Time Response Experiments with Single Dose and Chronic Treatment of Dieldrin on *Tribolium castaneum*

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Summary

After a single spray of dieldrin at different concentrations, insects die over a period of about 5 weeks, mostly in the first 3 weeks. The concentration of dieldrin in the insects decreases before the decline in mortality. After chronic poisoning some of the population tolerated the poison (at various concentration levels) and stayed alive. This final stage was reached after several weeks. For comparison, tests were also conducted with lindane, parathion and dichlofenthion. All produced an initial increase in mortality but subsequently the proportion of dead insects remained fairly constant up to 7 weeks.

Introduction

Soil insecticides may act as contact poisons, fumigants, and/or stomach poisons if consumed with roots. The activity of small doses of a persistent insecticide by contact is considered in this paper.

The insecticide chosen was dieldrin, main persistent metabolite of the soil insecticide aldrin.

Tribolium was used as a test insect because it cannot climb the glasswalls of petri dishes and therefore the contact action of pesticides can be studied in open dishes to minimize the influence of vapor. The animals were fed only in the week-end in clean dishes, to avoid contamination of the food.

If soil insects are placed in open dishes they die through drying and starvation. They need soil or moist sand to live in, and the amount of contact with this is different to measure, so the effect of insecticides on animals reared in this medium is a combined effect of contact, fumigant and stomach poison.

Dieldrin can have a long-lasting effect on the mortality of insects, as was found by Rehm, Garms and Weyer (5). When Anopheles larvae were given an LD50 dose of dieldrin, subsequent mortality was observed in pupae and imagines which had survived the larval dose. Moriarty (4) also found prolonged effects and Tamashiro and Sherman (6) showed that there was a latent toxicity for various chlorinated hydrocarbons. Watts (7) showed that topical application of dieldrin to adult locusts killed eggs and first instar, with dieldrin still present in the offspring.

The experiments described in this paper were designed to answer the following questions.

I. What is the effect of a single dose of different amounts

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acting by contact on a sample of a population in relation to time?

II. What is the effect of a chronic dosage of the insecticide by contact at different dosage levels on the same insect species in relation to time?

Material and Methods

Populations of Tribolium castaneum Hbst were reared at room temperature of about 20°C. The experiments were carried out at the same temperature. For the investigation of each concentration of insecticide, samples of 125 individuals were taken and divided between five petri dishes with internal dimensions of 1.7 X 9 cm. The insects were of mixed ages and both sexes but each experimental series was taken from the same population (Loosjes, 3). The controls were sprayed with a spraying fluid containing Shell wetting agent 1000 ppm in water. After spraying the insects were transferred to clean petri dishes with food. Counts of dead beetles were made twice a week. The results of the different concentrations of the spraying fluid were then compared.

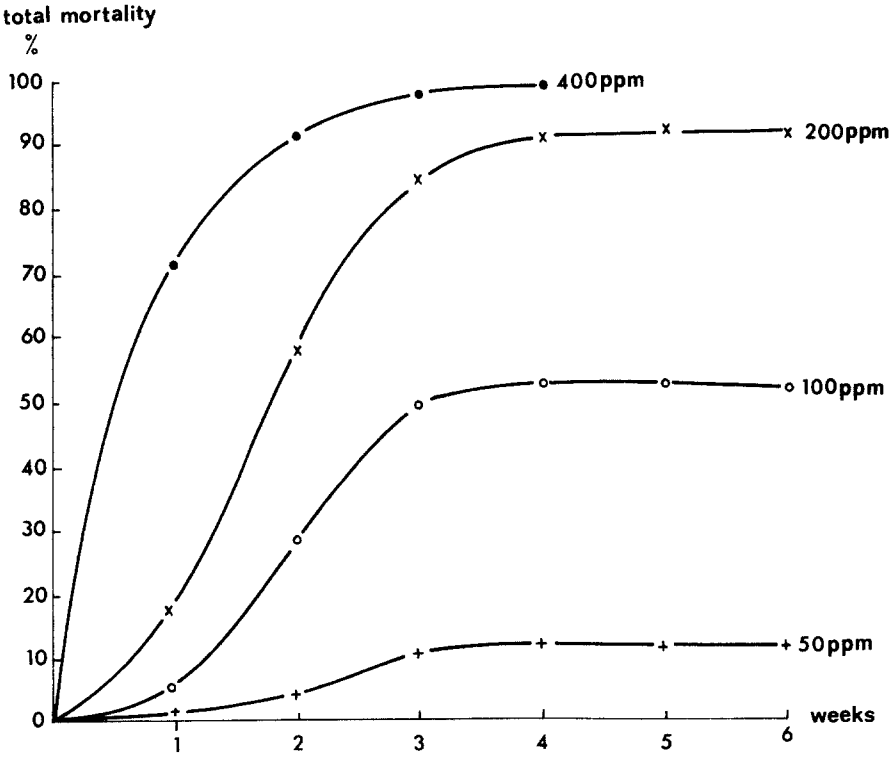

Fig. 1. Tribolium. Effect of a single dose of dieldrin sprayed on the insects. Concentration of dieldrin in the spraying fluid as the measure.

Chronic application was carried out by means of petri dishes with a poisoned layer on bottom and sides. One ml of a

solution of dieldrin in acetone was pipetted into a petri dish and whirled on a rotor for 10 min. (Loosjes, 2). The acetone evaporated and the insecticide adhered to the bottom and the wall of the dish. The petri dishes were renewed each day for a period of 5 days during which time no food was provided. The insects were put into clean dishes with food for 2 days and the same procedure was repeated until the experiment was terminated. The controls received the same treatment but with no insecticide in the acetone. Different concentrations of insecticide were compared.

In the single-dose test the natural mortality in the controls was so low that hardly any correction was necessary. Corrections in other tests were made with Abbott's formula (1). The dieldrin experiments were repeated to see whether the same trend was observed.

Results of Experiments

A. Single-dose experiments. Experiments were made with various concentrations of dieldrin in the spraying fluid. When mortality is plotted against time, S-shaped curves are obtained, which show that considerable time elapses before mortality diminishes. Many insects died regularly during the first three weeks, fewer for thennext 2 weeks and after 5 weeks hardly any (Fig. 1).

The experiment was repeated and the same trend was observed, showing that a single spray of dieldrin on a Tribolium population has a response which extends over several weeks.

From the 50 ppm series the amount of dieldrin in the insects was analyzed by gas chromatography at time intervals of a week (Fig. 2).

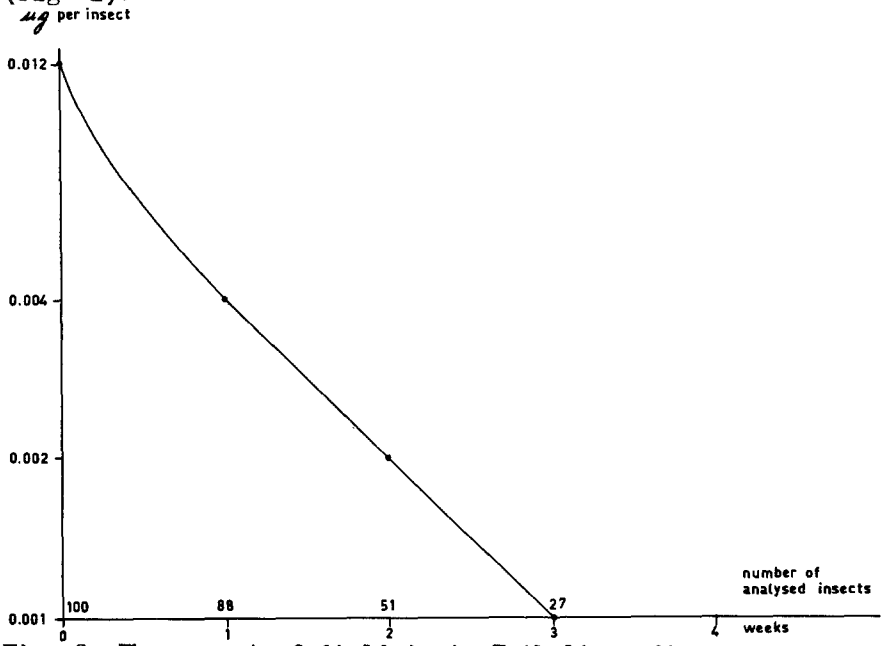

Fig. 2. The amount of dieldrin in Tribolium after a single spray of 50 ppm of dieldrin.

This showed that the dieldrin disappeared rapidly, and the mortality may partly be due to lesions caused by the dieldrin at the beginning of the experiment.

B. Continuous (Chronic) dosage at various levels. At concentrations 10 and 100 ppm all insects were killed in a relatively short time. At concentrations between 1 and 0.1 ppm mortality decreased from 100 % to practically nil. The final level was reached after a period of approximately 5-6 weeks.

Experiments were carried out with 0., 0.2, 0.4, 0.8, 1, 10 and 100 ppm of dieldrin in the acetone. The final mortality levels were: 8 % for 0.2 ppm, 18 % for 0.4 ppm and 61 % for 0.8 ppm (Fig. 3).

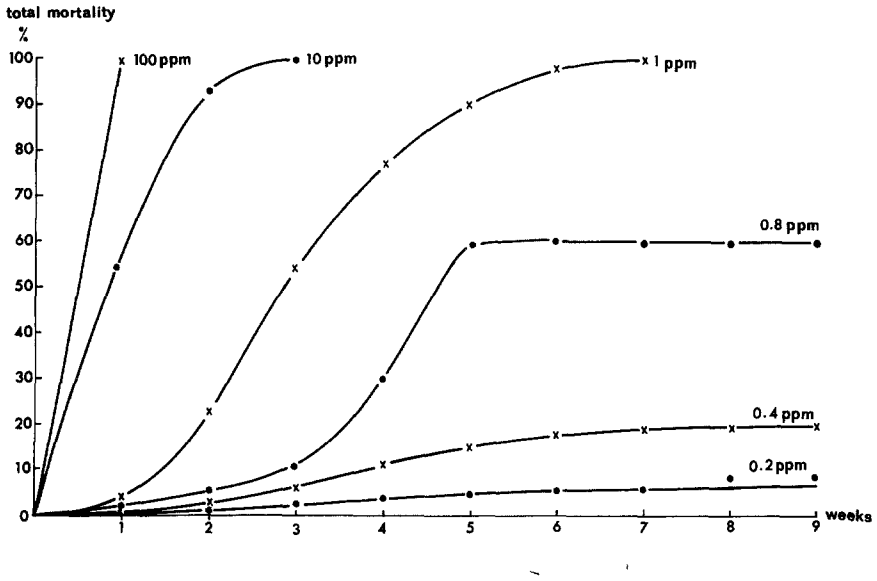

Fig. 3. Chronic poisoning of Tribolium. Concentration of dieldrin in the acetone as the measure (see text).

This experiment was repeated and the same trend was observed. For comparison, similar experiments were carried out with lindane as a single spray at 20 ppm and a chronic application at 0.2 ppm and 0.1 ppm (Fig.4) also a chronic application of parathion at various levels (Fig. 5) and of dichlofenthion (Fig. 6). An interesting result was that of various levels of dichlofenthion where a large variation in sensitivity of the population in relation to this compound appeared.

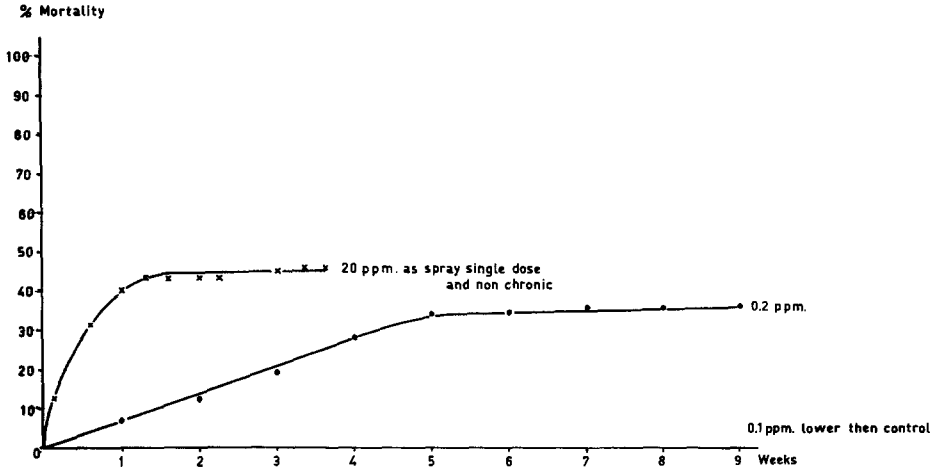

Fig. 4. Single dose and chronic application of lindane to Tribolium.

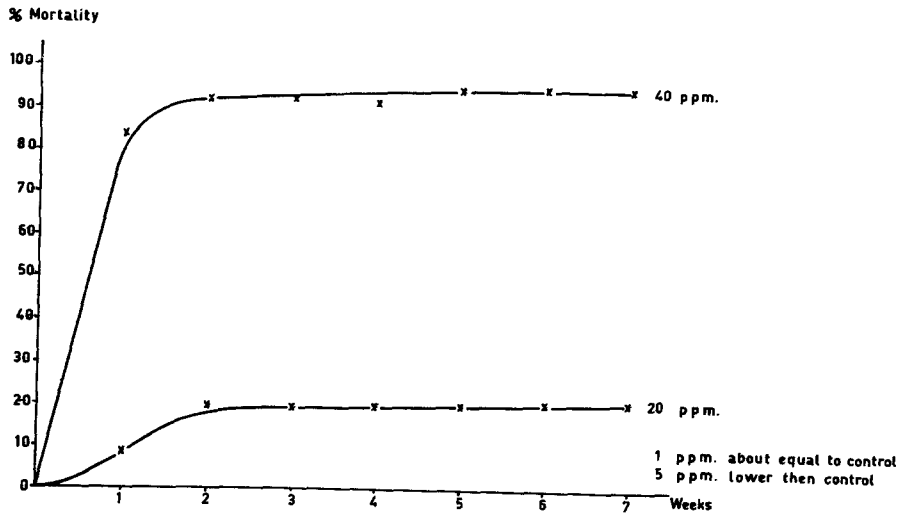

Fig. 5. Chronic application of parathion to Tribolium.

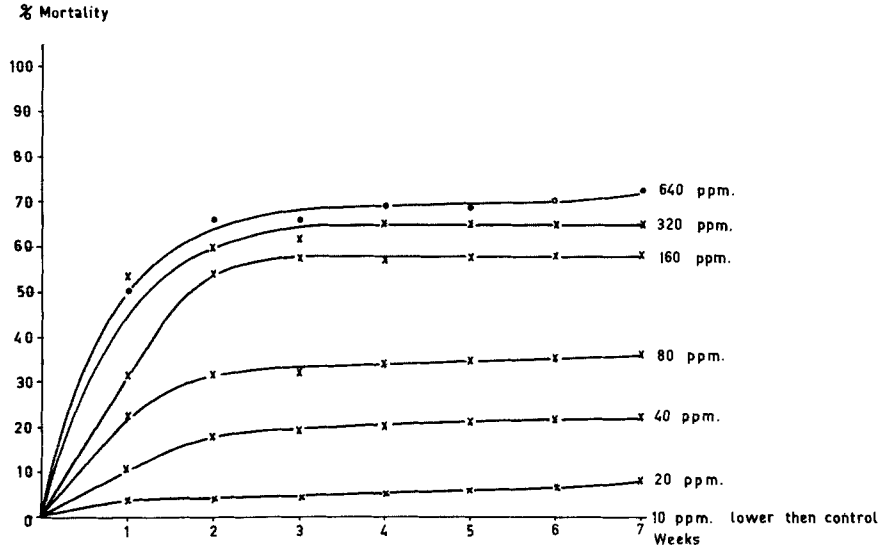

Fig. 6. Dichlofenthion: Chronic dose. A large variation in sensitivity for this compound appears to be present in a Tribolium population.

Conclusions

A single dose of dieldrin produced an effect for several weeks on a Tribolium population. Chronic poisoning at low levels leads to a condition where the physiological mechanisms of certain individuals in the population can cope with the daily intake. The more concentrated the poison the smaller the proportion of the population that is able to survive. This was also observed for the other active substances used in these experiments.

If this is also true for other insect species, it can be supposed that there are residual concentrations which by contact, do not give a 100% kill in the long run. An equilibrium between uptake and detoxification and/or excretion is perhaps established. Whether a small or a large proportion of the population will be able to cope with the environmental change depends on the susceptibility of the insects species and on the amount of pesticide.

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References

1. ABBOTT, W.S., J. econ. Ent., 18, 265-267 (1925).
2. LOOSJES, F.E., Meded. Landbouwhogeschool Gent 17, 88-93 (1952).
3. LOOSJES, F.E., Jaarboek P.D. 211-212. Versl. Meded. Plantenziektenkundige Dienst, Wageningen, 120 (1952).
4. MORIARTY, F., Ann. appl. Biol. 62, 371-393 (1968).
5. REHM, W.F., GARMS, R. and WEYER, F., Tropenmedizin Parasitologie 9, 200-204 (1958).
6. TAMASHIRO, M. and SHERMAN, M., J. econ. Ent. 48, 75 (1955).
7. WATTS, W.S., Nature, Lond. 221, 762-763 (1969).