BETWEEN SOIL FERTILITY AND TOXICITY OF PHENYL MERCURI TRIETHANOL AMMONIUM LACTATE

Soil	Fresh weight of check	No growth at:
	(gm)	*(p.p.m.)*
Yolo adobe clay	6.9	220.0
Yolo fine sandy loam	9.0	340.0
Yolo clay loam	12.1	more than 680.0

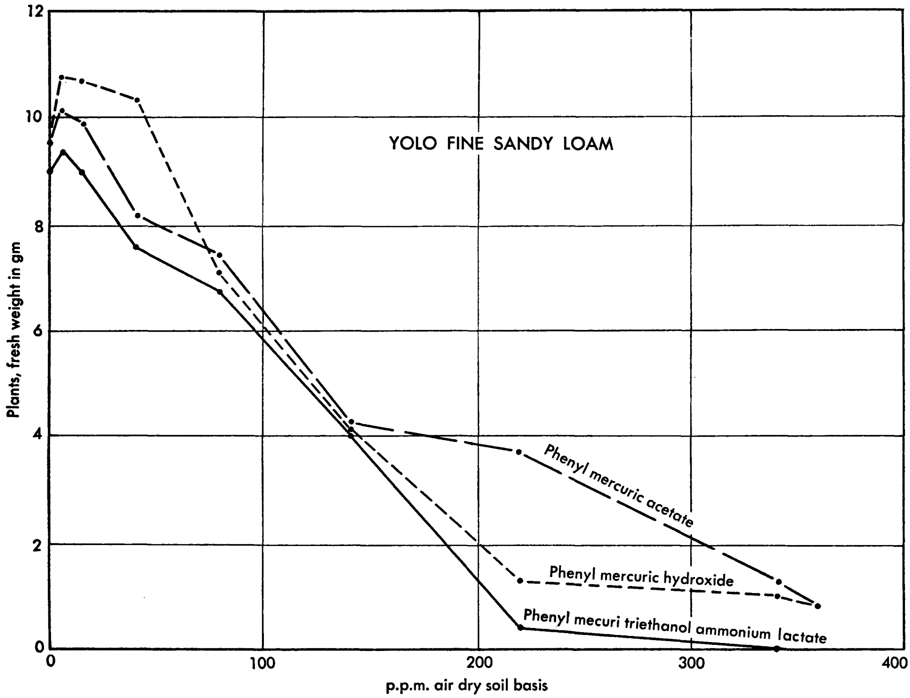

Fig. 1. Relation of crop yield to various concentrations of three phenyl mercuric compounds in Yolo fine sandy loam.

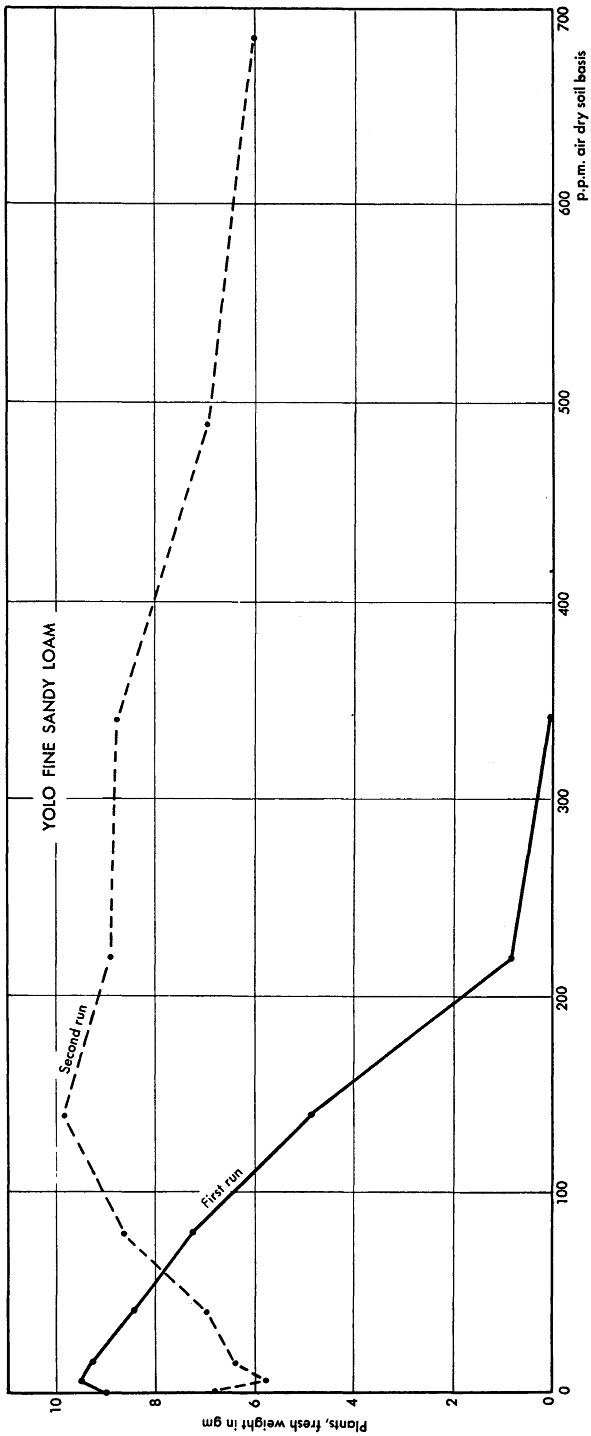

Fig. 2. Relation of crop yield to concentration of phenyl mercuri triethanol ammonium lactate in Yolo fine sandy loam.

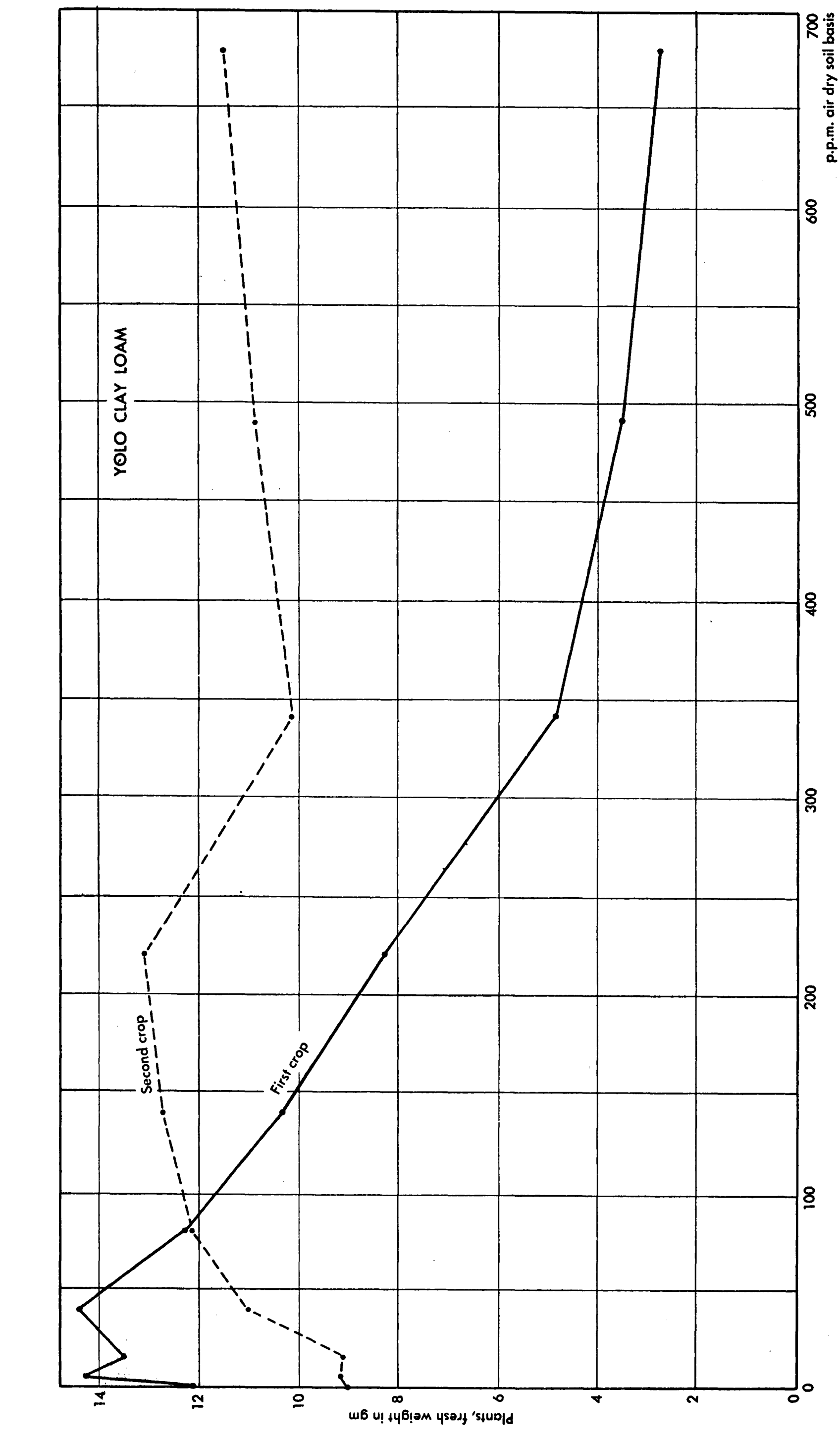

Fig. 3. Relation of crop yield to concentration of phenyl mercuri triethanol ammonium lactate in Yolo clay loam.

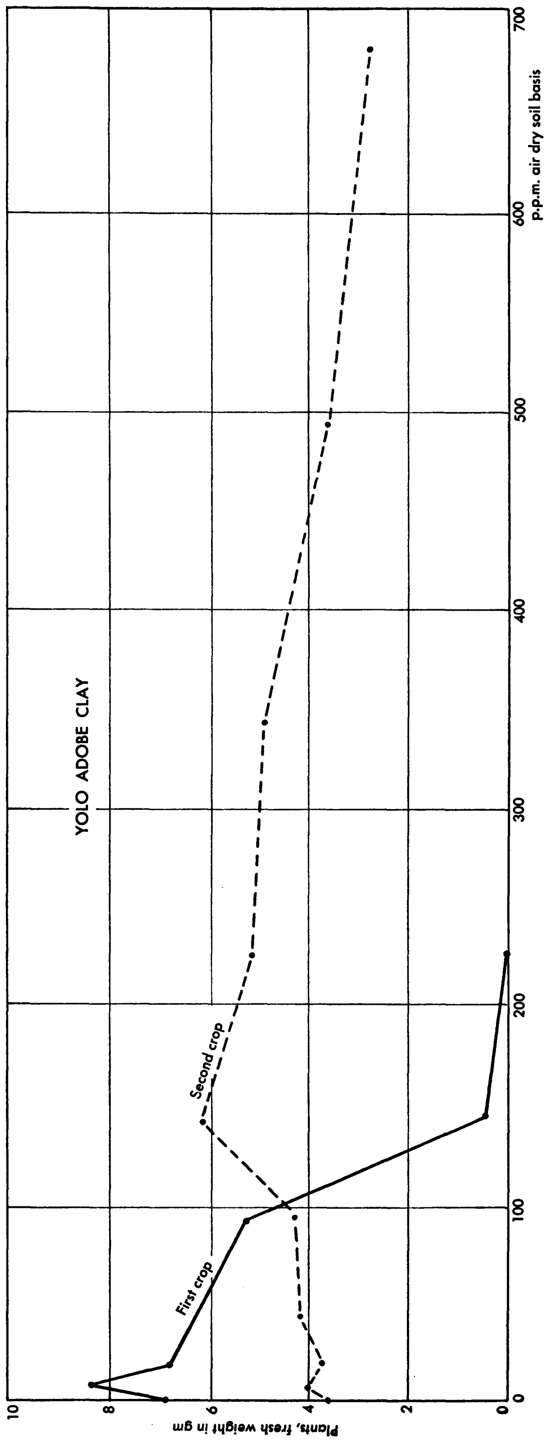

Fig. 4. Relation of crop yield to concentration of phenyl mercuri triethanol ammonium lactate in Yolo adobe clay.

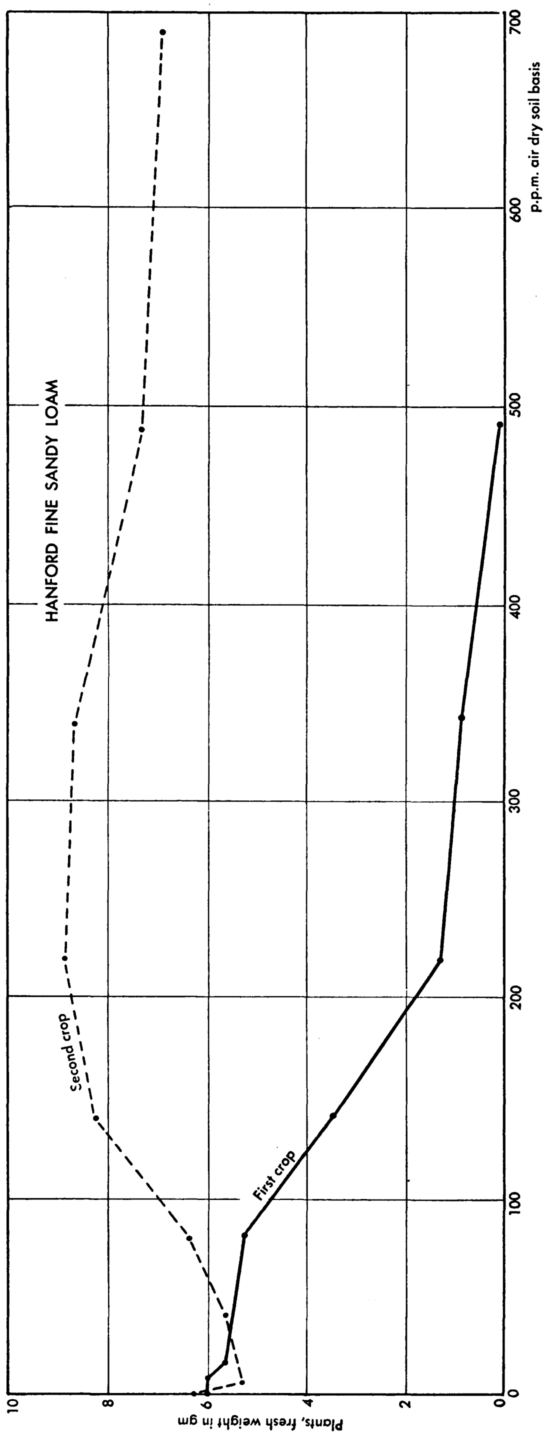

Fig. 5. Relation of crop yield to concentration of phenyl mercuri triethanol ammonium lactate in Hanford fine sandy loam.

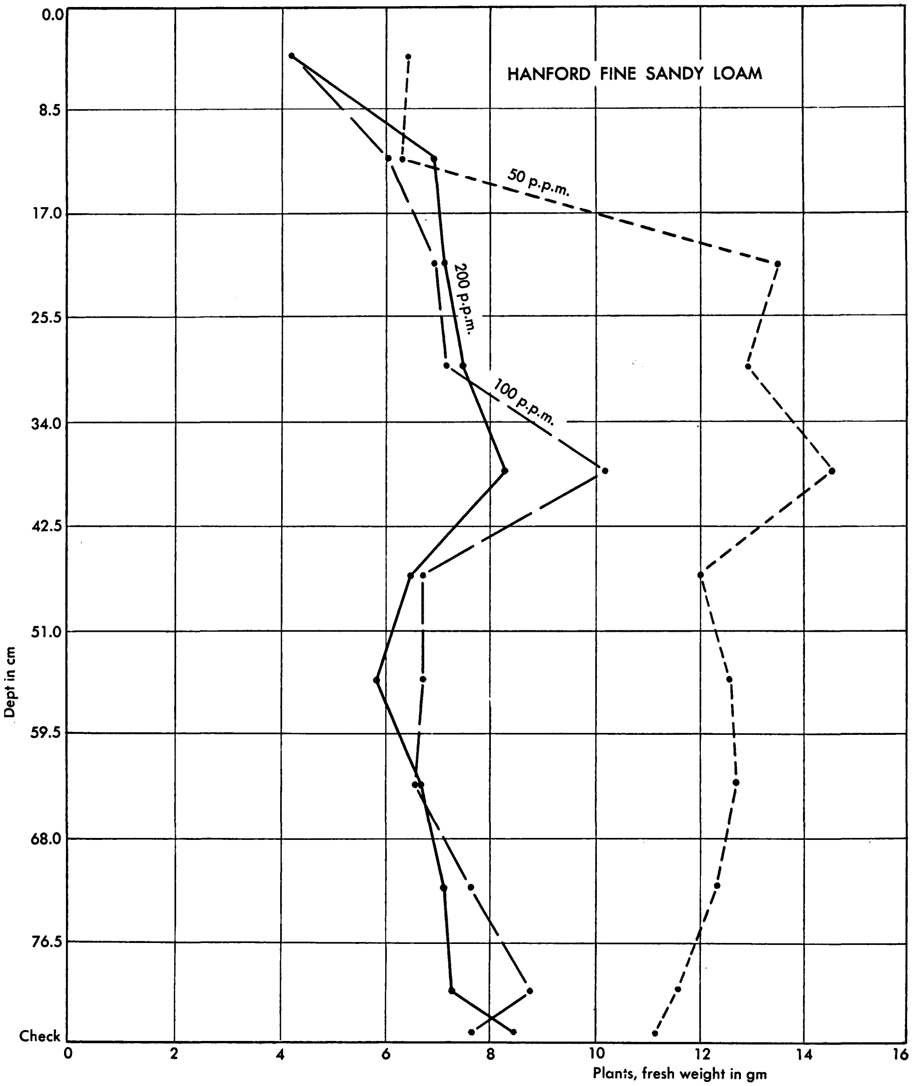

Fig. 6. Relation of crop yield to penetration of phenyl mercuric hydroxide in Hanford fine sandy loam.

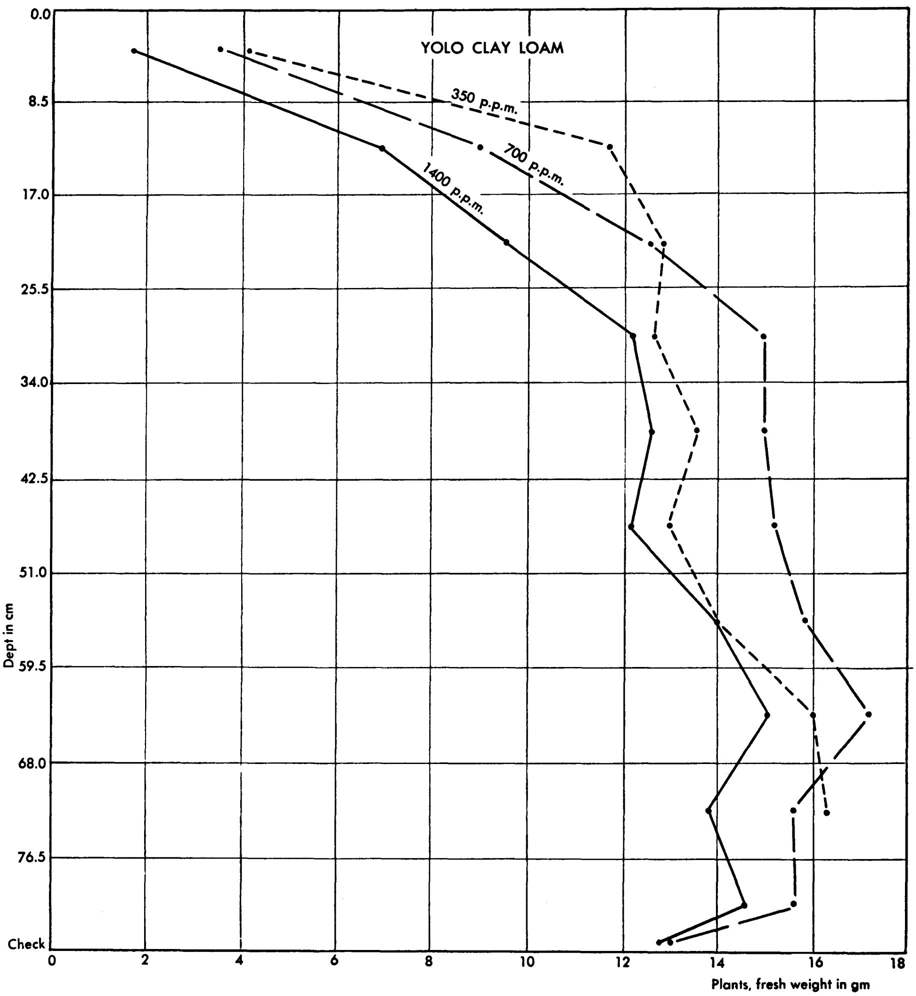

Fig. 7. Relation of crop yield to penetration of phenyl mercuric hydroxide in Yolo clay loam.

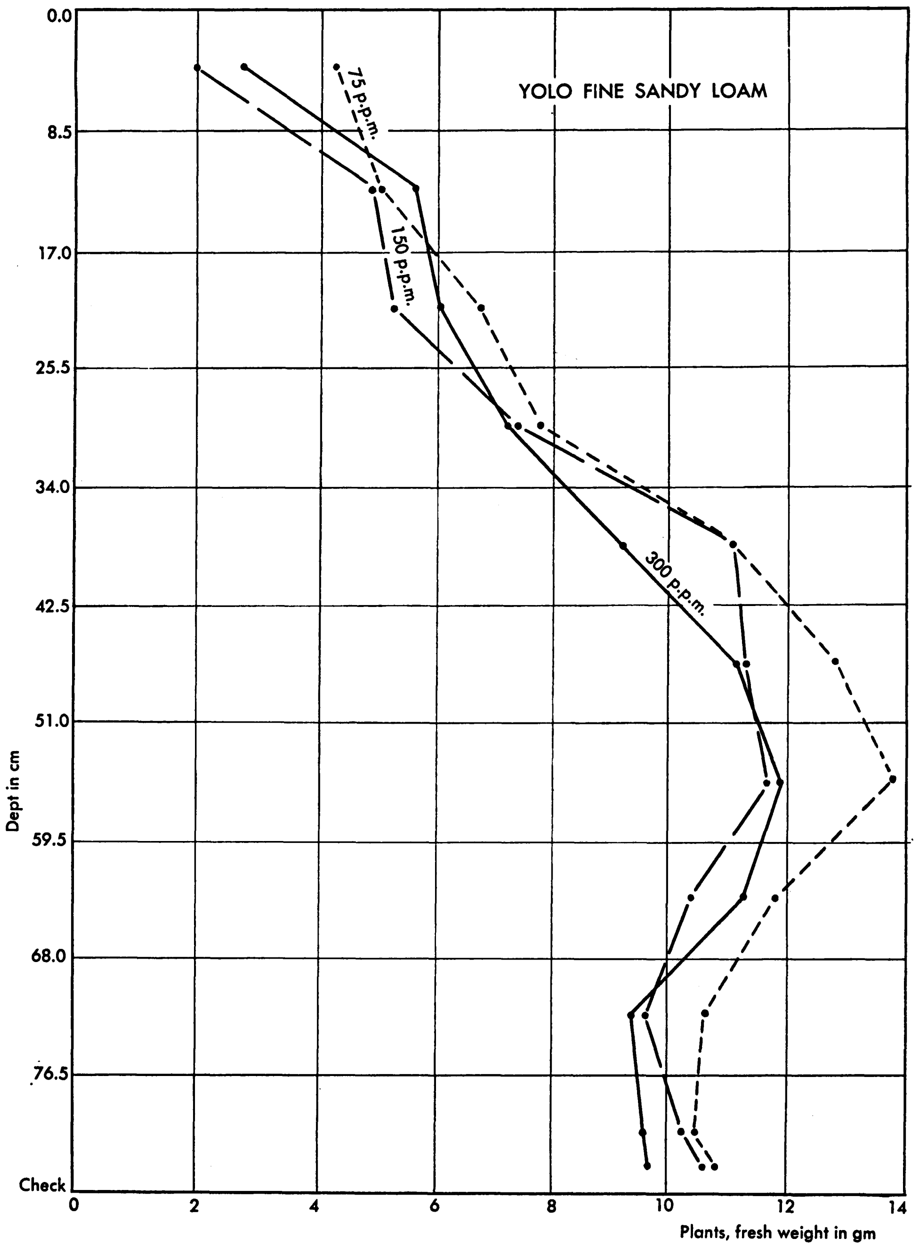

Fig. 8. Relation of crop yield to penetration of phenyl mercuric hydroxide in Yolo fine sandy loam.

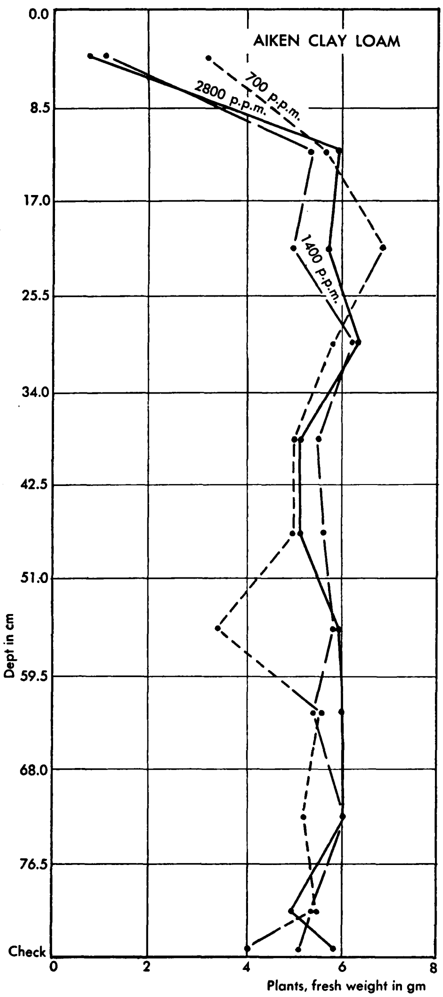

Fig. 9. Relation of crop yield to penetration of phenyl mercuric hydroxide in Aiken clay loam.

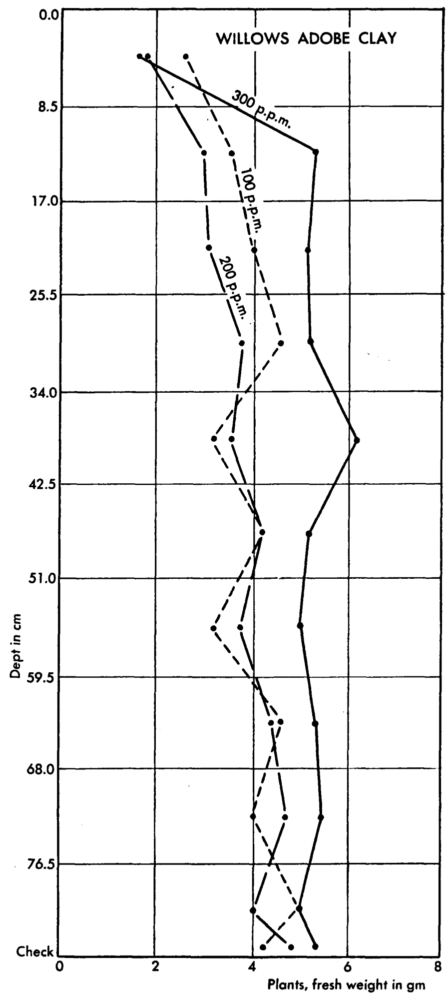

Fig. 10. Relation of crop yield to penetration of phenyl mercuric hydroxide in Willows adobe clay.

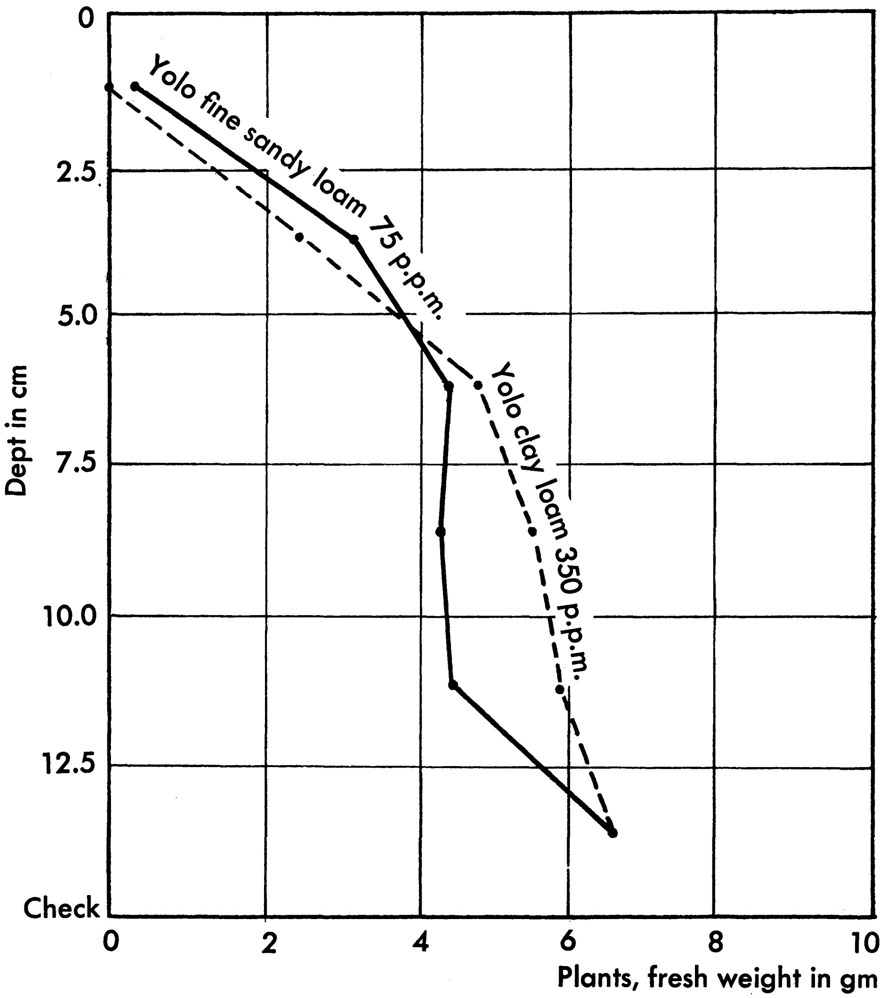

Fig. 11. Retention of phenyl mercuric acetate by two California soils.

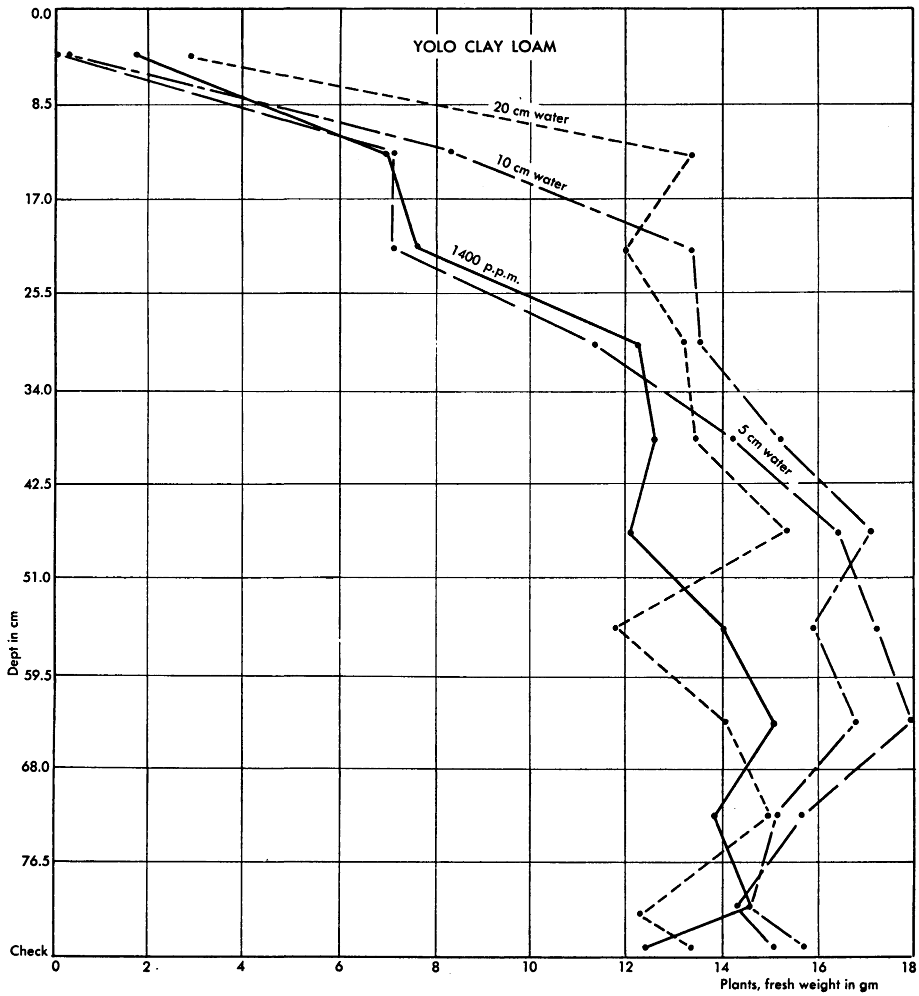

Fig. 12. Effects of leaching upon the location of phenyl mercuric hydroxide in Yolo clay loam.

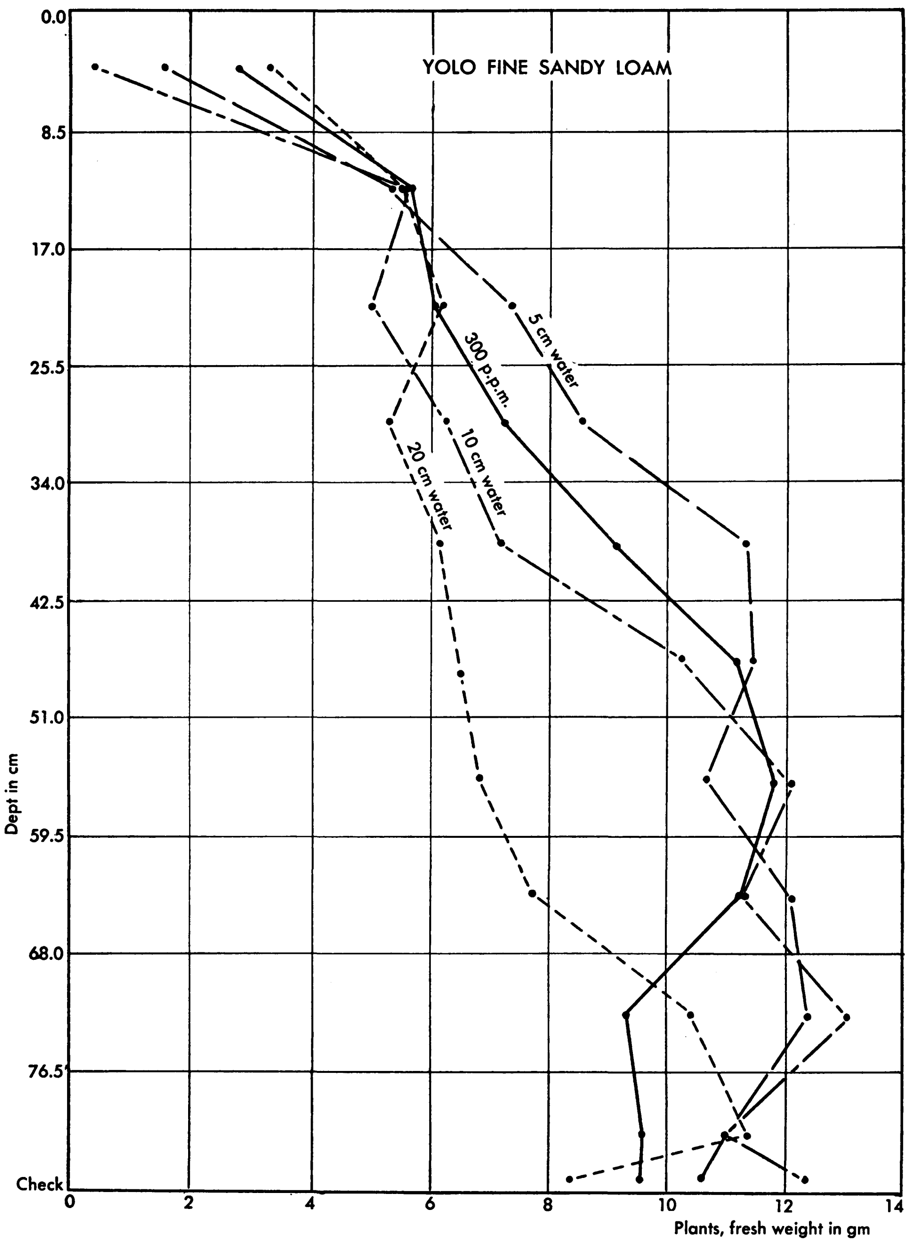

Fig. 13. Effects of leaching on the location of phenyl mercuric hydroxide in Yolo fine sandy loam.

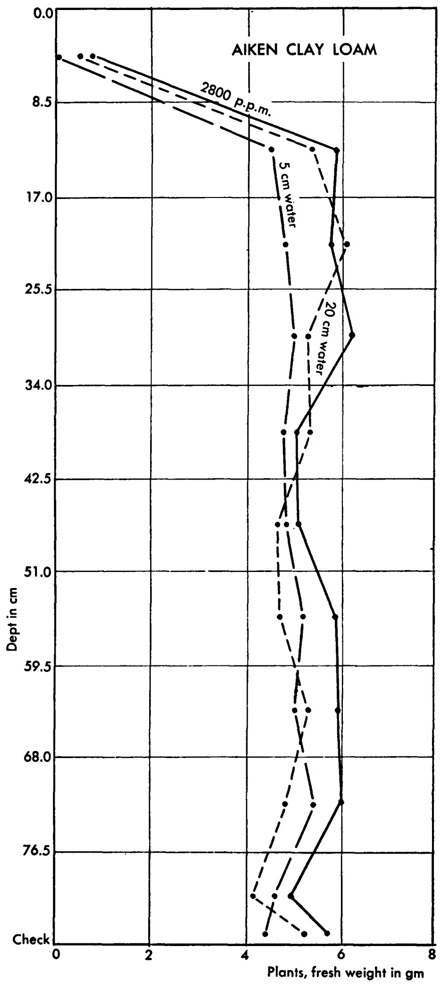

Fig. 14. Effects of leaching upon the location of phenyl mercuric hydroxide in Aiken clay loam.

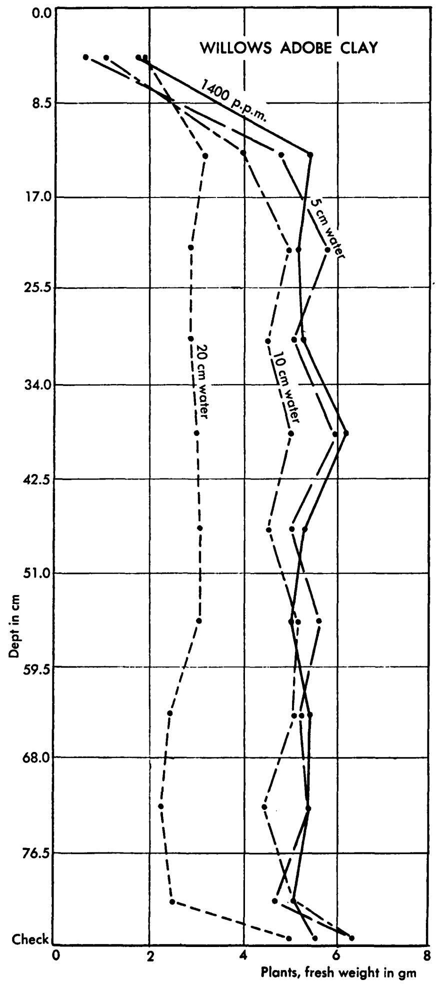

Fig. 15. Effects of leaching upon the location of phenyl mercuric hydroxide in Willows adobe clay.

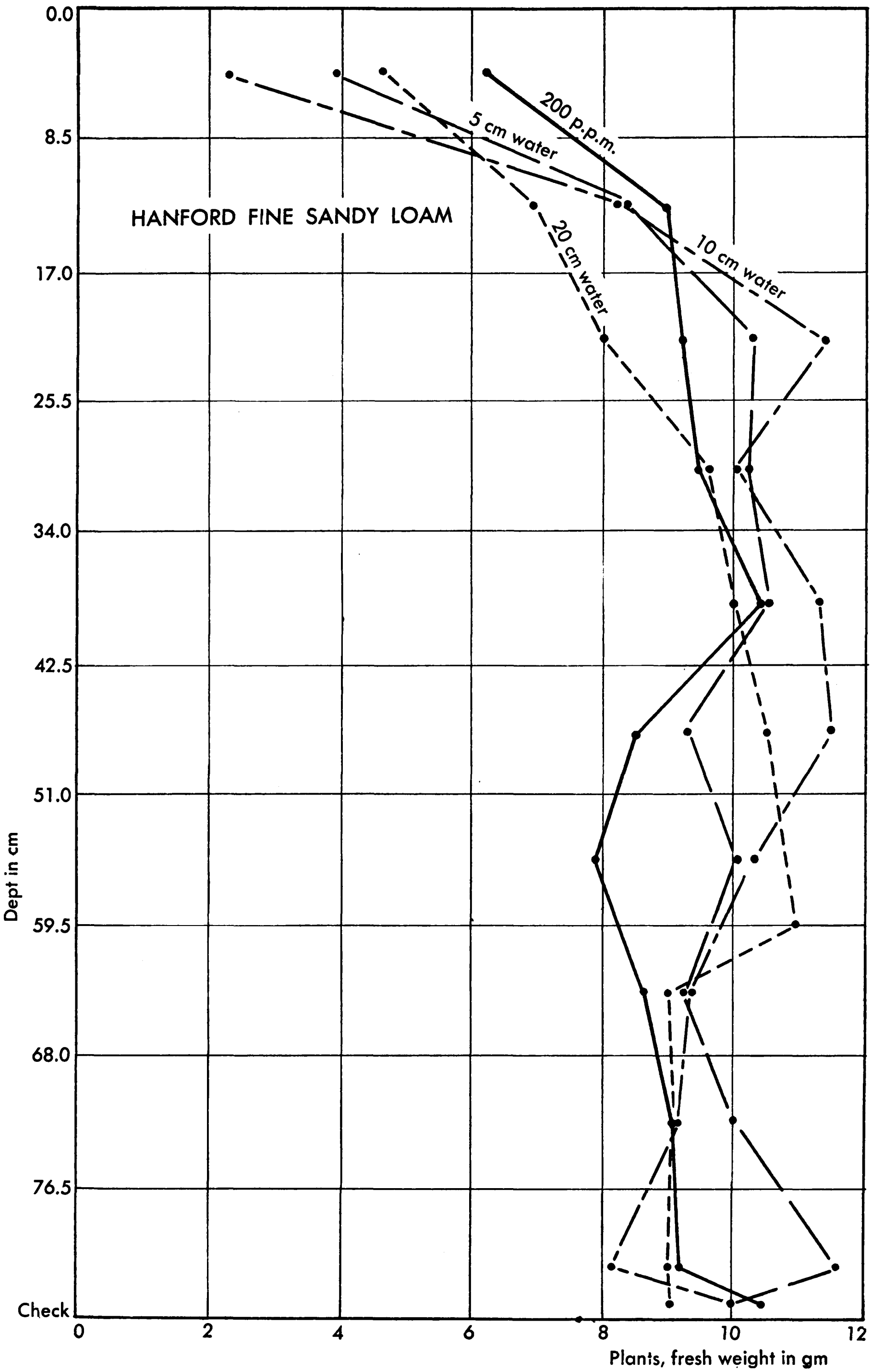

Fig. 16. Effects of leaching upon the location of phenyl mercuric hydroxide in Hanford fine sandy loam.

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