Mr. Sánchez Navarette: No.

Dr. Wiehe: Do not 'dead hearts' result in some of the drier parts of Mauritius?

Mr. Williams: When there are several borers near the top of a stalk, the top may die. This is different from a 'dead heart'.

Mr. Sánchez Navarette: Is it easy to find several larvae in a single stalk?

Mr. Williams: No. We usually find one or two.

D. W. Fewkes (Trinidad): In Trinidad we have three species of Diatraea and they do cause 'dead hearts' but only in young shoots, not in mature canes. Do you have any estimates of the damage caused by your stalk borer in Mauritius which can be used to gauge the effectiveness of parasites introduced for biological control.

Mr. Williams: No. We have, in fact, only succeeded in establishing one useful parasite species.

Mr. Mamet: We make counts of borer infestation in our variety trials but this, of course, is for the purpose of assessing varietal resistance.

CHEMICAL CONTROL OF THE SUGAR CANE FROGHOPPER
AENEOLAMIA VARIA SACCHARINA (DISTANT)

C. A. F. Merry, D. W. Fewkes, and A. J. Vlitos

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(Presented by Dr. D. W. Fewkes)

INTRODUCTION

The froghopper is the most serious pest of sugar cane in Trinidad. In recent years serious outbreaks of the pest have occurred in several of the sugar cane areas of Venezuela, Brazil, and Mexico. The adult insect with its sucking mouth parts feeds on the leaf, causing severe necrosis of tissue, which may lead to death of entire leaves. Severely attacked fields often lose 90% of their photosynthetic area. The economic losses due to the froghopper are correspondingly great, as the cost of control measures in Trinidad often exceeds $1,000,000 (British West Indies) per annum. Descriptions of froghopper damage and the life history of the insect have been fully given elsewhere. 8, 10, 18, 20, 21.

Various insecticides have been used since 1925 to combat either the nymphal or adult stages of the insect. Cyanogas (calcium cyanide) 5, 9, pyrethrum 13, sabadilla 14, DDT 14, and benzene hexachloride 14, have all been used with varying degrees of success. Benzene hexachloride (BHC) was widely adopted by some of the larger sugar estates until 1957–58. From 1954 to the present, resistance of the froghopper to BHC became apparent. During 1958, Caroni Ltd., the largest cane grower in Trinidad, introduced an organophosphorus compound, Trithion (O,O-diethyl S-p-chlorophenylthiophosphorodithioate) into their froghopper control programme 12. Trithion was an extremely potent weapon against BHC-resistant strains at a time when no other control measure was available.

Although Trithion gave a good residual control of nymphs, the initial kill was slow, and also Trithion was relatively expensive. Therefore in 1959, a programme was initiated to test new chemicals against froghopper nymphs 14.
Successful insecticides for froghopper control should: (a) be effective in controlling froghopper nymphs, both from the point of view of quick initial kill and residual action, (b) be relatively inexpensive, (c) be of low mammalian toxicity, and (d) represent diverse chemical groups, with the possibility of delaying the selection of resistant strains.

The present paper describes the results of field trials in which several new insecticides were compared with Trithion. Trials were conducted over a 2-year period, 1959 and 1960.

**MATERIALS AND METHODS**

The following compounds representative of the organophosphorus group, the chlorinated hydrocarbons and the carbamates, were evaluated for their effectiveness in controlling froghopper nymphs:

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Chemical composition and manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trithion</td>
<td>O,O-diethyl S-p-chlorophenylthiomethyl-phosphorodithioate (Stauffer Chemical Co.)</td>
</tr>
<tr>
<td>2. Thimet</td>
<td>O,O-diethyl S-(ethylthiomethyl)-phosphorodithioate (Cyanamid International)</td>
</tr>
<tr>
<td>3. Rogor</td>
<td>O,O-dimethyl S-(N-methylcarbamoylmethyl) phosphorothiolothionate (Fisons Pest Control Ltd.)</td>
</tr>
<tr>
<td>4. Nankor (Korlan)</td>
<td>O,O-dimethyl O-2,4,5-trichlorophenyl-phosphorothioate (Dow Chemical Co.)</td>
</tr>
<tr>
<td>5. Gusathion</td>
<td>O,O-diethyl-S-(4-oxy-1,2,3-benzotriazinyl-3-methyl)-dithiophosphate (Farbenfabriken Bayer AG)</td>
</tr>
<tr>
<td>6. PP 175</td>
<td>2,4-diamino-6-dimethoxophosphinothiolomethyl-s-triazine (Plant Protection Ltd.)</td>
</tr>
<tr>
<td>1. Sevin</td>
<td>r-naphthyl N-methylcarbamate (Union Carbide)</td>
</tr>
<tr>
<td>2. Telodrin</td>
<td>1,2,4,5,6,7,8,8-octachloro-3R,4,7,7a-tetrahydro-4,7-methanophthalan (Shell)</td>
</tr>
<tr>
<td>3. Thimet</td>
<td>2,4-diamino-6-dimethoxophosphinothiolomethyl-s-triazine (Plant Protection Ltd.)</td>
</tr>
</tbody>
</table>

The appropriate quantities of wettable powder and dust formulations were mixed with 2 1/2 cwt. per acre ground limestone as a diluent. Thimet, the only granular material used, was applied at the rate of 10, 15, 20, 30 and 40 lb. per acre (1, 1.5, 2, 3 and 4 lb. active ingredient per acre).

Excessive weed growth and the lower 'trash' leaves around the cane stools were removed prior to application to allow contact of the insecticide with the spittle mass on the surface of the soil.

Wettable powder and dust formulations were applied using a 'Rotver' hand duster, while the 'Cook Granula' hand applicator was used for Thimet.

Criteria for selection of experimental areas were (a) evenly distributed and high counts of nymphs particularly of early instars, (b) indications that the froghopper population was increasing within the area, and (c) uniformity of field beds and drains.

All experiments were carried out in ratoon cane of variety B 41227 and each
experiment was designed as a randomized block, with a minimum of 4 replicates and a plot size of \( \frac{3}{5} \) th of an acre.

Results of the various treatments were assessed by counting, at intervals of several days, the total number of live nymphs surrounding the bases of 3 cane stools chosen at random in each plot.

RESULTS

Trithion

Trithion at a concentration of 5.6 lb. active ingredient per acre was set as the standard treatment in all trials except in the initial experiment when 8.4 lb. a.i. per acre were employed. In all experiments Trithion provided a slow initial kill, followed by long residual control of nymphs. A typical result is presented in Fig. 1.

![Fig. 1. Control of froghopper nymphs by Trithion 5.6 lb. a.i. per acre.](image)

Thimet

Thimet at 2 lb. active ingredient per acre gave a rapid initial kill and a long residual control of nymphs. Thimet was also evaluated at 1, 1.5, 3 and 4 lb. a.i. per acre. The lower rates of application were effective for initial kill but gave variable residual control, while the higher rates, though giving excellent control, were considered too expensive. Thimet at 2 lb. a.i. was evaluated in 6 experiments, and the results presented (Fig. 2) are considered typical of its action.

Sevin

At 8.4 lb. active ingredient per acre, Sevin resulted in excellent nymph control and has been used successfully by the estates over a large acreage.

Sevin was evaluated in 7 trials during 1960. In all cases the chemical acted rapidly and residual control was as effective as Trithion. No differences were observed between the dust base, wettable powder or granular formulations of Sevin. Typical results are presented in Fig. 3.
Fig. 2. Control of froghopper nymphs by Thimet 2 lb. a.i. per acre.

Fig. 3. Control of froghopper nymphs by Sevin 8.4 lb. a.i. per acre.

Fig. 4. Control of froghopper nymphs by Telodrin 2.8 lb. a.i. per acre.
Telodrin

Telodrin, a chlorinated hydrocarbon, resulted in excellent nymph control in areas where resistance of nymphs to other hydrocarbons (DDT and BHC) had been observed previously. At the rate of 2.8 lb. active ingredient per acre Telodrin provided a rapid kill of existing nymphs, with good residual control of succeeding broods of nymphs (Fig. 4).

Rogor

Rogor acted rapidly to give an initial kill of nymphs, but was not as effective as Trithion, Thimet, Sevin or Telodrin in controlling later broods. (cf. Fig. 5 with Figs. 1, 2, 3 and 4).

Nankor (Korlan), Gusathion, and PP 175 were ineffective.

![Graph](image)

Fig. 5. Control of froghopper nymphs by Rogor 5.6 lb. a.i. per acre.

DISCUSSION

Sevin, Thimet and Telodrin were the three outstanding insecticides for the control of froghopper nymphs in Trinidad sugar cane. All three chemicals gave a quick initial kill and a residual control of nymphs for as long as the standard, Trithion. Apart from all other considerations, this residual effect coupled with the fast kill of existing nymphs is considered to be an advantage over the standard treatment.

Rogor also provided a quick kill of nymphs, but its residual effect was inferior to Trithion. At the time when these trials were in progress a major disadvantage of Trithion was its high cost. Sevin, Thimet and Telodrin were all less expensive than Trithion (see Table I) on a cost-performance basis.

Thimet has two advantages over the other insecticides evaluated in the present experiments. First, due to its granular form, the preliminary operation of mixing the insecticide with ground limestone is eliminated. Second, it has been noted that Thimet will give effective control of nymphs irrespective of whether the weeding and trashing operations (described under 'Materials and Methods') are carried out. Both these considerations represent a considerable saving of time and expense.

Thimet is reputed to act systemically, and although this has not been proved in the present trials, some evidence is available to support this claim. In 3 cases, fields were 'strip' treated with
TABLE I

RELATIVE COSTS PER ACRE OF TREATMENT WITH TRITHION, SEVIN, THIMET, ROGOR, AND TELODRIN (AT JUNE 1960)

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Commercial formulation</th>
<th>lb. a.i. per acre</th>
<th>Commercial material per acre (lb.)</th>
<th>Cost per lb. ($B.W.I.)</th>
<th>Cost per acre ($B.W.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trithion</td>
<td>25% dust base</td>
<td>5.6</td>
<td>22.4</td>
<td>1.28</td>
<td>28.67*</td>
</tr>
<tr>
<td>Sevin</td>
<td>50% dust base</td>
<td>8.4</td>
<td>16.8</td>
<td>1.03</td>
<td>17.28</td>
</tr>
<tr>
<td>Thimet</td>
<td>10% granular</td>
<td>2.0</td>
<td>20.0</td>
<td>0.78</td>
<td>15.60</td>
</tr>
<tr>
<td>Rogor</td>
<td>20% dust base</td>
<td>5.6</td>
<td>28.0</td>
<td>1.17</td>
<td>32.76</td>
</tr>
<tr>
<td>Telodrin</td>
<td>50% dust concentrate</td>
<td>2.8</td>
<td>5.6</td>
<td>3.12</td>
<td>17.47</td>
</tr>
</tbody>
</table>

* The present price for Trithion is 0.85 $ (B.W.I.) per lb. or $19.04 (B.W.I.) per acre.

Thimet, with untreated strips placed adjacent to the Thimet treated areas. The untreated areas were severely blighted, while the Thimet treated areas remained free of froghopper blight. As there was most likely a migration of adult froghoppers from the untreated to the treated areas, it is possible that Thimet had acted systemically to prevent blight. Yield data was recorded from one of these large-scale experiment fields. The following data relates to the influence of the insecticide on subsequent yields of sugar:

<table>
<thead>
<tr>
<th></th>
<th>Tons cane per acre</th>
<th>Tons cane per ton sugar</th>
<th>Tons sugar per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thimet treated</td>
<td>34.89</td>
<td>11.37</td>
<td>3.09</td>
</tr>
<tr>
<td>Untreated</td>
<td>29.27</td>
<td>15.81</td>
<td>1.87</td>
</tr>
</tbody>
</table>

With regards to mammalian toxicity, Sevin is an outstanding insecticide. Figures given (Table II) show that while Thimet is in the same range of mammalian toxicity as Trithion, Rogor is comparatively safe, and Sevin is virtually non-toxic. The relative mammalian toxicity of Telodrin is greater than the compounds mentioned above and therefore the chemical should be handled with caution.

TABLE II

RELATIVE MAMMALIAN TOXICITY OF TRITHION, SEVIN, THIMET, TELODRIN AND ROGOR

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Acute L.D.50 to rats (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oral</td>
</tr>
<tr>
<td>Trithion</td>
<td>10-30</td>
</tr>
<tr>
<td>Sevin</td>
<td>500-700</td>
</tr>
<tr>
<td>Thimet</td>
<td>7</td>
</tr>
<tr>
<td>Telodrin</td>
<td>not given</td>
</tr>
<tr>
<td>Rogor</td>
<td>200-240</td>
</tr>
</tbody>
</table>

* Using guinea pigs.

Following the development of resistance of the froghopper to BHC in 1954 and later, it is likely that one of the problems to be faced in the future is the development of resistance to one or more of the newer insecticides. It is hoped that a system of rotational use of insecticides of different chemical structure may preclude or delay the selection of resistant strains.

It is generally accepted that insect resistance to an insecticide is due to pre-adaptation, i.e.
that the 'R' (resistant) genes are present in the population and become predominant due to the selection pressure exerted by the insecticide. CROW is of the opinion that a susceptible population that has once been resistant is likely to increase rapidly in resistance when the insecticide is once again applied.

GORDON reported that one tentative solution to the problem of resistance was that of 'Intermittent Selection', which requires that an insecticide be used for a limited time, followed by either a period of natural control or a different insecticide. He goes on to state, however, that negative cross resistance is unlikely, and that when a second insecticide is used, the presence of 'R' genes for the first could be advantageous to the insect, because of active or latent cross resistance.

On the other hand LEWALLEN observed, from results of field and laboratory tests with malathion- and parathion-resistant strains of mosquitoes, that organophosphorus resistance was not stable and reversion to susceptibility occurred rapidly when selection pressure was removed. He suggests that due to reversion to susceptibility in resistant strains, organophosphorus insecticides might be rotated with other types of insecticides possessing different modes of action. He recommends that, to avoid the development of resistance, prolonged use of one insecticide should be discouraged.

With lack of sufficient basic knowledge of the mechanisms of resistance in the sugar cane froghopper, it is not known which of these views applies. However, as a biological control is at the present not feasible, both from the point of view of cultural operations and the lack of a suitable predator, the only available control of the froghopper is by insecticides.

'Sevin', 'Thimet', and 'Telodrin', represent different chemical groups. It is hoped that by some form of rotation of these three compounds, resistance to any one of them can be delayed or avoided in the future.

SUMMARY

1. Field experiments were conducted to evaluate some newer insecticides for the control of froghopper nymphs.
2. Sevin at 8.4 lb., Thimet at 2 lb., and Telodrin at 2.8 lb. active ingredient per acre, provided a more rapid initial kill of nymphs than Trithion at 5.6 lb. a.i. per acre, and as good a residual control as Trithion of succeeding broods of nymphs.
3. The relative merits of the insecticides for froghopper control, taking into account their efficacy against the nymphs, their mammalian toxicity and costs per acre, have been discussed.
4. The possibility of avoiding the selection of resistant strains by rotational field use of Sevin (a carbamate), Thimet (an organophosphate) and Telodrin (a chlorinated hydrocarbon) has been suggested.

ACKNOWLEDGEMENTS

The authors wish to thank the Cultivation Staff of Caroni Ltd. and Ste. Madeleine Sugar Co., Ltd., for their kind co-operation in providing and maintaining experimental areas. We also wish to thank Messrs. D. J. H. NEATE and I. D. LAWRIE (Agronomists), and the many field assistants without whose help these experiments would not have been possible. We are indebted to Mr. L. C. STRUGNELL for assisting in preparation of the figures.

We are indebted to the manufacturers for having provided sufficient amounts of the insecticides to enable us to conduct the trials.

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DISCUSSIONS

J. Wilson (S. Africa): Are insecticides applied as a prophylactic or on the basis of extent of outbreak?

D. W. FEWKES (Trinidad): Observations are started at the beginning of the season, and when a certain level of infestation is noticed, the insecticides are applied. Usually the level is about 10 nymphs to one cane stool.

Mr. Wilson: Are there any signs of varietal preference?

Dr. FEWKES: We have noticed that, in some of our variety trials, some varieties are less attacked than others, but this is not apparent in commercial plantations where a few varieties extend over large acreages and the insect has no, or little, choice.

A. VLITOS (Trinidad): One of the interesting things about the froghopper is that it causes a disease known as froghopper blight, which has many of the characteristics of a virus disease. When the insect is made to feed on sugar cane leaves, lesions are produced in about three weeks. It would be interesting to determine whether the lesions are due to some insect toxin or if they are caused by a virus.

G. WAGLEY (U.K.): What are the prospects of cane farmers, as opposed to estates, using chemical control methods?

Dr. FEWKES: We have contact with cane farmers' associations in Trinidad and advise them on the choice of chemicals. Many of the farmers follow our advice and have used insecticides such as Sevin and BHC for control of froghoppers but there are small farmers who just take a chance and do not use any insecticide. Sevin is recommended on account of its low mammalian toxicity.

A. WIEHE (Mauritius): Has resistance to BHC been maintained up to now?

Dr. FEWKES: The froghopper does not appear to have maintained itself entirely resistant to BHC.

Mr. WIEHE: Is there any evidence of Thimet having a systemic action?

Dr. FEWKES: We have some evidence of systemic action from small-scale experiments. This effect does not last for more than 8 days.

J. R. WILLIAMS (Mauritius): Was the development of resistance to BHC determined from field observation and experience alone or has it been confirmed by laboratory tests?

Dr. FEWKES: By field observations only.

C. G. HUGHES (Queensland): The development of insect resistance to BHC is an important subject to us in Australia where the chemical is used on a large scale against white grubs.
ENTOMOLOGY

Mr. Williams: I think the insect is indigenous to Trinidad. Presumably there is no hope of biological control?

Dr. Fewkes: It is indigenous to Trinidad. The possibilities of biological control have not been fully exhausted.

Mr. Wilson: Is the death of canes due to adult or nymphal feeding?

Dr. Fewkes: The adults are mostly responsible.

Mr. Wilson: Do affected canes sometimes recover?

Dr. Vlitos: There may be recovery. If the meristematic area is still intact, the young leaves will recover. Recovery of an entire field is rare.

Mr. Hughes: What is the extent of infestation in a blighted field?

Dr. Fewkes: Blight is noticeable where there is an average of about one adult per stem. As many as 20 adults per stem may be observed in a severely blighted field.

Mr. Williams: How are insecticides applied to cane fields against frog hopper in Trinidad? Do you make use of wind to carry dust over the fields?

Dr. Fewkes: The application of dust with rotary hand dusters is standard practice against nymphs. Against adults, Messenger dusters are used to blow the dust over a field when conditions are calm, usually in the evenings.

THE SUGAR CANE FROGHOPPER AND ITS CONTROL IN MEXICO

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(Presented by Dr. A. Gonzalez Gallardo)

INTRODUCTION

The froghopper, Aeneolamia postica Wilk. (Fig. 1), may be considered the second pest of sugar cane in Mexico. In 1961, this insect infested approx. 75,000 acres (about 30,000 ha) of cane in different parts of the country and, in addition, injured the pasture lands along the coast of the Gulf of Mexico.

The 'salivazo' as it is called among cane growers, is an insect indigenous to Mexico, where it feeds on wild grasses. Although it could have attacked cane before, the first damage to this crop was recorded as late as 1943; in this year it injured a great area cultivated to P.O.J. 36 in Cuatotolapan, Ver., on the Gulf coast and it