THE PATTERN AND PERSISTENCE OF DEPOSITS OF SEVIN, WITH AND WITHOUT SURFACTANTS, ON THE FOLIAGE OF FRUIT TREES I. APPLICATION BY CONCENTRATE SPRAYER[1]

D. P. PIELOU AND K. WILLIAMS[2]

Research Station, Research Branch, Canada Department of Agriculture, Summerland, British Columbia

Introduction

Most work involving the chemical anaylsis of insecticide deposits on foliage has been done with bulk samples of leaves. However, many analytical methods are now sufficiently sensitive that the small deposit on even one side of a single leaf may be determined. Determination of the residues on single leaves permits a more precise assessment of the distribution of deposit throughout a tree and allows one to obtain a more detailed picture of the deposit decline. The entomological importance of these matters in insect control is obvious. Difficulties in achieving effective control of certain insects and mites, in recent years, make such studies desirable. The understanding of certain aspects of insecticide resistance may be improved. The relative merits of 'heavy' and 'light' spraying (assumed to be equivalent to intense and moderate selection) have been argued in connection with the development of resistant strains. However, these arguments need modification if it is proven that there is a variegated pattern of deposit.

Methods

The insecticide used was Sevin[3] (1-methyl-*N*-naphthyl carbamate) 50 per cent wettable powder. The surface active spreader - sticker was Plyac[4] (polyethylene 629 emulsifiers and dispersants; estimated actual polyethylene, 25 per cent). Application was by concentrate air-blast sprayer[5] at a rate equivalent to eight pounds of formulated Sevin, in 50 Imperial gallons of water per acre. Where Plyac was used it was added at the rate of one Imperial gallon per acre. Rate of travel was 90 feet per minute (approximately one mile per hour); pump pressure was 300 pounds per square inch. There was no drip from the leaves at this rate of application. Marshall (2) has stressed that the absence of drip characterizes efficient concentrate spraying.

Cherry trees were used, variety Van, approximately 20 feet in maximum height. Leaf samples were taken at heights of 6, 10 and 14 feet. At each height there was one sampling point in each of the north, south, east and west quadrants of the tree. Each point was identified by a tag and leaves were collected within + or − 2 feet horizontally and + or − 1 foot vertically of the tag. On each sampling date leaves were picked at each point.

Leaves were carried from the orchard to the laboratory by their stems; they were handled with great care so as not to brush off any of the deposit. Insecticide deposits were removed from the leaves with the apparatus shown in Figure 1. The procedure is as follows. An individual leaf is placed on top of a screw-cap jar, S, the lip of which has been

[1] Contribution No. 100, Research Station, Research Branch, Canada Department of Agriculture, Summerland, British Columbia.

[2] Entomologist and Chemist, respectively.

[3] Union Carbide Chemicals Company, White Plains, New York.

[4] Allied Chemical Corporation, General Chemicals Division, New York 6, N.Y.

[5] Okanagan Turbo Sprayers Ltd., Penticton, British Columbia.

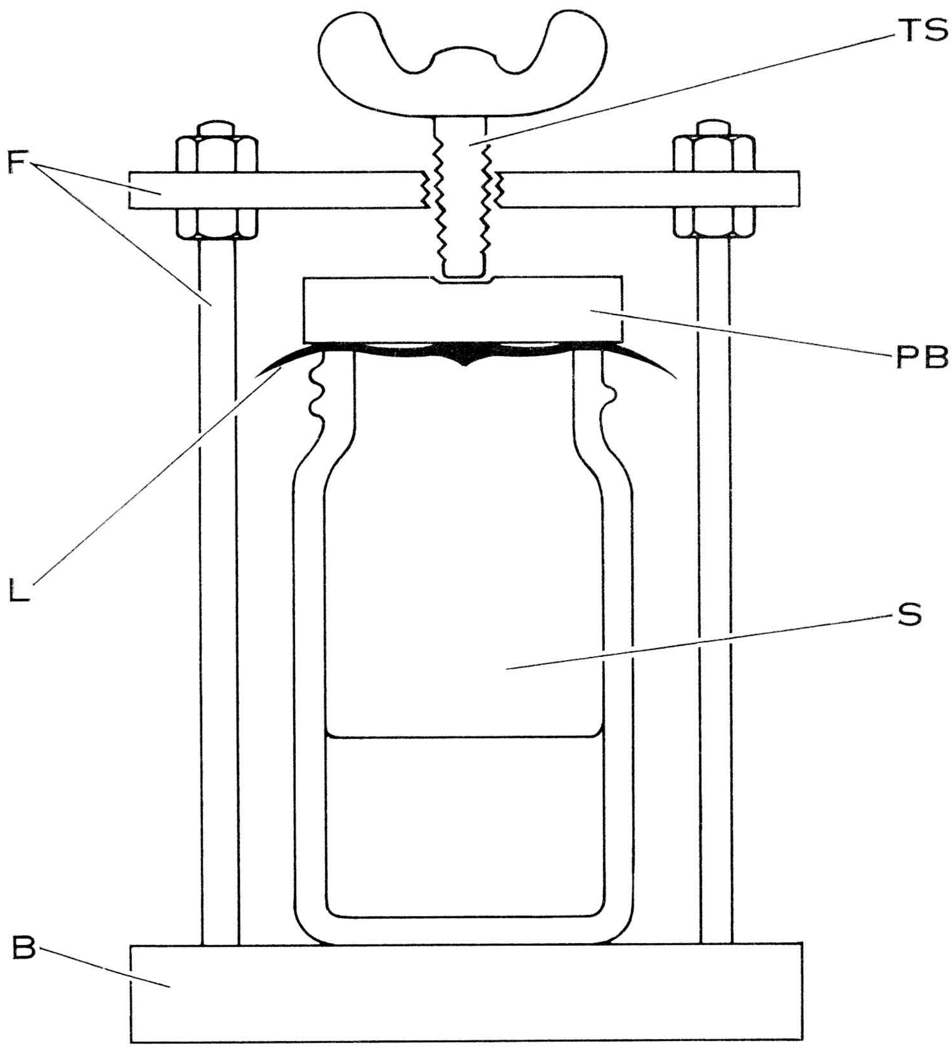

Fig. 1—Device for the removal of Sevin deposits from leaves. TS, thumbscrew; F, frame; PB, pressure block; B, base; S, solvent vessel; L, leaf

ground flat. This vessel contains 15 ml. of chloroform. The leaf is pressed in solvent-tight juxtaposition with the vessel by the pressure of the thumbscrew, TS, against the pressure block, PB. The thumbscrew is held by the rigid frame, F, attached to the base, B. The entire unit is placed on its side and agitated briskly for one minute. Experiment shows (5) that this action removes the entire surface deposit of Sevin from the leaf; and (using test leaves bearing a deposit on one side only) that there is no translocation by the chloroform from one leaf surface to another in this period. The extract is analyzed by the colorimetric method of Miskus, Gordon and George (3). Since the circular area from which the insecticide is removed is known exactly, the residue can be expressed in micrograms per sq. cm. On individual leaves, deposits as low as 0.4 micrograms per sq. cm. can be accurately determined and traces as low as 0.07 micrograms per sq. cm. can be detected. Of the leaves picked at each sampling point, on each occasion, half wwere analyzed for deposit on their upper surfaces, the others on their lower surfaces. It is not possible to measure deposits on the two surfaces of the same leaf with the apparatus described. However, more recently we have devised a method in which this is possible (5). It was not, however, used in this study.

Chemical analyses were made on leaves on all trees immediately after the spray had dried and 1, 4, 8, 11, 16, 22 and 32 days later.

During the period of the experiments the mean maximum temperature was 75.8° F., and the mean minimum, 50.6° F. There was no measurable rainfall in this period. Irrigation of the orchard was by low level sprinklers. None of the sprinkler water reached the lowest sampling level.

Results

Examination of the original data immediately suggested that there were no differences between the north, south, east and west sampling points. A preliminary analysis of variance confirmed this and the data were therefore pooled to form categories of leaf surface, surfactant treatment, height, and leaf replication. A detailed analysis of variance was then done on this basis. A summary of the results for days 0, 1 and 4 is shown in Table I. Subsequent to day 4, there were too many zero values in the chemical analysis data to allow further convincing analysis of variance. Examination of Table I shows that the conspicuous differences arise from the presence or absence of Plyac or between the two leaf surfaces. It will be noted that there are significant first-order interactions, but as these are different interactions on each of the three days, and are not repeated, it is doubtful if they have any biological meaning. Table II shows the mean values for deposits on leaves categorized into: (a) upper and lower surfaces; (b) presence and absence of Plyac treatment. The ratio of deposits between lower and upper surfaces, and between Plyac-treatment and non-treatment are also shown.

The data plotted in Figs. 2 and 3 also emphasize the trends seen in Table II and continue them beyond the point at which full analysis of variance was possible. In Fig. 2 the decline of deposits (upper and lower surfaces combined) has been compared for treatment with, and without, Plyac. To eliminate the factor of difference in initial deposits, and to give a truer picture of the rate of decline, the curves have been plotted as percentages of the initial deposits. In Fig. 3 are shown the differences in decline rate of Sevin deposits on the upper and lower surfaces of Plyac-free leaves. Again a percentage plotting is used to eliminate the effect of initial differences in deposit on the two surfaces. Curves similar to Fig. 3, but slightly shifted to the right, are produced if the data for Plyac-treated leaves are plotted in the same way.

It was noticed that the standard wettable powder produced a deposit, on both upper and lower surfaces, that was very easily removed by gentle pressure with an artist's watercolor brush. The addition of the Plyac, however, produced a deposit that was very much more difficult to remove by this method.

TABLE I

Analysis of Variance for Deposits of Sevin on Cherry Foliage. S.S., sums of squares; M.S., mean square; d.f., degrees of freedom; F., ratio.

		Day 0			Day 1			Day 4		
Source of variation	d.f.	S.S.	M.S.	F.	S.S.	M.S.	F.	S.S.	M.S.	F.
Between surfaces, S.	1	36.76612	36.76612	14.387**	119.70667	119.70667	42.388**	73.72768	73.72768	27.170**
Between heights, H	2	15.07491	7.53745	2.949	12.31916	6.15958	2.181	10.16200	5.08100	1.872
Between treatments, T	1	10.67333	10.67333	4.177*	30.24015	30.24015	10.708**	14.16039	14.16039	5.218*
S X H	2	7.33140	3.66570	1.434	1.65306	0.82653	0.293	22.67398	11.33699	4.178*
S X T	1	0.83068	0.83068	0.325	17.08594	17.08594	6.050*	0.01789	0.01789	0.007
H X T	2	16.92917	8.46459	3.312*	7.46943	3.73472	1.322	6.00507	3.00254	1.106
S X H X T	4	1.35723	0.33931	0.133	13.62158	3.40540	1.206	8.56048	2.14012	0.789
Between replicates	82	209.55563	2.5556		231.57611	2.82410		222.51008	2.71354	
	95	298.51847			433.67210			357.81757		

TABLE II

The Influence of Surface, and Presence of Plyac, on the Mean Deposits of Sevin on Cherry Foliage.

Time	Surface	Mean deposits of Sevin, micrograms per sq. cm.		Ratio: with
		With Plyac	Without Plyac	without
Day 0	Lower surface, L	3.31	2.46	**1.35**
	Upper surface, U	1.89	1.41	**1.34**
	Ratio: L/U	**1.75**	**1.74**	
Day 1	Lower surface, L	3.28	2.43	**1.35**
	Upper surface, U	1.85	0.95	**1.97**
	Ratio: L/U	**1.77**	**2.59**	
Day 4	Lower surface, L	3.23	2.33	**1.39**
	Upper surface, U	1.45	0.71	**2.04**
	Ratio; L/U	**2.23**	**3.28**	

Discussion

The work described in this paper shows that variations in deposit between leaf surfaces, on cherry trees up to a height of 14 feet at least, are essentially random except in one important respect. Initial deposits of Sevin are about 75 per cent higher on the lower surface than on the upper. Even in the absence of rain, as in this work, there is a marked tendency for this relative difference to increase, until the residual deposits have fallen to a low value. The half-life of the initial deposit is approximately two and a half days longer on the lower surface than on the upper (Fig. 3). In the presence of rain, or of high sprinkler water falling on the foliage, this divergence is likely to be further increased. Under such conditions deposits of wettable powder are rapidly

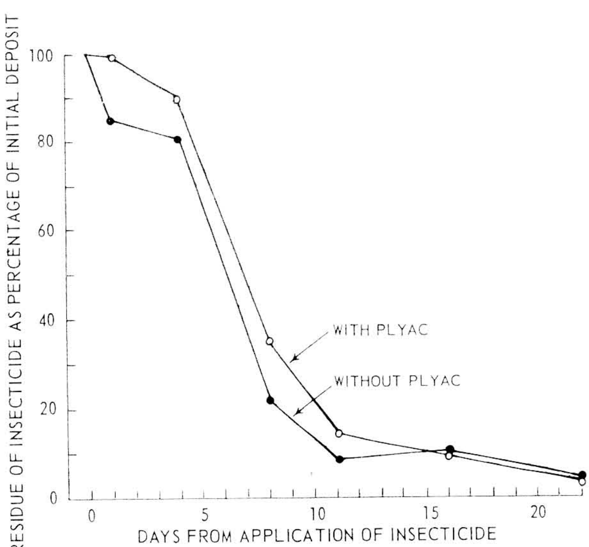

Fig. 2—The influence of Plyac on the rate of decline of Sevin deposits on cherry foliage in the absence of rain. The decline is plotted on a percentage basis as the presence of Plyac induced a substantially larger initial deposit on the foliage.

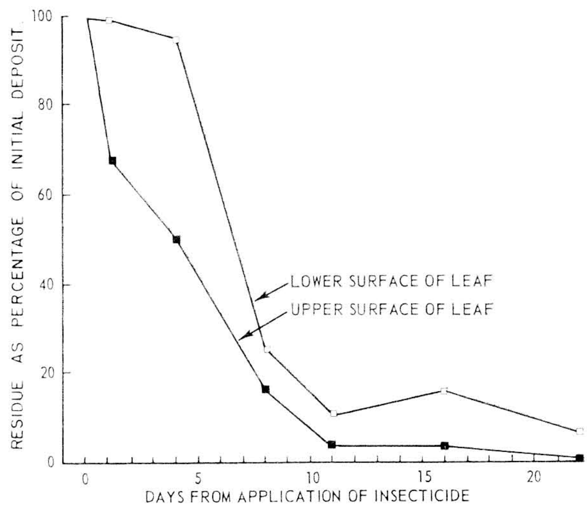

Fig. 3—Differences in the rate of decline of Sevin deposits on the upper and lower surfaces of cherry foliage in the absence of rain. The decline is plotted on a percentage basis as the initial deposits were approximately 75 per cent higher on the lower surfaces than on the upper.

reduced on apple leaves (6). More recently it has been shown that most of this loss, in dwarf apple trees subject to overhead sprinkling, is from the upper surface of the leaves (4). In fact when bulk samples of foliage reveal an appreciable deposit the whole of the insecticide may be concentrated on the lower leaf surfaces. The implications for the control of insects or mites that prefer one side of a leaf are obvious.

The addition of Plyac to the Sevin results in an increase of about 35 per cent in the initial deposits for a fixed output rate of the machine. The reasons for this are not certain. However, observations made with a laboratory atomizer sprayer (4) suggest that this may be as much the result of reduced rebound loss (caused by a decrease in surface tension and consequent loss of structural strength and elasticity of the drops), as of the adhesive qualities of the Plyac. It is also noteworthy that the addition of this surfactant, though it causes an increase in initial deposits, does not alter the initial partition ratio of the total deposit between lower and upper leaf surfaces. This strongly suggests that it is some inherent characteristic of the leaf, and not formulation, that induces the higher deposits on the lower surfaces.

Plyac is stated (1) to have some waterproofing or "rain resistant" qualities. This point was not examined in this work since no rain fell during the experiment; and irrigation was by low level sprinklers. Nevertheless, the Plyac treatment resulted in a somewhat slower decline of deposits even after making allowance for the greater initial deposits. It appears likely that this is the result of a lessening of loss caused by leaf-to-leaf abrasion. The influence of Plyac in improving resistance to loss by gentle brushing has been noted. However, experiments on isolated leaves in a wind tunnel (4) show that wind itself does not cause appreciable loss of deposit. But wind-induced rubbing of leaf against leaf must cause considerable loss. The matter would bear detailed investigation particularly if a quantitative method of measuring the abrasive forces could be devised. More effective substances than Plyac, or a different rate or formulation, could conceivably produce a greater effect on persistence. Some preliminary experiments (4) suggest that certain acrylic polymers, at suitable rates, have an enormous influence on the abrasion resistance of insecticide deposits but, also, that resistance to abrasion loss is not necessarily identical with resistance to rain loss.

Summary

An analysis of the inter-leaf pattern of Sevin deposited on cherry foliage, by concentrate air-blast sprayer has been made. There were no differences in mean deposit up to a height of 14 feet; nor were there any differences associated with leaves collected from different quadrants of the trees. Initially, deposits were approximately 75 per cent higher on the lower sides of the leaves than on the upper. Subsequent erosion of the deposits was faster on the upper surfaces so that the disparity was emphasized with time. There was no rain during the experiment; if there had been, there is evidence that this disparity would have been enhanced. The addition of an amount of Plyac, equal in its content of active ingredient to that of the Sevin, resulted in initial deposits approximately one-third higher than in its absence. The rate of decline of deposits was also somewhat slower when Plyac was present. In the absence of rain, loss of deposit by leaf-to-leaf abrasion is thought to be an important factor in the disappearance of a pesticide from foliage.

References

(1) General Chemical Division, Allied Chemical Corporation. 1959. Plyac spreader-sticker. Bull. New York 6, N.Y.

(2) Marshall, Jas. 1958. Concentrate spraying in deciduous orchards. Publ. 1020. Can. Dep. Agr., Ottawa.

(3) Miskus, R., H. T. Gordon, and D. A. George. 1959. Colorimetric determination of 1-naphthyl **N**-methylcarbamate in agricultural crops. **J. Agr. Food Chem.** 7: 613-614.

(4) Pielou, D. P., and K. Williams. Unpublished observations.

(5) Pielou, D. P., K. Williams, and F. E. Brinton. 1962. Differences in the deposition and persistence of pesticides on the upper and lower surfaces of leaves. **Nature.** 195: 256-257.

(6) Williams, K. 1961. Note on the effect of rain, and sprinkler irrigation, on the persistence of spray residues of Guthion and Sevin on apple leaves. **Canadian J. Plant Sci.** 41: 449-451.

(Received for publication).

Pleroma obliquata Sm. and P. conserta Grt. from ova laid by obliquata (Lepidoptera: Phalaenidae)

The progeny of a batch of ova laid by **P. obliquata** in April, 1960, consisted not only of the expected **obliquata** but also of 2 specimens of **P. conserta** in March 1961.

Many of the pupae remaining were alive, so they were kept over in a flower pot in an open shed. During March and April, 1962, there emerged 12 **conserta** and 4 **obliquata.**

Close examination of a series of these two species indicates that **conserta** is a melanic form of **obliquata.** One or two individuals showed a gradation between the two. **P. obliquata** is uniformly grey with dark a.m. and p.m. lines; **P. conserta** has primaries of solid black except for the grey outer margin and a contrasting white costal area on which an extension of the otherwise concealed a.m. and p.m. lines are plainly evident. It may be that a prolonged pupal period results in a larger proportion of **conserta.**

The foregoing suggests that **conserta** and **obliquata** are forms of one species. Since **conserta** was described by Grote in 1881 and **obliquata** by Smith in 1891, **obliquata** is a form of **conserta.**

—*George A. Hardy, Provincial Museum (Rtd.), Victoria, B.C.*