DIAZINON: A SUMMARY OF RECENT WORK ON A NEW ORCHARD INSECTICIDE[1]

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This paper is an interim report summarizing, up to the present, the main findings of the Summerland Laboratory on the insecticide Diazinon.

Diazinon (Geigy Agricultural Chemicals, 1956) was introduced recently by the Geigy Company of Switzerland, the firm that produced DDT and, therefore, largely initiated the modern era of pest control. Apparently Diazinon was obtained in a search for an insecticide that would control DDT-resistant house flies; such a material besides having high insecticidal action, must have good residual action (on inanimate surfaces at least) and relatively low human toxicity.

Chemically, Diazinon belongs to the phosphoric acid ester group of enolisable heterocyclic systems. Described chemically as 0, 0-diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate, it is unusual in containing a pyrimidine, or 1, 3 diazine ring (a cyclic configuration of four carbon and two nitrogen atoms) together with an isopropyl and a conventional organic phosphate group. The expense of adding the pyrimidyl group leaves some doubt as to whether the price of Diazinon can be made competitive with other orchard insecticides. At present the technical chemical is imported from Switzerland and only the formulation is done in the U.S.A.

The data available on the toxicity of Diazinon to man and animals suggest that it is more toxic than malathion, but less toxic than parathion or TEPP, for example. According to Swiss workers (Buxtorf and Spindler, 1954), results on rats show that, by oral administration, parathion is about 60 times as toxic as Diazinon (so that Diazinon is approximately equal in toxicity to DDT). Malathion is almost harmless to rats, being about one-tenth as toxic as DDT or Diazinon. However, with week-old calves, U.S. Department of Agriculture workers (Radeleff *et al.*, 1955) obtained less promising results. Parathion, by oral administrations, was found to be twice as toxic as Diazinon, Diazinon 20 times as toxic as malathion, and malathion itself twelve times as toxic as DDT. DDT, as far as calves are concerned, is the least harmful material. The fact that DDT and malathion are reversed in sequence of toxicity, as between rats and calves, shows the difficulty of extrapolating such results to man and other animals on the basis of weight. Further, when the toxic action of dermal sprays on calves is considered, somewhat different figures hold. Parathion is then ten times as toxic as Diazinon, and Diazinon ten times as toxic as malathion. The last figures are probably the most valuable. In the surface-to-weight ratio calves are more like men than rats, and danger in the orchard is more likely to come from dermal effects than from oral ingestion.

One of the main points in favour of Diazinon as an orchard insecticide is that we have never observed any phytotoxic effects with either wettable powders or emulsions, even at much higher concentration than would ever be used in practice. And the likelihood of spray damage is a major aspect to consider in the introduction of a pesticide. We have not yet tested Diazinon against a full range of fruit varieties, in particular, against yellow varieties of apples, in which there are reports from elsewhere (Buxtorf and Spindler, 1954) of slight damage. As an example of our own results we

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may cite a comparative test of malathion, a material that is particularly likely to damage cherry, and diazinon. Malathion applied with a high-volume gun sprayer at eight pounds of 25 per cent wettable powder per 100 gallons (four times normal concentration) caused severe injury to cherry, moderate injury to apricot, and slight injury to peach. At double that strength the result was death, severe injury, or total defoliation to all soft fruits except prunes. But Diazinon at 30 pounds of 25 per cent wettable powder per 100 gallons (*i.e.* 15 times the recommended dosage) did not cause noticeable fruit or leaf injury to any type of fruit tree, including cherry.

High residual action and stability are claimed for Diazinon when used on walls. On living plant tissue the residual action is not necessarily the same. In lieu of specific chemical tests of deposit decline, long term action is demonstrated by satisfactory control of some insect for which effective coverage is necessary over an extended period. The codling moth, *Carpocapsa pomonella* (L.), the worst orchard enemy in British Columbia, is the best example of such an insect. A comparison was therefore made in 1955 by Dr. J. Marshall (unpublished) of the Summerland laboratory, using paired trees in an orchard heavily infested with the moth; one tree of each pair was sprayed with 50 per cent DDT wettable powder at 1.5 pounds per 100 gallons (12 ounces of active ingredient), the other with 25 per cent Diazinon wettable powder at two pounds per 100 gallons (8 ounces of active ingredient). Seven tree pairs were used. Two cover sprays were applied against the first brood and one against the second brood. At the end of the season the percentage of wormy fruit were: DDT, 12.9; Diazinon, 12.4; unsprayed checks, 79.1. In 1956 further trials were carried out in another heavily infested orchard. In this instance a concentrate sprayer was used, and four cover sprays of 25 per cent Diazinon wettable powder were applied at nine pounds (2.25 pounds of active ingredient) per acre. For a comparison, 50 per cent DDT wettable powder was applied at six pounds (three pounds of active ingredient) per acre. Both these rates are somewhat lower than would be used commercially. At harvest time the percentages of wormy fruit were 10.7 in the DDT plot and 4.8 in the Diazinon plot. In view of the high infestations in both orchards, and the concentrations of active ingredients that were used, there is no doubt that Diazinon was at least as effective against the codling moth as DDT. In the latter orchard the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), was also abundant and the percentages of fruit showing typical injury by this pest at harvest time were: DDT plots, 10.1; Diazinon plots, 0.8. In another orchard 25 per cent Diazinon was applied as a single dilute spray at two pounds per 100 gallons against the bud moth on apple and cherry trees; control was nearly perfect.

A special point of interest with Diazinon is the very wide range of orchard pests that it is effective against. Particular insecticides aften prove to be effective against a particular group of insects — soil or cotton insects, for instance. Up to the present there has been no single insecticide with a wide "spectrum" against orchard insects. DDT and parathion together, or DDT and malathion together, have been the nearest approach to this. Diazinon we consider to be an insecticide that will do all either of these combinations will do, and perhaps something more as well.

Diazinon is therefore a "general" insecticide. In the past, when entomologists in British Columbia were more concerned about hypothetical dangers from the destruction of parasites or predators, they were more prone to recommend selective insecticides as a safeguard. It appears to the authors, however, that disharmony (sufficient to cause economic loss) between chemical control and natural control of insects by indigenous enemies has been overstated, at least under the conditions of the semi-arid

British Columbia interior. Further, biological control with introduced parasites plays a minor part among all but two orchard pests in this part of British Columbia. There is, therefore, a lessening of interest in British Columbia in highly selective insecticides (which mean a multiplicity of materials and costs) and a revival of interest in more general insecticides that promise cheaper, or, at least, simpler spray schedules; this point of view is readily appreciated by the grower.

The effectiveness of Diazinon against the codling moth has already been mentioned. This is important from another aspect. Resistance to DDT, which was developed quickly in species like house flies. is, after a longer period of grace, beginning to appear in the codling moth. In one area of Australia it is extremely high (Smith, 1955); it is noticeable in parts of the eastern U.S.A. (Clancy, 1955) and there are reports of measurable increases in resistance from Washington State. It may be expected in British Columbia in time. Diazinon appears to be an answer.

Against aphids, both on apple and on stone fruits, the material is excellent. At one or two pounds per 100 gallons perfect control has been obtained against the black cherry aphid, *Myzus cerasi* (F.); the green peach aphid, *Myzus persicae* (Sulz.); the mealy plum aphid, *Hyalopterus pruni* (Geof.) [= *H. arundinis* (F.)]; the thistle aphid, *Anuraphis cardui* (L.); the woolly apple aphid, *Eriosoma lanigerum* (Hausm.); and the apple aphid, *Aphis pomi* Deg. Against the black cherry aphid, Diazinon seems to have a special place, because malathion readily damages cherry, parathion is not recommended because of toxicity to human beings, lindane is apt to taint the fruit, and nicotine is often ineffective at low temperatures early in the season when spraying is necessary. Even if a grower has failed to spray early in a season, when other aphicides are most valuable, he can get adequate control of the black cherry aphid with a summer application of Diazinon even though the aphids are then protected by the tightly curled foliage. Similarly, the green peach aphid was perfectly controlled in 1954 with Diazinon, in an orchard where malathion had earlier proved unsatisfactory. With the apple aphid, however, re-infestation from neighbouring orchards is a constant problem and against that species Diazinon has been no better than malathion or lindane. Under the severe aphid attacks of 1955 and 1956 repeated spraying was, therefore, necessary with Diazinon as with other materials. In commercial orchards it is expensive to apply insecticides repeatedly for aphids only. However, if the insecticide is used for other purposes (*e.g.*, Diazinon for the codling moth cover sprays), repeated application may be economically feasible.

Diazinon gives good control of overwintered nymphs of soft scales, *Lecanium* spp., on peach and apricot. It is also effective as an early summer spray against the San Jose scale, *Aspidiotus perniciosus* Comst.

Against orchard mites, Diazinon, in a single application, has given very good results against the active stages of the clover mite, *Bryobia arborea* M. & A. (*B. praetiosa* of authors, in part); the European red mite, *Metatetranychus ulmi* (Koch); the yellow mite, *Eotetranychus carpini* (Oudms.) [=*E. carpini borealis* (Ewing)]; the McDaniel spider mite, *Tetranychus mcdanieli* McG.; and the apple rust mite, *Vasates schlechtendali* (Nal.) (Downing, 1957). However, residual control is not so good as with specific miticides. But if Diazinon were applied in the repeated cover sprays for codling moth control, growers would probably be little concerned with mites unless phosphate-resistant strains of the European red mite were present. Diazinon is not effective against such mites. At the present they pose a major problem for which specific miticides are required. Apart from this, however, Diazinon has an advantage over specific miticides in that most of them have a tendency to dmaage foliage.

We have done no tests with Diazinon against the rosy apple aphid, the pear psylla, "cat facing" bugs, or cherry fruit flies, but results from elsewhere indicate that Diazinon is very effective in these cases.

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TICK PARALYSIS IN CATTLE IN BRITISH COLUMBIA IN 1957[1]

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Several serious outbreaks of tick paralysis in cattle were caused by the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, in the Nicola-Kamloops area of British Columbia in the spring of 1957. These were favoured by prolonged tick activity during a late spring, and by lack of, or inadequate, spraying of animals with BHC. Several rain showers also served to weaken residues that originally may have been sufficiently strong to afford normal protection from the ticks.

The first outbreak occurred on April 10 at the J. Lauder ranch, Merritt. Three hundred yearling cattle, which had not been bothered by ticks during the past three years and hence had not been sprayed, became infested with clusters of several dozen engorging ticks per animal. Ten were paralyzed in the field; three of these died. The remaining animals were rounded up and sprayed the following day with BHC at the recommended rate of 4 ounces of wettable powder (Ortho BHC 10 Wettable, 10 per cent gamma isomer; California Spray-Chemical Corporation, Portland, Oregon) per gallon of water.

On April 19, at Drew's ranch, Stump Lake, 32 yearlings in a herd of 118 became paralyzed. The herd, which had been sprayed with BHC wettable powder (Ortho BHC 10 Wettable) at 2 ounces per gallon of water two weeks previously, was resprayed; and stricken animals were deticked in the field and each given 600,000 units of penicillin to safeguard against pneumonia. Seven animals died.

The following day a large outbreak was reported by the Nicola Stock Company at what is known locally as the Saxon Field, about six miles up Quilchena Creek. This area has been heavily infested with ticks for many years, and in 1944, in a derris-sprayed herd of 1,230 yearlings, 400 were paralyzed and 50 were lost. In 1957, the herd had been sprayed with BHC, but at only $\frac{1}{2}$ ounce of wettable powder (Ortho BHC 10 Wettable) per gallon of water, resulting in little residual protection. When the writer visited the area on April 21, nine cowboys were searching some ten square miles

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