SOME INSECTICIDE TESTS AGAINST THE ELEGANT GRASSHOPPER

ZONOCERUS ELEGANS, THNB.

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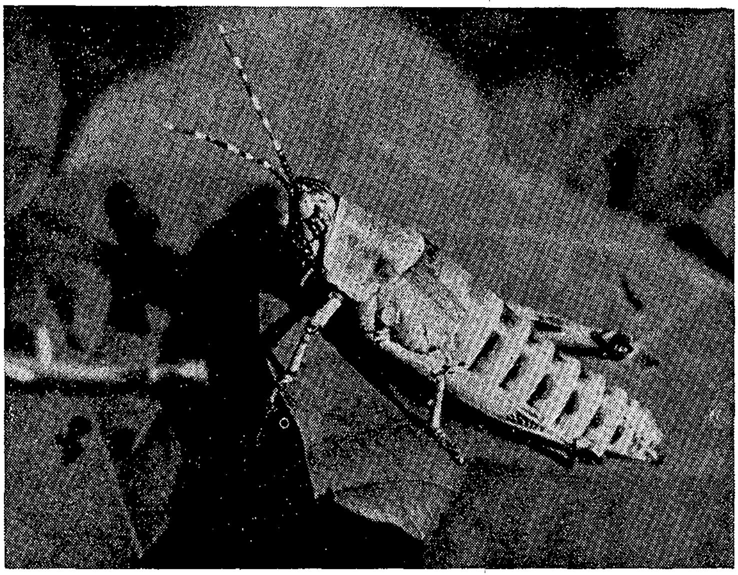

Introduction.

The elegant grasshopper, or *totoviyane*, occurs practically all over South Africa but is most common in the Natal Coast area. It feeds on a wide variety of plants, both wild and cultivated, and sometimes does considerable damage in vegetable and flower gardens. Although it only occasionally attacks sugarcane and has never caused serious damage to this crop, enquiries regarding its control frequently reach the Experiment Station. It was considered, therefore, that an investigation into the effect on it of various insecticides would be of value.

Zonocerus elegans, probably on account of the unpleasant odour which has earned for it the Afrikaans name of "stink-sprinkaan," is relatively free from natural enemies. A nematode worm has been found parasitising an adult in the Transkei, and a small red mite commonly lives as an external parasite on the hoppers but apparently has little effect on them. More important is a fly, a species of *Sarcophaga*, which sometimes parasitises considerable numbers of the insects. While specimens were being collected for the present investigation it was found that several species of Mantids fed on the young hoppers. However, none of these natural enemies appears to control the grasshoppers; in general, birds and other vertebrates seem to avoid feeding on them.

A paper by van der Merwe and Kent[2], published in 1925, gives an account of the life history, distribution, food plants and natural enemies of *Z. elegans*. The authors also describe insecticide tests which they carried out against it. Most of these were on the effects of arsenical poisons, including Paris green, lead arsenate, calcium arsenate and sodium arsenite, either sprayed on the foliage of food plants or used in poison baits. Of these, the most effective was sodium arsenite which acted as both a stomach and a contact poison. It has, however, the disadvantage of being toxic to plants, so that it can only be recommended for use on the foliage of weeds and plants of no value, and is moreover dangerously poisonous to cattle. Consequently mechanical control measures have had to be relied on to a great extent. These measures, which include swatting and hand-collecting of the insects, sometimes prove somewhat laborious, especially after the insects have dispersed from the small swarms in which they occur during the first few weeks after hatching.

Material and Methods.

The grasshoppers used in the experiments described below were collected by sweeping with a net in gardens and fields at the Experiment Station. Collection began at the beginning of October, soon after the eggs started to hatch. Stocks of insect material were kept in cages consisting of a wooden framework with sides of wire gauze, the dimensions of which were $50 \times 25 \times 25$ cm. About a thousand insects could be kept in each cage, where they were fed on the foliage of blackjack plants, *Bidens* *pilosa*, Linn. As the material was used up, it was replenished by further collection.

Since it was difficult to obtain sufficient insects all of the same age, the material used in the first five tests consisted of a mixture of hoppers of the first three instars. The specimens used in each replication, however, were taken at random from the stock cages, so that the error arising from the fact that a mixed population was used was probably not very great. The sixth experiment was carried out about a month later and the average age of the insects was consequently greater. This probably accounts for the somewhat lower kill for Gammexane obtained in this test.

For the insecticide tests, the hoppers were placed in smaller cages. Each of these consisted of a cylinder of perforated zinc 12 cm. in dameter and 14 cm. in height. The top and bottom were closed by means of squares of paper held in position by rubber bands or string. The insects in these cages were fed on blackjack foliage which was changed every day, or in some cases on alternate days, when mortality counts were done.

At the start of all the experiments each cage contained 100 hoppers. In the first two experiments mortality counts were taken only on the first three days after treatment, but in later tests counting was continued until the mortality as shown by successive counts was not significantly greater for any treatment than for the control. Mortality after this period was thought to be due to causes other than the application of insecticides.

Insecticides used in the Tests.

The insecticides used in these tests were the following:—

1. DDT dust—a 2½ per cent. agricultural dusting powder in which the diluent was talc;
2. Gammexane "O"—a dusting powder containing 2 per cent. of the gamma isomer of benzene hexachloride;
3. Gammexane "B"—a dusting powder containing 0.5 per cent. gamma benzene hexachloride;
4. "M"—a proprietary insecticide of the carbolic dip type;
5. Lead arsenate powder in suspension in water;
6. Sodium fluosilicate in solution in water;
7. Pyrethrum powder—a proprietary brand consisting of the flowers dried and ground;
8. A Pyrethrum spray made up in kerosene;
9. A 5 per cent. solution of DDT in kerosene;
10. The Pyrethrum spray made up in 5 per cent. DDT solution in kerosene instead of in kerosene alone;
11. Kerosene, introduced as a control against the Pyrethrum and DDT sprays made up with kerosene;
12. "H"—a proprietary insecticide containing pyridine;
13. "MP"—a proprietary brand of hexaethyl tetraphosphate diluted with water to 1 part in 1,200 as recommended by the makers.

Estimation of Quantities of Insecticides applied. Pieces of paper 12 square inches in area were weighed and placed in cages similar to those used in the experiments. These were then treated with ten times the amount of insecticides applied in the tests and weighed again. In each case, six replications were done and from the results the amounts of insecticide that would be applied to an acre were calculated. This method is far from accurate but gives results within close enough limits for practical purposes. These figures give the amount of insecticide which would be required if it were necessary to apply the material to the whole surface of an acre. In actual practice the amount required would be considerably less, especially if the insects were treated while they were still in the small swarms which they form during the first few weeks after hatching.

First Test.

In the first experiment, six replications were done of each treatment, with six controls. The insecticides used were Gammexane "O" and DDT dust at a rate equivalent to ten pounds per acre, and the carbolic insecticide "M," diluted, as recommended by the makers, to 4 per cent. with water and applied at ten gallons per acre. The insects were placed in the cages with a supply of blackjack foliage and the insecticides were dusted or sprayed through the perforated zinc sides of the cages. The percentage mortality two days after treatment is given in Table I.

TABLE I.

Mortality per hundred Hoppers after two days.

Cage No.	Control.	DDT.	"M".	Gammexane.
1	2	1	0	100
2	1	3	0	98
3	0	3	0	100
4	3	0	0	100
5	0	2	0	99
6	1	2	0	99
Totals	7	11	0	596

Statistical analysis of these figures is hardly necessary, but the difference between totals for treatments required for significance was calculated. The required figures were found to be 7.7 and 10.6

for significance at odds of 19 to 1 and 99 to 1 respectively.

Second Test.

In the second test the DDT powder and the carbolic insecticide "M" were applied in considerably larger amounts, namely the equivalent of 100 pounds of DDT and 80 gallons of the 4 per cent. emulsion respectively. The mortality up to the third day after treatment is given in Table II.

TABLE II.

Mortality per hundred Hoppres after three days.

Cage No.	Control.	"M".	DDT.
1 ...	2	16	100
2 ...	0	55	75
3 ...	0	70	36
4 ...	5	91	89
5 ...	0	45	48
6 ...	4	54	78
Totals...	11	331	426

The required difference between totals for these figures is found to be 162.6 at 19 to 1, and 231.4 at 99 to 1. The large size of the required figures in this case is due to the great variation in mortality between the replications in each treatment. The difference in kill between "M" and DDT is thus not significant.

Third Test.

The insecticides used in this test were Gammexane "O" at the equivalent of 10 pounds per acre, the material "M" as a 10 per cent. emulsion in water used at the rate of 30 gallons per acre, lead arsenate as a suspension of 1 ounce per gallon of water, and sodium fluosilicate as a solution of 1 ounce per gallon, the last two being applied at a rate equivalent to 30 gallons per acre. The two stomach poisons, lead arsenate and sodium fluosilicate, were sprayed on to the foliage in the cages and this was left for two days during which considerable feeding by the hoppers occurred. The 10 per cent. carbolic insecticide produced serious burning of the foliage. Table III shows the mortality five days after treatment.

TABLE III.

Mortality per hundred Hoppers after five days.

Cage No.	Control.	Gammexane.	"M".	Lead arsenate.	Sodium fluosilicate.
1 ...	4	89	82	27	41
2 ...	3	100	100	44	44
3 ...	1	100	94	23	77
4 ...	2	98	100	22	51
5 ...	0	100	85	47	32
6 ...	3	97	90	25	16
Totals ...	13	584	551	188	261

The required difference between totals was calculated to be 122.3 for significance at 19 to 1 odds and 166.7 for significance at 99 to 1. The fact that the material "M" is here practically as effective as Gammexane is offset by the fact that at the concentration necessary to produce this high kill the material burns the foliage of plants. The two stomach poisons are significantly less effective than the contact poisons.

Fourth Test.

In the fourth test, eight replications were carried out for each treatment, with eight controls. The insecticides used were DDT dust at a rate equivalent to 20 pounds per acre, Gammexane "O" at 10 pounds per acre, the carbolic insecticide "M" as a 4 per cent. emulsion in water used at a rate equivalent to 100 gallons per acre, the Pyrethrum spray diluted to 10 per cent. in kerosene, the 5 per cent. DDT in kerosene spray, and a mixture consisting of the Pyrethrum spray diluted with the DDT solution instead of with plain kerosene. The last three sprays were used at a rate equivalent to 20 gallons per acre.

Mortality counts were continued for a longer period in this series as it was thought that some of the materials used, particularly the DDT dust and spray, might require longer to show their full effect than was allowed in the first three tests. However, the mortality after the eighth day was not significantly greater for any treatment than for the control.

Mortality figures up to the second and the eighth days after treatment are given in Tables IV and V.

TABLE IV.

Mortality per hundred Hoppers after two days.

Cage No.	Control.	DDT dust.	Gammexane.	"M".	Pyrethrum powder.	Pyrethrum in kerosene.	DDT in kerosene.	Pyrethrum and DDT in kerosene.
1 ...	0	0	85	0	0	10	75	62
2 ...	0	0	94	2	1	24	37	68
3 ...	0	4	98	3	0	33	47	89
4 ...	0	7	86	8	8	20	55	76
5 ...	0	9	99	2	3	9	68	69
6 ...	0	5	97	0	5	18	74	70
7 ...	0	0	95	0	20	17	63	65
8 ...	0	10	98	5	5	19	50	46
Totals	0	35	752	20	42	150	469	545

TABLE V.

Mortality per hundred Hoppers after eight days.

Cage No.	Control.	DDT dust.	Gammexane.	"M".	Pyrethrum powder.	Pyrethrum in kerosene.	DDT in kerosene.	Pyrethrum and DDT in kerosene.
1 ...	0	11	100	6	24	30	95	72
2 ...	0	15	100	5	31	43	70	86
3 ...	3	40	99	9	52	44	56	100
4 ...	0	25	98	14	50	25	90	85
5 ...	4	19	100	5	26	11	100	80
6 ...	0	26	99	8	16	37	90	81
7 ...	0	13	100	5	63	22	81	89
8 ...	0	42	100	10	32	19	58	69
Totals	7	191	796	62	294	231	640	662

For the data in Table IV the significant difference between totals for treatments was calculated to be 64.3 at 19 to 1 and 85.8 at 99 to 1. The corresponding figures for the data in Table V were 88.9 and 118.6, respectively.

It will be seen that the Gammexane dust produces most of its effect within the first two days, while the DDT dust and spray and the Pyrethrum powder are apparently slower. The addition of Pyrethrum to the DDT spray possibly causes it to act more quickly but does not appreciably increase the total kill.

Fifth Test.

In the fifth test kerosene was introduced to discover to what extent the kill obtained with the sprays made up in kerosene was due to the action of this material by itself. The insecticides used were kerosene, the Pyrethrum extract and the DDT solution in kerosene, the proprietary insecticide "H" containing pyridine, and "MP," the proprietary brand of hexaethyl tetraphosphate, all at a rate equivalent to 20 gallons per acre, and Gammexane dust "O" at 10 pounds per acre.

The mortality up to the eighth day after treatment is given in Table VI.

TABLE VI.

Mortality per hundred Hoppers after eight days.

Cage No.	Control.	Kerosene.	Pyrethum in kerosene.	DDT in kerosene.	"H".	"MP".	Gammexane.
1 ...	2	13	8	100	0	0	98
2 ...	3	12	15	81	0	0	90
3 ...	0	8	20	80	0	5	95
4 ...	4	12	20	75	0	3	100
5 ...	2	9	15	74	2	0	93
6 ...	0	14	14	74	0	2	100
7 ...	0	8	24	55	0	0	100
8 ...	1	7	9	60	1	0	95
Totals	12	83	125	599	3	10	771

The differences between totals required for significance were calculated to be 48.1 and 64.6 at odds of 19 to 1 and 99 to 1, respectively. It will be noticed that the kerosene by itself produced a significant kill, but that the difference between the Pyrethrum solution and the kerosene alone is just too small to be significant at 19 to 1. The two proprietary insecticides are ineffective against this insect. Gammexane is significantly better than the DDT solution and does not burn the leaves of plants as does the kerosene in which the DDT is dissolved.

Sixth Test.

After the above tests had been completed, a cheaper grade of Gammexane powder containing 0.5 per cent. of the gamma isomer of benzene hexachloride became available. This substance, here referred to as Gammexane "B", was tested against the product used in the earlier experiments, both being used at a rate equivalent to 10 pounds per acre. Unfortunately large numbers of hoppers were no longer available so that the experiment had to be designed with only four replications of each treatment and four controls. The insects used were also somewhat older which probably accounts for the lower total kill obtained from each treatment. The mortality figures up to the eighth day after dusting are given in Table VII.

TABLE VII.

Mortality per hundred Hoppers eight days after treatment.

Cage No.	Control.	Gammexane "O".	Gammexane "B".
1	5	88	70
2	4	89	67
3	3	79	90
4	4	86	95
Totals	16	342	322

The difference between totals required for significance is found to be 65.1 at 19 to 1 and 98.5 at 99 to 1. Thus, in this experiment, no significant difference in effectiveness between the two materials can be found.

Possible Dangers in the Use of Gammexane.

There is some danger in applying Gammexane in large quantities as it may possibly have a harmful effect on soils and consequently on the crops grown in them. In the first place, the substance has an unpleasant odour which may be transmitted especially to root crops grown in soils which have recently been treated. However, odour-free miscible oils and solutions containing benzene hexachloride are now being developed and there is some hope that the unpleasant odour will eventually be eliminated from other benzene hexachloride preparations.

Although only relatively few plants have been reported to be adversely affected, even by fairly large applications of benzene hexachloride, there is some danger of leaving harmful residues in the soil if large quantities are used. However, the amount which would be necessary to control outbreaks of *Zonocerus* is so small that concentrations high enough to be harmful are not likely to occur.

There is little danger to man or domestic animals, although benzene hexachloride has been reported to have caused headaches and irritation to the skin and eyes of some people who have been exposed to it in the dust form.

A recent paper by Petty[1] summarises the information on this and a number of other recently developed insecticides.

Practical Applications.

In rough field trials, Gammexane dust "O" and DDT dust were applied to small swarms of *Zonocerus*. The swarms dusted with Gammexane disappeared completely while those treated with DDT appeared to be little affected.

Gammexane dust, both in laboratory and field tests, was consistently the best of the materials used. It can be applied very satisfactorily by means of a relatively inexpensive duster of the bellows type, such as is supplied by the S.A. Fumigation Co. (Pty.) Ltd. One or two puffs of dust applied to each cluster of newly-emerged hoppers will be sufficient to kill practically all of them. It is suggested that inspection should be carried out at weekly intervals from about the end of September until the end of October or the first few weeks in November. Any clusters of young hoppers could then be treated with Gammexane dust and destroyed.

Summary.

Experiments are described in which a number of insecticides, including both stomach and contact poisons, were tested in the laboratory against the Elegant Grasshopper, *Zonocerus elegans* Thnb. Gammexane dust was found to be the most effective of the materials tested.

REFERENCES.

[1] Petty, B. K. (1947): Some Properties of New Insecticides. Fmg. in S.A., **22,** No. 260, 889.

[2] van der Merwe, C. P., and Kent, C. C. (1925): The Elegant Grasshopper (*Zonocerus elegans* Thunb.). J. Dept. Agric. Union of S. Africa, **10,** No. 1, 29.

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The President said that this paper was an excellent example of how controlled experiments could give useful information.

Dr. Dodds thought that the paper supplied further evidence of the powerful nature of some of the new insecticides, in this case, Gammexane. It would appear that in low concentrations the insecticide "M" was a rather remarkable life preserver, although Dr. Dick assured us that there was no significant difference between it and the controls. It was, even in more concentrated application, still far behind the more modern insecticides.

Dr. Dick replied that the point raised was interesting. It was perhaps possible that the insecticide "M", being also a disinfectant, had had a beneficial action as it could attack fungus diseases.

Mr. Dymond queried whether the new insecticides might not have a lasting, or at any rate a temporary, harmful effect on the soil micro-flora or bacteria.

Dr. Dick referred Mr. Dymond to a paper by Petty in "Farming in South Africa" in which the effect of Gammexane on various forms of life was summarised. He did not think it could persist for long in soil.

Dr. Dodds stated that being organic chemicals one would not expect these new insecticides to persist in the soil like arsenic. Some people had thought that mercury compounds, such as are used as seed disinfectants, might be harmful to the soil. Dr. Bourne had shown however, that there was no reason for alarm as far as mercury compounds, such as the product known as Aretan was concerned, as mercury is eventually firmly fixed by the sulphur in soil.