DIMETHOATE, A SYSTEMIC OF LOW MAMMALIAN TOXICITY, AS AN ORCHARD INSECTICIDE IN BRITISH COLUMBIA[1]

D. P. PIELOU AND R. S. DOWNING[2]

Introduction

Until quite recently systemic insecticides have been of high, or moderately high, mammalian toxicity. Now systemics of low mammalian toxicity have been developed. Among these is dimethoate[3] (marketed in Europe as Rogor[4]), formerly known by the code numbers E. I. 12880 and NC 262 in Canada. The active ingredient is described chemically as *O,O*-Dimethyl *S*-(*N*-methylcarbamoylmethyl) phosphorodithioate, according to the nomenclature adopted by Martin (8). Discovery of the properties of the chemical appears to have been simultaneous and independent in the U. S. A. and in Europe. The available commercial products appear to be very similar (1, 5) in characteristics; however, formulation, and the actual industrial procedure of synthesis, may be different for the different products, and may lead to small differences in performance. Cyanamid dimethoate has been available as a 50 per cent wettable powder, and as an emulsifiable concentrate (46 per cent "solubilized liquid concentrate" containing four pounds active ingredient per U. S. gallon); Rogor as an emulsifiable concentrate containing 320 grams active ingredient per litre.

The acute oral toxicity (LD 50) of this compound to male rats is in the range 200 to 300 milligrams per kilogram of body weight. The corresponding range for dermal toxicity is 750 to 1,150 milligrams per kilogram (1, 5). The toxicity of the older systemic, demeton (*O,O*-Diethyl *O*-2 (ethylthio) ethyl phosphorodithioate) is approximately 60 times greater orally, and 10 times greater dermally, than that of dimethoate (6). The new material is comparable with DDT in so far as hazards to the operator are concerned. It is, for an insecticide, of unusually low toxicity to fish (5). In Canada, dimethoate has been registered for use on a number of non-bearing crops; and on bearing apples and pears, where a torenance of 2.0 parts per million has been established.

In our work at Summerland dimethoate has been tried aganst apple aphid, pear psylla and tetranychid mites; pests that have been difficult to control in recent years.

Control of Pear Psylla

The pear psylla, *Psylla pyricola* Foerst., after a quiescent period of many years (10) has once again come into prominence as a serious fruit pest in the Okanagan Valley. Resistance to malathion [*S*-(1,2-Dicarbethoxyethyl)-*O,O*-dimethyl phosphorodithioate] the recommended control material until 1958 (2), appears widespread (4). Difficulties, or failures in control, have been reported with other organo-phosphorus insecticides, and even with rotenone, once a widely recommended material.

In 1958 D. J. Marshall conducted some experiments in which he used dimethoate in two orchards. Dr. Marshall has allowed mention of his unpublished findings. In the orchards concerned, malathion, applied at 12 pounds of 25 per cent wettable powder per 100 gallons[5], did not give satisfactory control. However, the two dimethoate liquid formulations (NC

[1] Contribution No. 48 from the Research Station, Canada Department of Agriculture, Summerland, British Columbia.
[2] Entomologists.
[3] Common name; originally coined by American Cyanamid Company, Stamford, Connecticut, U.S.A.
[4] Trademark of Montecatini, Rome, Italy. Distributed in Canada by Fisons (Canada) Limited, Toronto, Ont.
[5] Gallons are Imperial gallons except where otherwise indicated.

262 and 12880), applied at the rate of 32 ounces per 100 gallons, gave such promising results that it was decided, in 1959, to continue the work using lower rates of application.

The first trial in 1959 was carried out in an orchard of Bartlett pears on June 17. The trees were sprayed with a high-pressure (425 pounds per square inch), high-volume, gun sprayer. There were seven to ten trees per plot and two plots per treatment. Approximately seven gallons of dimethoate 46 per cent emulsion, diluted one pint per 100 gallon, were applied per tree. As a comparison, malathion was applied in similar amounts at a dilution of 1.5 pounds of 25 per cent wettable powder per 100 gallons. After the application, examinations of the leaves were made at intervals. Fifty leaves (10 from each of five central trees) were picked per plot and examined in the laboratory by stereomicroscope. Results are shown in Table 1.

TABLE 1—Effectiveness of dimethoate emulsion against pear psylla*

Treatment	Number of nymphs per 50 leaves				
Insecticide per 100 gal.	June 24	July 7	July 21	July 30	Aug. 10
Dimethoate, 1 pt.	33	10	22	32	110
Malathion, 1½ lb.	44	118	resprayed		
Check — no treatment	108	836**	9	5	61

* Treatment date, June 17.
** Sprayed with dimethoate, July 8.

Table 1 shows that dimethoate gave commercial control (an average of less than one nymph per leaf) for 43 days. Malathion gave commercial control for only seven days. The malathion plots were resprayed, with another experimental insecticide, when the average number of nymphs rose above two per leaf; the results of this spraying are not relevant to this investigation. On the check plots, after 20 days, the average number of nymphs per leaf was over 80 times that of the dimethoate plots and approximately 8 times that of the malathion plots. The latter fact indicates that although control with malathion was poor, total malathion-resistance had not been reached in this orchard. The check plots were subsequently sprayed with dimethoate and the results from this application confirmed the effectiveness of the material.

A second trial was carried out in an orchard of Bartlett, Bosc and Flemish pears on August 5. These applications were made with a concentrate air-blast sprayer of the turbine axial-flow type. One gallon of 46 per cent emulsifiable dimethoate in 50 gallons of water was applied per acre; nozzle pressure was 300 pounds per square inch and the rate of travel 1.5 miles per hour, a recommended speed for the 20 x 20-foot planting. Evaluation of effectiveness was made as in the previous experiment; the results are shown in Table 2.

TABLE 2—Effectiveness of concentrate spraying against pear psylla*

Treatment	Number of nymphs per 50 leaves		
Insecticide per acre	Aug. 12	Aug. 21	Aug. 31
Dimethoate, 46%, 1 gal. in 50 gal. water	0	0	6
Check — no treatment	92	132	172

* Treatment date, Aug. 5.

It cannot be assumed, though it is probable, that the superior results obtained, compared with the previous experiment, were the result of concentrate spraying because of the differences in plant and insect development at the two dates; and because the temperature, at the time of application, was 10 °F. higher in the latter case. In this experiment some foliage injury was observed on the Bartlett variety but not on the other two varieties; about one-fifth of the foliage area was affected.

Since experience in British Columbia (9) is that wettable powders, in concentrate spraying, are less phytotoxic than emulsions, a third experiment was carried out in a Bartlett orchard. This trial was conducted later in the season, on October 2, when infestation was very high. Application was made with the air-blast concentrate sprayer as in the second trial; and conditions were approximately the same. Dimethoate 50 per cent wettable powder was applied at rates of 8 and 12 pounds per acre, the checks received no treatment. There were seven to ten trees per plot and two treatments per plot. Because insect numbers were high, evaluation was made using the "mite-brushing" technique (7), which proved to be applicable to psyllids. In view of the stage of the season, a single evaluation of results on Octaber 9 was judged sufficient. At that date nymph counts averaged zero per 50 leaves at the 12 pound rate of application and two per 50 leaves at the 8 pound rate. On the check plots the average was 532 per 50 leaves. No foliar damage was observed. In other work (4) on pear psylla, dimethoate proved at least the equal of any other new material being tested.

Control of the European Red Mite

Resistance to various organo-phosphorus materials is common throughout the Okanagan Valley (3) in the European red mite, *Panonychus ulmi* (Koch). Though dimethoate is such a compound it was nevertheless deemed advisable to check its efficiency against this pest. Experiments were carried out in an orchard of semi-dwarf Red Delicious apples. Mites were sampled by the brush method (7) and, before spray application, averaged 12.3 mites per leaf in the orchard. Applications of insecticide were made on June 26 by high-pressure (420 p.s.i.) gun sprayer; approximately four gallons of spray fluid were used on each tree. There were three trees per plot and three replications per treatment. Results are shown in Table 3.

TABLE 3—Dimethoate and malathion against resistant European red mite*

Treatment	Average number mites per leaf	
Dilute application	July 3	July 9
Dimethoate, 0.05% active	5.7	27.0
Malathion, 0.05% active	11.0	30.3
Check — no treatment	24.3	41.6

* Treatment date, June 26.

Control of Reinfestation by Apple Aphid

Although both dimethoate, and malathion, treatments showed a significant reduction of mites after seven days, as compared with the check, the reduction was quite insufficient to constitute commercial control. Moreover, after 13 days, populations were not significantly lower than on the check plots. It was concluded that resistance to organo-phosphorus materials will preclude recommendation of dimethoate as a miticide in the Okanagan Valley. Experiments with mites were, therefore, terminated at this point.

By Spray Application

The current problem in the control of apple aphid, *Aphis pomi* DeG., is not so much that of the immediate effectiveness of freshly deposited insecticides on the insects, but of the effectiveness of residual deposits in the prevention of reinfestation from outside sources (13). It is a common occurrence, when sprays are applied against this sphid, for an efficient aphicide to give complete kill (11, 12) but for reinfestation to occur as the result of recolonization, by winged forms, from neighboring trees or orchards. A true persistent effect of an aphicide can be demonstrated only if invaders are given the opportunity of recolonizing aphid-free, but sprayed, trees; there is then no question that newly observed aphids originated from outside sources and are not the survivors, or offspring of survivors of indifferent spraying.

The experiments were carried out in 1958 in an orchard of dwarf (Malling *IX* rootstack) apple trees, approximately seven feet high, planted five feet apart, and in rows ten feet from each other. Two rows, of varieties Golden Delicious and McIntosh, were kept free of aphids, up to the time of the experiment, by repeated spraying with nicotine. Alternate rows were left untreated, as a source of infestation; and a high population of aphids developed on these. Plots of trees in the *aphid-free* rows (three trees per plot, two plot replications for each variety) were sprayed on July 7 with dimethoate emulsifiable concentrate, one pint per 100 gallons. Subsequently observations were made on the five subterminal leaves (omitting the terminal "bud") of tagged twigs. Five twigs were tagged per tree. Aphids were counted on both dorsal and ventral leaf surfaces, and the leaves left undisturbed till the next count. Tests showed that there was no error in counting up to 40 aphids per leaf, an error of + 3 up to 70 per leaf and an error of + 6 up to 100 per leaf. In numbers above 100 per leaf, aphids were estimated by counting the numbers in one part of the leaf and then judging what fraction this was of the whole population on the leaf. Counts on all trees, on all plots, were made 3, 7, 14, 17, 22, 25 and 31 days after application. Though there were generally more aphids on the more distal leaves of the group of five, figures were pooled to give a mean value per leaf. Comparison is made with the results for Sevin (*N*-Methyl-l-naphthyl carbamate), an efficient residual aphicide of the non-systemic type (13), applied at the rate of one pound 50 per cent wettable powder per 100 gallons. The results obtained are shown in Table 4.

TABLE 4—Recolonization of aphid-free apple leaves; means aphids per leaf

Treatment and variety	Days after application: 0	3	7	14	17	22	25	31
Dimethoate Golden D.	0.00	0.10	0.10	0.50	0.40	0.56	0.46	1.90
McIntosh	0.00	0.08	0.30	0.00	0.00	0.00	0.14	0.71
Sevin Golden D.	0.00	0.10	0.34	1.10	0.91	4.41	16.40	15.20
McIntosh	0.00	0.06	1.44	0.71	1.20	2.66	13.80	18.90
No treatment Golden D.	0.00	16.40	39.30	115.00	106.00	118.00	350.00	220.00
McIntosh	0.00	13.90	31.00	28.00	49.10	38.10	160.00	80.80

This table shows that Sevin gave a highly significant reduction over the check after 31 days. However, good commercial control (indicated on the basis of field experience as a mean of one aphid per leaf) was evident for only 17 days. Dimethoate was significantly better than Sevin from the seventh day onward, and good commercial control was evident up to 31 days. In these experiments dimethoate therefore performed almost twice as well as Sevin. The method of evaluation ignored the cluster of aphids in the terminal "bud" of the twig as these are not easy to count in the field. In a further evaluation, six such buds per tree were removed, from each tree in each plot, 33 days after application. They were placed in alcohol and the aphids counted later. The results of these counts, in aphids per bud, were as follows: checks, 151; Sevin, 29.9; dimethoate, 5.7. These figures confirm the superiority of dimethoate.

By Trunk Applications

Some years ago a limited experiment suggested that demeton might give effective aphid control when painted on the trunks of young trees early in the season (4). The possibility of such effective systemic action with dimethoate was therefore investigated. In the dwarf orchard described above, a row of 30 Red Delicious apple trees was selected. These trees had a trunk diameter of approximately 1½ inches. Individual trees were treated in randomized plots in three ways as described below.

(a) An average of 1.3 millitres of the emulsifiable concentrate was painted on the basal part of the stem of each tree with an artists' No. 10 brush. The trunks were painted all round, over a length of about six inches, approximately nine inches above the ground.

(b) First-aid medical "bandaids" were taken, and 0.3 millitres of concentrate applied to the pad of the bandaid. Four such bandaids were then arranged around the trunk of the tree approximately nine inches above the ground but below the first branch. Each tree therefore received 1.2 millitres of concentrate. The bandaids were completely covered with polythene film and the film secured to the trunk. The hypothesis behind the use of the bandaids was that a small, but continuous, supply of systemic would be available to the tree for a long period; and that, unlike the brush applications, the chemical would not tend to evaporate, or be washed away, by sprinkler irrigation water.

(c) Checks; these trees received no treatment.

The trunk applications were made on May 1. Aphid counts, on the five subterminal leaves of tagged twigs, were made directly in the field, as in the previous experiments, on June 3, July 4 and August 6. Results are shown in Table 5.

TABLE 5—Effectiveness of trunk application of dimethoate, applied May 1

Treatment	Mean number aphids per leaf		
	June 3	July 4	Aug. 6
In bandaids, 1.2 ml. per tree	0.31	0.92	1.91
By paint brush, 1.3 ml. per tree	0.69	1.21	154.00
Check — no treatment	10.33	45.70	170.50

It will be seen that bandaid applications gave commercial control for between two and three months; application by paint brush for between one and two months. However, if this procedure is adopted by growers for use on small trees or nursery stock, two applications by paint brush rather than one by bandaid, may be more economical of time and labour.

Some bark damage was evident in trees that received either form of trunk application. However, these trees did not seem to suffer any lasting effects, and two years later were not obviously different in any way from the check trees.

Summary

Dimethoate is a systemic insecticide of low mammalian toxicity and of great promise against fruit pests in the Okanagan Valley. Effective rates of spray application have been: one pint of emulsifiable concentrate per

100 gallons in dilute application; eight pounds of 50 per cent wettable powder per acre in air-blast application. Against the pear psylla, *Psylla pyricola* Foerst, dimethoate gave better, and more lasting, control than malathion. Against a strain of the European red mite, resistant to organophosphates, it did not provide commercial control, although it performed significantly better than malathion. In the persistence of its residual effects dimethoate was outstanding in preventing reinfestation of apple by apple aphid, *Aphis pomi* DeG. Here, under circumstances of severe reinfestation, commercial control by spray application was evident for four weeks; control was about twice as good as with Sevin, a relatively persistent non-systemic insecticide. Excellent control of aphids on young trees was obtained by painting small amounts of undiluted liquid concentrate, or by applying the concentrate in bandaids, to the lower parts of the trunks in May. In the former case effective control was apparent for one to two months; in the latter for two to three months. Trunk applications gave rise to a limited amount of bark injury that, however, did not prove to be permanent.

References

1. American Cyanamid Company. 1959. Dimethoate (E.I. 12880). Jamphlet. Stamford Research Laboratories, Stamford, Conn. U.S.A.
2. Anonymous. 1958. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster.
3. Downing, R. S. 1954. Strains of the European red mite, **Metatetranychus ulmi** (Koch) resistant to parathion and malathion in British Columbia. Proc. Ent. Soc. British Columbia 51: 10-11.
4. Downing, R. S. Unpublished observations.
5. Fisons Pest Control Limited. 1959. Rogor 40 Technical Information. Pamphlet. Cambridge, England.
6. Fisons Pest Control Limited. 1960. Safety in the use of insecticides. Pamphlet. Cambridge, England.
7. Henderson, C. F., and H. Y. McBurnie. 1943. Sampling technique for determining populations of citrus red mite and its predators. U.S. Dept. Agr. Circ. 671.
8. Martin, H. 1958. Guide to the chemicals used in crop protection. Suppl. to 3rd ed. Canada Dept. Agr., Ottawa.
9. Marshall, J. 1958. Concentrate spraying in deciduous orchards. Canada Dept. Agr. Pub. 1020.
10. Marshall, J., and H. F. Olds. 1947. The pear psylla in British Columbia. Proc. Ent. Soc. British Columbia 43 (1946): 1-3.
11. Pielou, D. P., and R. S. Downing. 1958. Trithion as an orchard insecticide. Proc. Ent. Soc. British Columbia. 55: 17-23.
12. Pielou, D. P., and M. D. Proverbs. 1958. Diazinon: a summary of recent work on a new orchard insecticide. Proc. Ent. Soc. British Columbia 55: 3-6.
13. Pielou, D. P., and K. Williams. The effectiveness of residues of insecticide in preventing reinfestation of apple leaves by apple aphid, **Aphis pomi** DeG. I. Diazinon, Trithion and Sevin. In preparation.

NOTE ON PREDATION BY CALOSOMA FRIGIDUM KBY. ON OPEROPHTERA BRUCEATA HLST.

On June 2, 1959, eight miles west of Chetwynd (Little Prairie), B.C., a carabid, *Calosoma frigidum* Kby., was found preying upon the larvae of Bruce spanworm, *Operophtera bruceata* Hlst. Eighteen beetles were counted on the trunk and branches of ten trembling aspen trees. To gain its prey a carabid would start at the axis on the upper surface of a curled leaf, and using its mandibles, puncture the curled leaf tissue, driving the larva before it. When both beetle and larva reached the open end of the habitaculum the beetle would drop to the under side and seize the larva as it wriggled out. Neither rain nor wind seemed to deter the beetles' activity.

—*T. A. D. Woods, Forest Biology Laboratory, Vernon, B.C.*