Reduction of Foliar Dislodgable Pesticide Residues from Orange Trees through Spray-washing with Water or Lime Solution

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Organophosphorus pesticides are used extensively for the control of pests attacking California citrus; some of the more important compounds are azinphosmethyl, dimethoate, dioxathion, ethion, malathion, methidathion, naled, parathion, and phosphamidon (STATE OF CALIFORNIA 1974). The hazard posed by some of these compounds, especially parathion, to field workers who enter treated groves has been the concern of several investigators. The major source of the toxicants has been attributed to foliar dislodgable residues (QUINBY and LEMMON 1958, WESTLAKE et al. 1973, GUNTHER et al. 1974, POPENDORF and SPEAR 1974, SPEAR et al. 1975, POPENDORF et al. 1975) and to orchard soil dust residues (GUNTHER et al. 1975, SPENCER et al. 1975). Research has been directed primarily toward determining the underlying factors that precipitate the sporadic episodes of worker illnesses (ADAMS et al. 1976) and toward estimating safe reentry conditions either through the use of mathematical models (SERAT 1973, SERAT and BAILEY 1974) or on-the-spot field analysis (SMITH et al. 1976).

Foliar residues can be reduced by water-washing of trees with an oscillating boom sprayer (WESTLAKE et al. 1973). Although this method is not an economically attractive solution for reducing foliar residues, it was desirable to establish the optimum conditions for reducing residues in case the need arises rapidly to reduce undesirable residue levels. Parathion-treated trees were washed with an oscillating boom spray rig and parameters such as gallons of water per acre, nozzle pressure, oscillations per minute, spray-cone and boom angle, and vehicle speed were systematically altered. Trees were also washed with lime solution to determine if the alkaline solution would enhance hydrolytic degradation of parathion or dioxathion.

MATERIAL AND METHODS

Application. Parathion 25% WP or dioxathion 8 lb/gal EC was applied to plots of navel orange trees located on the Citrus Research Center, Riverside, California. For the water-washing test parathion applications were made at a rate of 8.75 lb a.i./2,500 gal/A with an oscillating boom spray rig moving at 1.4 mph and using a 16° spray-cone angle. For the lime-washing tests, 10 lb a.i. of parathion was applied at 2,500 and 100 gal/A or 5 lb a.i. of dioxathion at 1,250 and 100 gal/A. Vehicle speed was 1.4 mph for the dilute and 1.6 mph for the low-volume application.

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Treatment dates varied and are given in the footnotes to each table.

Washing tests. Trees were water-washed with an oscillating boom spray rig and lime-water washed with either an oscillating boom spray rig or an air-blast sprayer. Rates and mechanical settings are given in the accompanying tables. Plots for the water-washing tests consisted of 4 or 6 trees and 4 replicate sets of 40 or 48 2.5-cm diameter leaf discs were taken before and again after the trees were washed. Plots for the lime-water washing tests each consisted of 8 trees and 3 replicate sets of samples were taken. The foliar dislodgable residues were removed by the procedure of GUNTHER et al. (1974). The solvent used for the final partitioning step was hexane for the water-washing test samples and benzene for the lime-water-washing for parathion, and hexane for dioxathion samples. Pesticide quantitation was by gas chromatography using an alkali flame ionization or flame photometric detector.

RESULTS

The trees were washed 3 to 5 days post-treatment which is a period of relatively rapid residue dissipation. The unwashed control plots all showed a residue reduction between sampling intervals. The data in Table I show that, as expected, the amount of foliar residue removed increased with the quantity of water used. The average amount of residue removed was 59, 65, 75, and 81% with 1,500, 2,000, 2,500, and 3,000 gal of water/A, respectively. It is concluded that boom oscillation rate was not critical as the average amount of residue removed was 71, 72, and 67% at 29, 53, and 78 oscillations/min, respectively. The data in Table II show no trend in the percent residue reduction with different nozzle pressures. The data in Table III indicate that possibly a low vehicle speed may reduce washing efficiency. The data in Table IV show that neither variations in the spray-cone angle nor the tilting of the boom slightly (30°) forward, such that water contacts the top of the tree first to wash the trees successively from top to bottom as the vehicle passes the tree, made any difference.

Lime solution was applied to parathion- and dioxathion-treated trees to determine if the alkaline solution would enhance pesticide degradation. The data in Table V show that foliar dislodgable residues were not decreased by a 100 gal/A low-volume lime application. A greater than 50% reduction of parathion occurred with a lime application of 50 lb/2,500 gal/A and essentially little or no reduction of dioxathion occurred with a lime application of 25 lb/1,250 gal/A. The results indicate that the total amount of water used per tree is the main factor in reducing foliar residues and not the presence of lime in the spray solution. The results are consistent with the data in Table I; minimal reduction is expected with a water volume of 1,250 gal/A and good reduction with 2,500 gal/A.

TABLE I

Effect of amount of water used and oscillation rate of the boom sprayer on the efficiency of reduction of foliar dislodgable parathion residues from orange trees.[a]

Water Used, gal/A	Oscillations per min	Parathion, μg/cm² 1-Day Pre-wash	1-Day Post-wash	Reduction, %
1,500	29	0.13 ± 0.02	0.07 ± 0.01	46
	53	0.20 ± 0.05	0.07 ± 0.01	65
	78	0.17 ± 0.04	0.06 ± 0.01	65
2,000	29	0.13 ± 0.04	0.04 ± 0.01	69
	53	0.14 ± 0.03	0.05 ± 0.01	64
	78	0.13 ± 0.04	0.05 ± 0.01	62
2,500	29	0.18 ± 0.05	0.03 ± 0.01	83
	53	0.20 ± 0.02	0.04 ± 0.01	73
	78	0.16 ± 0.05	0.05 ± 0.01	69
3,000	29	0.14 ± 0.02	0.02 ± 0.01	86
	53	0.20 ± 0.08	0.03 ± 0.01	85
	78	0.15 ± 0.06	0.04 ± 0.01	73
Unwashed	--	0.16 ± 0.03	0.12 ± 0.04	25

[a] Applied September 13, 1973; washed 5 days post-treatment; sampled one day before and after washing. Spray-cone angle was 16°, nozzle pressure was 550 psi, and vehicle speed was 1.5 mph.

TABLE II

Effect of water delivery pressure on the efficiency of reduction of foliar dislodgable parathion residues from orange trees spray-washed with 2,500 gal of water/A.[a]

Nozzle Pressure, psi	Parathion, μg/cm² 1-Day Pre-wash	1-Day Post-wash	% Reduction
300	0.098 ± 0.038	0.040 ± 0.009	59
400	0.186 ± 0.051	0.042 ± 0.004	77
500	0.126 ± 0.029	0.050 ± 0.007	60
600	0.108 ± 0.017	0.038 ± 0.007	65
Unwashed	0.094 ± 0.030	0.054 ± 0.004	43

[a] Applied March 15, 1974; washed 4 days post-treatment; sampled one day before and after washing. Spray-cone angle was 16°, oscillations per min was 29, and vehicle speed was 1.5 mph.

TABLE III

Effect of vehicle speed on the efficiency of reduction of foliar dislodgable parathion residues from orange trees spray-washed with 2,500 gal of water/A.[a]

Vehicle speed, mph	Oscillation per min	Parathion, $\mu g/cm^2$		Reduction, %
		Pre-wash	Post-wash	
0.9	39	0.091 $\pm$ 0.045	0.065 $\pm$ 0.010	29
1.4	60	0.054 $\pm$ 0.012	0.029 $\pm$ 0.005	46
1.9	78	0.096 $\pm$ 0.012	0.054 $\pm$ 0.020	44
Unwashed	--	0.057 $\pm$ 0.020	0.047 $\pm$ 0.013	18

[a] Applied August 25, 1975; washed 3 days post-treatment; sampled the same day as the washing. Spray-cone angle was 16° and nozzle pressure was 550 psi.

TABLE IV

Effect of spray-cone angle and oscillating boom angle on the efficiency of reduction of foliar dislodgable parathion residues from orange trees spray-washed with water.[a]

Water Used, gal/A	Cone angle, degrees	Boom angle, degrees	Parathion, $\mu g/cm^2$		Reduction, %
			Pre-wash	Post-wash	
2,200	16	0[b]	0.086 $\pm$ 0.015	0.026 $\pm$ 0.003	70
	32	0	0.166 $\pm$ 0.062	0.046 $\pm$ 0.007	72
	48	0	0.108 $\pm$ 0.006	0.031 $\pm$ 0.007	71
2,500	16	0	0.097 $\pm$ 0.027	0.031 $\pm$ 0.004	68
	16	30	0.098 $\pm$ 0.036	0.026 $\pm$ 0.006	73
Unwashed	--		0.086 $\pm$ 0.014	0.056 $\pm$ 0.023	35

[a] Applied September 5, 1975; washed 3 days post-treatment; sampled the same day as the washing. Vehicle speed was 1.4 mph, oscillations per min was 60, and nozzle pressure was 500 psi for the cone angle study and 550 psi for the boom angle study.

[b] 0° represents a boom perpendicular to the ground (normal position) and 30° represents a tilt in the direction of vehicle movement.

TABLE V

Effect of lime application on the efficiency of reduction of foliar dislodgable parathion and dioxathion residues.

Pesticide[a/]	Pesticide Treatment[b/] lb a.i.	Pesticide Treatment[b/] gal/A	Hydrated Lime Treatment[c/] lb	Hydrated Lime Treatment[c/] gal/A	Residue, $\mu g/cm^2$ Pre-lime	Residue, $\mu g/cm^2$ 7-Day Post-lime
Parathion	10	2,500	Untreated		0.8 ± 0.2	0.2
			50	2,500		<0.1
			50	100		0.3
Parathion	10	100	Untreated		4.6 ± 0.3	1.7
			50	2,500		0.7
			50	100		1.5
Dioxathion	5	1,250	Untreated		0.7 ± 0.1	0.5
			25	1,250		0.6
			25	100		0.4
Dioxathion	5	100	Untreated		1.2 ± 0.1	1.7
			25	1,250		1.2
			25	100		1.5

a/ Applied November 18, 1971 to navel orange trees located on the Citrus Research Center, Riverside, CA. Oversprayed with lime 4 days post-application.

b/ 25% WP parathion or 8 lb/gal EC dioxathion.

c/ Oscillating boom at 100 oscillations/min; 400-425 psi nozzle pressure; 1.4 (dilute) or 1.6 (low-volume) mph vehicle speed.

CONCLUSIONS

The volume of water applied is the single important factor in reducing foliar dislodgable residues by tree-washing with an oscillating boom spray rig, and none of the other washing parameters tested could be altered so as to increase washing efficiency and allow a reduction in the amount of water used. The additiion of lime to the washing solution did not enhance dissipation of foliar dislodgable residues of parathion or dioxathion.

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