Potential Residue Problem Associated with Low Volume Sprays on Citrus in California

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Low volume spraying in its present state of development for use on citrus crops in California represents a marked change from the conventional spray practices and because of its intrinsic nature requires a complete reappraisal of certain secondary or post-application effects. Those of primary concern are the ones most likely to be affected by the substantial increase in the amount of pesticide/unit volume of spray. Foremost among these is the effect on the deposition of the active material and the subsequent attenuation of the residue. Other workers investigating the use of low volume spraying on tree crops have made extensive evaluations of the variant physical factors affecting the magnitude of deposits and the resultant effects on control achievements, e.g., Brann (1,2), Himel (3), and Kristensen and Graham (4). While some of these studies included comparisons with dilute spray applications, there appears to have been no purposeful effort to evaluate the relative levels of the persisting residues. Preliminary studies to compare the magnitude of residues resulting from low volume and dilute spray applications have been completed; the results and their significance constitute the basis for this report.

The term 'low volume spraying' could denote a broad range of usages distinct from dilute spraying but at this juncture in its development for use on citrus in California, the connotation is to the application of approximately 100 gallons of spray/acre. This amount is in contrast to gallonages ranging from several hundred to over 3500 gallons of dilute spray/acre, depending primarily on tree size, density, nature of the pest control problem, and material being used. These highest amounts represent spraying for the attainment of complete film wetting of all aerial surfaces of the tree.

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Somewhat lesser amounts of spray could be utilized to obtain this degree of coverage if it were economically feasible to take a longer time to complete the application. This is typically the case in most other citrus-producing areas of the world and the dilute spray gallonages used in California represent maximum levels.

To suggest the possibility of reducing the amount of spray gallonage from these levels to the 100 gallons per acre level implies reliance on less than film-type wetting coverage and the need to increase the pesticide concentration as a compensating provision. The ideal substitution for the film coverage of spray would be a uniform deposition of small droplets in a stiple pattern on the plant surfaces throughout the tree structure. The formation of optimal droplet sizes is critical since overly small droplets will fail to impinge and deposit and overly large droplets greatly limit the number of droplets and correspondingly the physical attainment of a stiple pattern of small closely-deposited droplets. Corollary to the suitable formation of spray droplets within an optimal size range is the capability of the unit to distribute and deposit the droplets on all exposed tree surfaces.

As it became evident from background studies that sprayer units being made available on the market were substantially capable of achieving the physical requirements for low volume spraying, bioassay tests, based on the optimal operating procedures for such equipment and the use of various recommended pesticides, were undertaken against scale insect, thrips, and mite pests of citrus in California to determine the ultimate suitability of such treatments as substitutes for the dilute or semi-concentrate applications currently in use. To the extent that these trials indicate that any real promise for the use of the low volume spray method was dependent upon the use of higher spray concentrations, it became necessary to consider possible effects on the relative deposition and persistence of these materials and their relationship to residue tolerance requirements.

The study upon which this report is based was designed to characterize the relative extent of this problem with each of eight key materials in relation to their established usage patterns.

Materials and Methods

Materials evaluated were carbaryl, chlorobenzilate, dicofol, dimethoate, dioxathion, malathion, parathion, and phosphamidon. Each material was applied as a low volume spray application at the rate of 100 gallons/acre and as a dilute spray application at the gallonage rate representative of the amount normally used for the specific material in control usages on citrus trees of the type used in the test (Table 1). The only available or most frequently used formulations were selected but with malathion and parathion both emulsifiable concentrate and wettable powder formulations were tested.

Low volume applications were made with a Bean E-200 TR unit at 400 p.s.i. pressure and fan speed of 2600 r.p.m. Dilute applications were made with a mechanically oscillated boom sprayer unit at 500 p.s.i. pressure. Ground speeds of the two units were 1.6 and 1.4 m.p.h., respectively.

Applications were made in a mature navel orange grove in Corona, California with a normal spacing of 20 feet between trees in each axis direction. Four application dates were involved to permit expeditious processing of the fruit samples in the laboratory for residue recoveries. Parathion and dimethoate treatments were applied on February 25, 1971, the carbaryl, chlorobenzilate, and phosphamidon treatments on March 10, the dioxathion treatments on March 19, and the dicofol and malathion treatments on March 24. Two sets of 20 fruit each and 60 leaf disc samples from each of four replicates were taken 5 days after application and transported directly to the processing laboratory. One sampling of fruit and leaves was taken from the tree area in the row center axis (0° reference position), parallel with the movement of the spray equipment. The other set of samples was taken from the tree area closest to the passing spray equipment (90° reference position). Samples were taken 3 to 7 feet above ground level. Leaf samples consisted of circular sections from the centers of the leaves in position on the tree, using a leaf punch device which deposited the sample section in a glass sample jar.

Fruit were sampled by cutting the fruit-bearing stem approximately 2 inches above the attachment to the

TABLE 1

Composition of low volume and dilute spray treatments used in residue study.

Material	Formulation	Amount per 100 gallons	Conc. per 100 gallons	Method of application	Gallons per acre
carbaryl	80% WP	1.2 lbs	1X	Dilute	2500
"	"	30 lbs	25X	Low volume	100
chlorobenzilate	4 lbs/gal EC	5 oz	1X	Dilute	1500
"	"	75 oz	15X	Low volume	100
dicofol	4 lbs/gal EC	0.8 pt	1X	Dilute	1500
"	"	12 pts	15X	Low volume	100
dimethoate	2.67 lbs/gal EC	0.75 pt	1X	Dilute	500
"	"	3.75 pts	5X	Low volume	100
dioxathion	8 lbs/gal EC	0.4 pt	1X	Dilute	1500
"	"	6 pts	15X	Low volume	100
malathion	25% WP	2.5 lbs	1X	Dilute	2500
"	"	62.5 lbs	25X	Low volume	100
"	8 lbs/gal EC	0.625 pt	1X	Dilute	2500
"	"	15.625 pt	25X	Low volume	100
parathion	25% WP	1.5 lbs	1X	Dilute	2500
"	"	37.5 lbs	25X	Low volume	100
"	4 lbs/gal EC	0.375 qt	1X	Dilute	2500
"	"	9.375 qts	25X	Low volume	100
phosphamidon	8 lbs/gal EC	0.5 pt	1X	Dilute	500
"	"	2.5 pts	5X	Low volume	100

TABLE 2

Tree area and average residue loads[a] on navel orange fruit and leaves 5 days after application of equivalent amounts of material per acre in low volume and dilute spray applications

Material and formulation	Sample area	Leaves (mg/cm^2) Low vol.	Leaves (mg/cm^2) Dilute	Fruit (p.p.m. in rind) Low vol.	Fruit (p.p.m. in rind) Dilute	Ratio Low vol.: Dilute Leaves	Ratio Low vol.: Dilute Fruit
carbaryl (WP)	0°	3.8	1.3	13.5	10.8	3:1	1:1
	90°	15.6	1.1	43.0	9.2	14:1	5:1
	Av.	9.7	1.2	28.2	10.0	8:1	3:1
chlorobenzilate (EC)	0°	0.7	0.2	3.1	2.5	4:1	1:1
	90°	1.1	0.2	8.7	2.6	6:1	3:1
	Av.	0.9	0.2	5.9	2.6	4:1	2:1
dicofol (EC)	0°	2.2	0.7	5.2	4.6	3:1	1:1
	90°	3.2	0.7	11.4	4.0	5:1	3:1
	Av.	2.7	0.7	8.3	4.3	4:1	2:1
dimethoate (EC)	0°	0.1	0.1	0.5	0.5	1:1	1:1
	90°	0.1	0.1	1.4	0.8	1:1	2:1
	Av.	0.1	0.1	1.0	0.6	1:1	2:1
dioxathion (EC)	0°	3.6	2.2	5.4	3.6	2:1	2:1
	90°	6.9	0.8	10.6	3.2	9:1	3:1
	Av.	5.2	1.5	8.0	3.4	3:1	2:1
malathion (WP)	0°	5.7	0.2	11.8	7.0	28:1	2:1
	90°	12.5	0.4	37.2	10.6	31:1	4:1
	Av.	9.1	0.3	24.5	8.8	30:1	3:1

fruit and then cutting the stem just above the fruit button after the fruit had been positioned over the opening of a 3-gallon glass jar. The sample jar was kept in the row middles to avoid the inclusion of any other contaminated material.

Results and Discussion

The treatment comparisons and results are provided in Tables 1 and 2.

The data presented in Table 2 clearly demonstrate that low volume applications of a representative selection of pesticides commonly in use on citrus in California generally result in significantly higher residues on fruit and leaf surfaces than applications of the same amount of active ingredient per acre in the presently used dilute gallonages. Since current guidance to growers with regard to re-entry intervals to insure the safety of workers and with regard to fruit residues to meet tolerance requirements is based on dilute spray practices, the heavier residue loads resulting from low volume applications suggest the need to provide the grower with entirely different guidelines for such applications and the interim liability of growers and the citrus industry pending the development of such guidelines. Unless time allowances or other means are invoked to compensate for the higher residue loads, growers using low volume sprays may expose their workers, specifically pickers and pruners who have substantial contact with the trees for long periods of time, to unsafe working conditions and/or may subject their marketed fruit to seizure because of residues that exceed the tolerance requirements.

While it is possible that some materials may be used effectively at lower amounts/acre when applied as low volume sprays and that improvements in the sprayer units will enhance this possiblity, it presently appears that equivalent amounts of material/acre such as used in this test will be required. In any event, substantial reductions in the amounts of material/acre would probably be required to produce a 1:1 residue ratio for low volume versus dilute applications.

TABLE 2 (continued)

Material and formulation	Sample area	Leaves (mg/cm^2) Low vol.	Dilute	Fruit (p.p.m. in rind) Low vol.	Dilute	Ratio Low vol.: Dilute Leaves	Fruit
malathion (EC)	0°	2.3	0.3	8.5	8.0	8:1	1:1
	90°	6.3	0.3	33.0	7.1	21:1	5:1
	Av.	4.3	0.3	20.8	7.6	14:1	3:1
parathion (WP)	0°	3.0	0.4	6.7	3.6	8:1	2:1
	90°	4.7	0.4	14.2	3.3	12:1	4:1
	Av.	3.8	0.4	10.4	3.4	10:1	3:1
parathion (EC)	0°	2.3	0.2	5.7	3.0	12:1	2:1
	90°	3.4	0.3	15.4	2.5	11:1	6:1
	Av.	2.8	0.2	10.6	2.8	14:1 b/	4:1
phosphamidon (EC)	0°	0.5	0.2	1.8	0.5	2:1	4:1
	90°	0.6	0.1	4.7	0.8	6:1	6:1
	Av.	0.6	0.2	3.2	0.6	3:1	5:1

a/ Analytical details will be presented elsewhere. Fruit and leaf values represent 4 field replicates each.

b/ Aberrancy resulting from decimal rounding of values.

The difference observed among materials, between formulations, and between plant substrates are not explainable on the basis of present information. The tendency for the residues from low volume applications to be considerably higher on leaf surfaces may be particularly important with regard to time intervals required for the safe re-entry of workers into treated properties. The observed differences further support the conclusion that detailed residue studies for each material suggested for use in low volume spray applications must be completed before recommendations and guidance can be provided growers.

Residues resulting from dilute applications were relatively similar on fruit and leaves sampled from the 0° and 90° reference positions in the peripheral areas of the trees. In contrast the residues resulting from low volume applications were generally, and often appreciably, higher on the fruit and leaf surfaces close to the operating sprayer unit (90° reference position). While this disparity in depositing capability relates to the operational inadquacy of the low volume sprayer unit used in this study, it was shown in studies completed by Carman and Jeppson (3) that the other available low volume sprayer units provided similar deposition patterns. Because of this tendency it may be more difficult to determine safe re-entry periods following low volume spray applications and greater variability in the residues found on fruit samples may be encountered.

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