# Grasshopper Control With Chemical Sprays and Dusts

OKLAHOMA AGRICULTURAL EXPERIMENT STATION
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# In Brief

Poisoned bait, used for many years, has often given erratic control of grasshoppers, particularly in alfalfa. During the past few years, many new chemicals have been developed, some of which are very poisonous to grasshoppers. These have been studied continuously to determine conditions and methods for applying them with greatest efficiency. Results of tests reported in this bulletin are summarized briefly as follows:

DDT is not a satisfactory grasshopper poison using quantities which would be practical and economical in Oklahoma.

Insecticides which gave most effective control as sprays are chlordane, 1.0 to 1.5 pounds per acre; toxaphene, 1.5 to 2.0 pounds per acre; and parathion, 0.2 to 0.3 pound per acre of the actual insecticidal material. Most effective control is obtained by spraying these on succulent plants during May when the nymphs have nearly all hatched and are feeding. As the season progresses, costs increase and control decreases.

Benzene hexachloride is most satisfactory when applied as a dust at the rate of 0.5 to 0.6 pound of the gamma isomer per acre. Compared with other materials, it is especially useful later in the season when temperatures are high and most grasshoppers have reached the adult stage.

High temperature, increased speed, and percent kill of the insecticides tested, with the exception of DDT, for which this was reversed.

Plants sprayed or dusted with these insecticides remained poisonous to grasshoppers feeding on them as follows: parathion about two days, toxaphene and gamma benzene hexachloride less than one week, chlordane and aldrin between one and two weeks, and dieldrin between two and three weeks. Grasshoppers may be found dying in fields after poisonous residues have disappeared, due to slowness of kill.

Aldrin and dieldrin show much promise as grasshopper insecticides but, together with parathion, are not yet recommended for practical use because of their extreme toxicity to warm-blooded animals.

All of the materials tested acted both as stomach and contact poisons.

**Precautions:**

Care should be taken to prevent livestock from feeding on plants that have been treated with any of these chemicals. The operator applying them should avoid contact with them to as great an extent as possible. The use of masks and gloves is cheap insurance. It is also advisable to bathe and change clothing, particularly after using materials which are known to be highly poisonous to warm-blooded animals. If possible, plants should be treated before or after their blooming period in order to reduce the killing of bees.

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**ON THE COVER:** A close-up of the head of a differential grasshopper enlarged six times. This is one of the most destructive species in Oklahoma. (Picture by G. A. Bieberdorf of the Oklahoma Agricultural Experiment Station).

# Grasshopper Control
# With Chemical Sprays and Dusts

By

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During the past few years new chemicals have been synthesized which are very toxic to those species of grasshoppers which damage crops. Tests of these new chemicals under Oklahoma conditions were begun by the Experiment Station in 1946.

This bulletin reports results obtained in both laboratory and field experiments during the years 1946 to 1949 inclusively. The tests were made on three of Oklahoma's most destructive species: the differential, two-striped and migratory grasshoppers.

All of the poisons tested except DDT gave excellent control, however, it was evident that any of the insecticides under certain conditions might give very poor kills. One of the purposes of these experiments was to determine to some extent the conditions which affect control. All of the materials have certain advantages and disadvantages which must be considered in determining which one to recommend.

## Where and When to Apply Sprays and Dusts

The economic species of grasshoppers discussed in this bulletin overwinter in the egg stage. Clusters of eggs or pods are placed in the soil, mostly in grassy or weedy fence rows and roadsides, creek beds, banks of ditches, pastures, and the margins of fields. In spring, the migratory grasshoppers are first to hatch and the differential grasshoppers are last. Hatching usually takes place from the middle of April to the middle of May. Unusually warm seasons cause early hatching and cold wet seasons retard it. Generally, hatching is complete by the middle of May, so this period becomes the most important time to apply insecticides. The effectiveness of control is gradually lost as the grasshoppers grow and distribute themselves over wider areas. By the last of June, some of them will be reaching the adult stage. These have wings and may fly great distances, complicating control considerably since many acres may become infested and adults are not so easily killed as nymphs.

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The marginal hatching areas just described should be closely watched. If they are poisoned at the right time, less material and labor will be required, kills will be greater and crops better protected. Figure 1 shows characteristic marginal damage in an alfalfa field. Migratory grasshopper nymphs hatched in the fence row and roadside. A concentration of these nymphs at the margin resulted in almost complete destruction of plants as they progressed into the field. A spray or dust used at this time would give high returns.

## Precautions

Treat any insecticide as a poison. Avoid inhaling dusts or sprays. A mask may be somewhat uncomfortable, but it is always a good investment. If material gets on clothes, these should not be worn again until they are washed. Bathe after handling insecticides—this is particularly important with parathion, aldrin and dieldrin.

Do not apply these materials to plants which will be eaten by man or livestock. If alfalfa is harvested and the stubble treated, the next crop should be safe. Margins, fence rows, etc., which are not grazed should be sprayed to kill nymphs.

## Chemicals Tested

**DDT.**—First of the new compounds available was DDT. It was not used extensively in experiments on grasshoppers because it was found very early to be rather ineffective.

**Benzene hexachloride (BHC).**—During the war the British developed their compound "British 666" for controlling insects, particularly flea beetles. This chemical gave excellent results in Oklahoma in 1946 when it was used as a dust in the field. It is now called benzene hexachloride or BHC. Since the gamma part of the compound is the toxic agent, it is the amount of this fraction we are interested in when considering formulations for grasshopper poisons.

**Chlordane.**—A third chemical to appear with promise was chlordane. In its concentrated form, it is a thick viscous substance. Although not soluble in water, it lends itself well to the preparation of wettable powders and oil emulsions which will mix with water.

**Toxaphene.**—Shortly after chlordane was developed, another compound called chlorinated camphene was prepared. This chemical, as an insecticide, is now known as toxaphene. It has been manufactured quite economically. Its low price and availablity have given it some advantage.

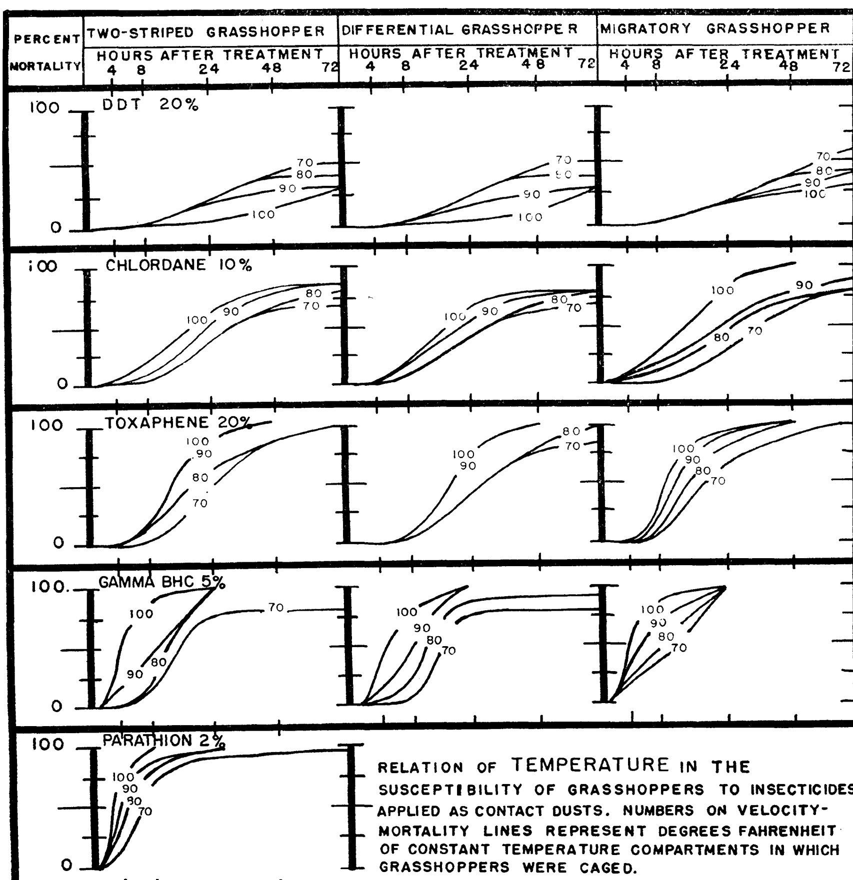
**Parathion.**—Parathion was developed in Germany during the war but was not tested extensively on grasshoppers in the United States until 1947. It was found to be very effective and is comparatively inexpensive, **but** its great toxicity to man and animals makes it hazardous to use.

Fig. 1.—Marginal damage in alfalfa caused by second generation nymphs of the lesser migratory grasshopper. Such an infestation could be destroyed quickly by timely spraying or dusting of the roadside and fence row.

**Aldrin and Dieldrin.**—Two compounds called aldrin and dieldrin appeared during 1949. Excellent results were obtained with them in tests in the summer of that year. These are also very poisonous to warm-blooded animals and would be hazardous to use.

## Relation of Temperature to Control

Results obtained by applying any insecticide in the field may vary in accordance with certain natural factors which exist at the time. One of the most important of these is temperature. Some measurement of the effect of this factor was made by dusting grasshoppers with the different materials and placing them in constant temperature compartments for ob-




RELATION OF TEMPERATURE IN THE SUSCEPTIBILITY OF GRASSHOPPERS TO INSECTICIDES APPLIED AS CONTACT DUSTS. NUMBERS ON VELOCITY-MORTALITY LINES REPRESENT DEGREES FAHRENHEIT OF CONSTANT TEMPERATURE COMPARTMENTS IN WHICH GRASSHOPPERS WERE CAGED.

Fig. 2

servation.* Results of this experiment are shown in Figure 2. It is evident that an increase in temperature increased the rate of kill and often the percent of kill. DDT was the exception; this insecticide increased rate and percentage of mortality with a decrease in temperatures.

Poor grasshopper control has often resulted from the use of bran bait poisons when temperatures were high. The insects go upward on plants in order to escape soil temperatures; and by the time they return to the ground, bait is often dry and unpalatable to them. The use of chemical sprays and dusts reduces the effect of this situation and high temperature may favor a larger kill.

## Residual Characteristics of the Different Insecticides

When plants in a field have been sprayed or dusted, how long will they remain toxic to grasshoppers? An attempt was made to answer this question by treating alfalfa in the field and feeding the treated plants to caged individuals. Results of this experiment are shown in Figure 3 (sprays) and Figure 4 (dusts).

Food was made available to the caged grasshoppers at different time intervals. For example, one hour after a plot was sprayed, the treated plants would be made available to grasshoppers in two different cages. Fresh plants would be supplied to these individuals daily from the same plot, with no other food available to them. Daily records were kept on mortality for three weeks. In order to measure residual toxicity of the insecticide in this treated plot, two more cages of grasshoppers would start feeding on the plants 24 hours after the spray was applied. Two more cages were started 48 hours later, etc., all cages being checked in the same manner as the first ones described.

This procedure was run through twice during a season for two years. Grasshoppers used were late instar nymphs of the differential grasshopper or adult migratory grasshoppers. Insecticides were applied at rates which are generally recommended for good control in the field.

It can be seen on the graphs (Figures 3 and 4) that all materials except gamma BHC killed faster and gave higher percentages of mortality when applied as sprays rather than dusts. The GBHC showed little difference between these two methods of application. Of the insecticides tested, all showed considerable toxicity. GBHC was the least toxic, but it is important to note that poisoning in this experiment would occur almost entirely as the result of feeding on treated plants, a stomach poison effect. Very little contact poisoning would be expected. This indicates that GBHC kills to a great extent by contact and fumigation.

Parathion remained for the shortest period of time as an effective toxic residue. After 24 hours, little or no poisoning resulted to grasshoppers feeding on the treated alfalfa.

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* Rhoades, W. C. and C. H. Brett, *The Relation of Temperature in the Susceptibility of Grasshoppers to Synthetic Insecticide Dusts.* Jour. Kans. Ent. Soc. 21 (2): 66-70. April, 1948.

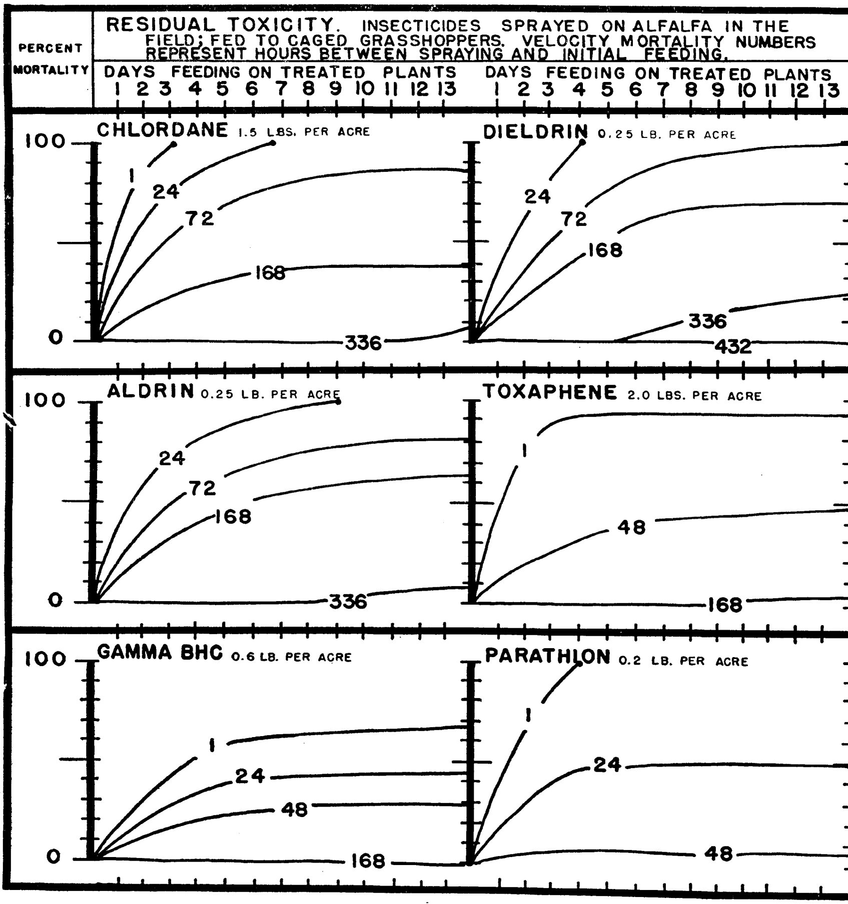


Fig. 3

Toxaphene had lost most of its residual effectiveness after 48 hours. At the end of 168 hours, there was only slight evidence of any toxicity.

Chlordane and aldrin in the amounts used were similar in their residual-toxic characteristics. These materials apparently remained at a toxic level for nearly 336 hours (two weeks), tapering gradually to a nearly complete loss of effect at the end of this time.

Dieldrin was somewhat superior to the other materials as a residual poison. Definite effects of poisoning were evidenced by grasshoppers which started feeding on plants when the dieldrin application was two weeks old. By the end of three weeks, however, no remaining poison could be detected by means of the feeding test.

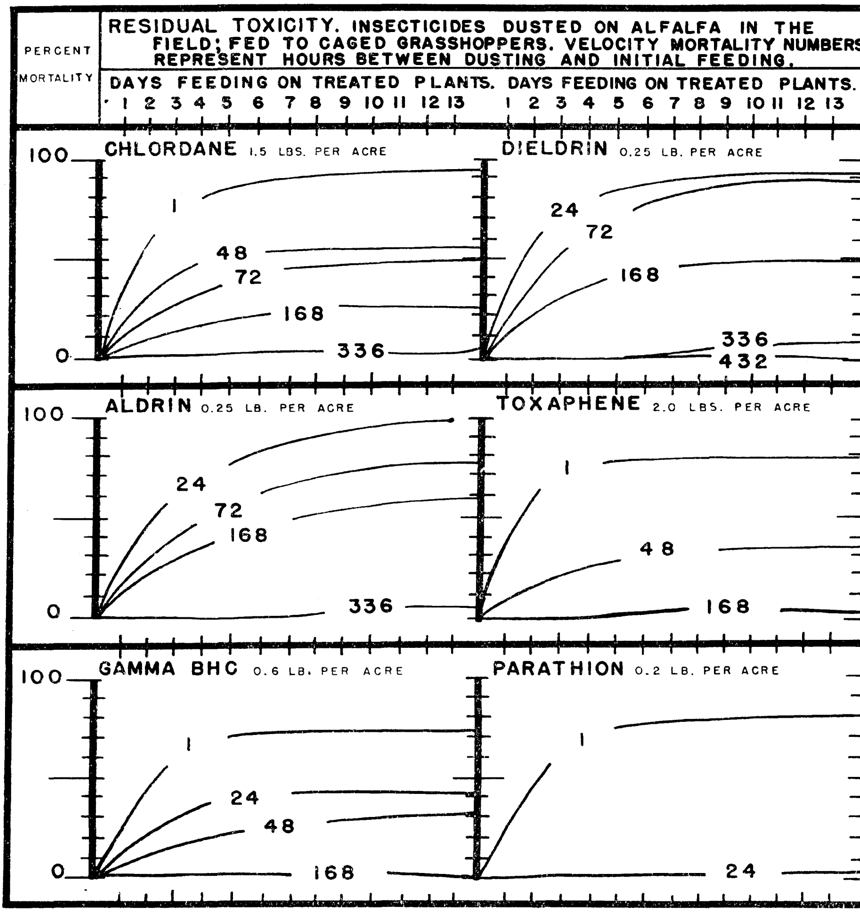


Fig. 4

These differences in durability of residues are perhaps due to chemical stability of the insecticides. Any loss by evaporation, chemical breakdown, or failure of the substance to remain attached to plant surface, would reduce its effectiveness Dilution due to plant growth is, of course, an important factor affecting the concentration of a material at any given time.

## Contact Effect of Different Insecticides

An important part of the kill obtained with synthetic insecticides in field application results from contact. Laboratory studies were made of this effect by placing grasshoppers in two-quart fruit jars. A 50 milligram puff of dust was admitted per jar. After five minutes, the insects were transferred to cages and supplied with fresh, untreated alfalfa. Results of such tests appear in Figure 5, Adult **Melanoplus differentialis** grasshoppers used in this experiment were collected during the early part of the breeding season. These individuals were very vigorous and about as resistant to toxins as any population of economic grasshoppers. Untreated individuals lived in cages for weeks without mortality.

Contact kills are shown in both Figures 2 and 5. Graph lines in Figure 5 indicate the effect of dilution starting with concentrations which are generally used in field application. By comparing the upper and lower ends of these lines and considering the concentrations used, it appears that dieldrin is more toxic than any of the other materials. High mortality was obtained even with a dust of 0.015 percent Aldrin was somewhat less toxic than dieldrin; good kills resulted with the 0.015 percent dust, but more time was required. Gamma BHC was about equal to these materials with a concentration of 0.37 to 0.75 percent. Chlordane was about equal at a concentration of 0.8 percent. Toxaphene was least poisonous, equalling the other insecticides at the level of about a 5.0 percent concentration.

## Relation of Plant Condition to Effective Control

Another important factor involved in the success of grasshopper control is the type of vegetation. If an insecticide remains as a residue and acts to a great extent as a stomach poison, it should be more effective against infestations on succulent plants than against those on dry plants with less foliage.

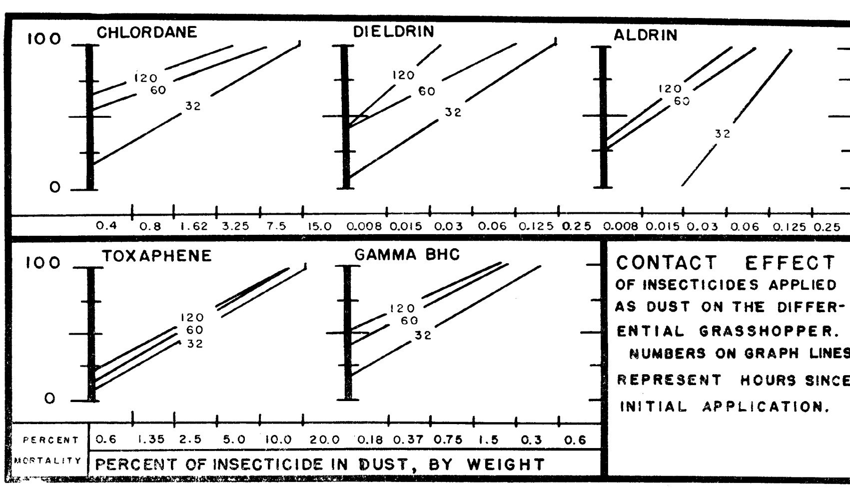


Fig. 5

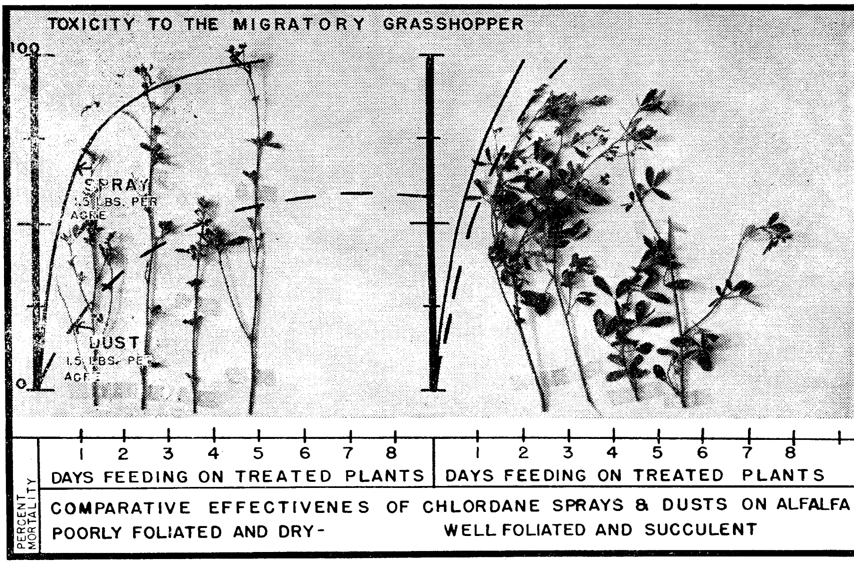


**Fig. 6**

Figure 6 shows results of a field-laboratory test designed to measure the vegetative factor to some extent. Plots of dry and poorly foliated plants were dusted and sprayed with chlordane at the rate of 1.5 pounds per acre. In the same manner, well foliated and succulent plants were treated. These plots served as the source of food for caged grasshoppers. Velocity mortality curves show effectiveness of the treatment dropped considerably where the poor vegetation was used, especially when the insecticide was applied as a dust.

## Comparative Effectiveness of Different Insecticides Applied as Sprays and Dusts in the Field

Table 1 shows results of three years' testing of different insecticides in the field using sprays and dusts applied with power equipment. Some of these data can be explained on the basis of information gained by the field-laboratory tests just described. For example, it can be noted that benzene hexachloride and parathion dusts applied at low temperatures (50°F.-60°F.) were slower acting and less effective than when applied at higher temperatures. It is also evident that chlordane dusts applied to dry, defoliated alfalfa plants were much less effective than on those well foliated and succulent.

Velocity mortality in the field is comparable to laboratory results. Parathion killed most rapidly, attaining maximum between 8 to 24 hours. Gamma BHC attained a maximum by the end of 24 hours and chlordane and toxaphene by the end of 48 hours.

Rate of application necessary to obtain good control in the field with the greatest economy can be estimated fairly well by comparing graphs showing field laboratory tests with results in the field (Table 1). Thus, it appears that 0.5 to 0.6 pound of actual gamma BHC per acre is an adequate concentration, providing conditions are favorable to the action of this material. As a stomach poison, sprays were no better than dusts. As a contact poison, dusts were very effective especially when temperatures were high. This indicates an advantage in using GBHC as a dust, particularly during a period when plants are in poor condition and the weather is hot. Parathion applied at 0.2 to 0.3 pound per acre gave much the same effect except that it was faster in its action, and dusts showed little if any advantage over sprays. Little residual effect was obtained using these materials.

Chlordane sprays showed a distinct advantage over dusts. This material left an effective residue for about one week and was an excellent stomach poison. All tests indicate that from 1.0 to 1.5 pounds of actual toxicant per acre would give good results providing conditions are favorable. Succulent vegetation upon which grasshoppers are feeding is of considerable importance. Excellent control during the early season was obtained where migratory grasshopper nymphs were feeding on the remaining leaves of alfalfa stubble. Toxaphene applied at the rate of 1.5 to 2.0 pounds per acre gave results comparable to those for chlordane. Both of these materials are slower in their action than parathion or gamma BHC, and both of them function best when used as sprays rather than dusts.

*TABLE I.—Mortality of Grasshoppers Following Insecticide Applications in the Field.**

| Treatment | No. Acres Treated | Lbs. Actual Insecti-cide per acre | Predominant Insects** | Temperature (F) Range during first 8 hours | Vegetative Habitat | Hours After Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 8 | 24 | 48 | 168 |
| Gamma BHC Dust | 2.5 | 0.2 | Mex. Adults<br>Diff. Nymphs | 80°-95° | Dry, defoliated alfalfa | 0.0 | 1.0 | 22.0 | ---- | ---- |
| | 1.0 | 0.33 | Mex. Nymphs | ------- | Native pasture | ---- | ---- | 91.9 | 94.6 | 89.2 |
| | 2.5 | 0.4 | Mex. Adults<br>Diff. Nymphs | 80°-95° | Dry, defoliated alfalfa | ---- | 13.5 | 33.0 | ---- | ---- |
| | 1.0 | 0.42 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 75.0 | 93.3 | 60.8 |
| | 0.5 | 0.5 | Mex. Nymphs<br>Diff. Nymphs | 80°-95° | Alfalfa, small, poor condition | ---- | 90.0 | 100.0 | ---- | ---- |
| | 1.0 | 0.5 | Biv. Nymphs<br>Mex. Adults | 50°-60° | Weedy, irrigation ditch | 10.0 | 72.8 | 75.5 | ---- | 75.0 |
| | 2.0 | 0.5 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 66.0 | 69.0 | 92.0 | ---- | 92.5 |
| | 2.5 | 0.6 | Mex. Adults<br>Diff. Nymphs | 80°-90° | Alfalfa, dry, defoliated | ---- | 30.0 | 57.0 | ---- | ---- |
| | 2.5 | 0.8 | Mex. Adults<br>Diff. Nymphs | 80°-90° | Alfalfa, dry, defoliated | ---- | 64.0 | 84.0 | ---- | ---- |
| | 1.0 | 5.0 | Biv. Nymphs | 50°-60° | Weedy, irrigation ditch | 5.3 | 98.0 | 100.0 | ---- | ---- |
| Gamma BHC Spray | 1.0 | 0.24 | Mex. Nymphs<br>Diff. Adults | ------- | Vetch, good condition | ---- | ---- | 80.7 | 79.3 | 55.3 |
| | 1.5 | 0.5 | Mex. Nymphs | 70°-79° | Alfalfa stubble | -- | ---- | 95.3 | 97.3 | 100.0 |

TABLE I. (Continued)

| Treatment | No. Acres Treated | Lbs. Actual Insecti-cide per acre | Predominant Insects** | Temperature (F) Range during first 8 hours | Vegetative Habitat | Hours After Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 8 | 24 | 48 | 168 |
| Parathion Dust | 2.0 | 0.1 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 38.0 | 63.0 | 80.0 | ---- | 85.0 |
| | 1.0 | 0.2 | Mex. Adults<br>Biv. Nymphs | 50°-60° | Weedy, irrigation ditch | 0.0 | 11.2 | 8.0 | ---- | 10.0 |
| | 2.0 | 0.2 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 79.0 | 95.0 | 97.0 | ---- | 92.0 |
| | 1.0 | 0.16 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 72.7 | 72.7 | 51.8 |
| | 1.0 | 0.14 | Mex. Nymphs | ------- | Native pasture | ---- | ---- | 75.8 | 78.8 | 78.8 |
| | 1.0 | 0.4 | Mex. Adults<br>Biv. Nymphs | 50°-60° | Weedy, irrigation ditch | 63.6 | 92.0 | 91.0 | ---- | 95.0 |
| Parathion Spray | 1.0 | 0.08 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 65.3 | 68.0 | 66.7 |
| | 1.5 | 0.2 | Mex. Nymphs | 70°-79° | Native pasture | ---- | ---- | 100.0 | 97.5 | 99.2 |
| Chlordane Dust | 2.5 | 0.5 | Mex. Adults<br>Diff. Nymphs | 80°-95° | Alfalfa, dry, defoliated | ---- | 0.0 | 1.3 | ---- | ---- |
| | 2.0 | 0.5 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 0.0 | 14.0 | 33.0 | ---- | 60.0 |
| | 1.0 | 0.6 | Mex. Nymphs | ------- | Native pasture | ---- | ---- | 77.2 | 80.0 | 65.7 |
| | 1.0 | 0.8 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 87.2 | 75.0 | 65.7 |
| | 2.5 | 1.0 | Mex. Adults<br>Diff. Nymphs | 80°-95° | Alfalfa, dry, defoliated | -- | 0.0 | 7.0 | ---- | ---- |

TABLE I. (Continued)

| Treatment | No. Acres Treated | Lbs. Actual Insecticide per acre | Predominant Insects** | Temperature (F) Range during first 8 hours | Vegetative Habitat | Hours After Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4 | 8 | 24 | 48 | 168 |
| Chlordane Spray | 1.0 | 0.52 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 78.6 | 75.0 | 64.3 |
| | 1.5 | 1.4 | Mex. Nymphs | 70°-79° | Alfalfa stubble | ---- | ---- | 98.5 | 99.3 | 100.0 |
| Toxaphene Dust | 2.0 | 1.0 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 0.0 | 21.0 | 29.0 | ---- | 55.0 |
| | 2.0 | 2.0 | Mex. Adults<br>Diff. Nymphs | 83°-92° | Alfalfa, tall, good condition | 0.0 | 26.0 | 32.0 | ---- | 55.0 |
| | 1.0 | 4.0 | Mex. Adults<br>Biv. Nymphs | 50°-60° | Weedy, irrigation ditch | 0.0 | 39.0 | 34.5 | ---- | 85.0 |
| | 1.0 | 8.0 | Mex. Adults<br>Biv. Nymphs | 50°-60° | Weedy, irrigation ditch | 0.0 | 32.1 | 22.1 | ---- | 90.0 |
| | 1.0 | 1.28 | Mex. Nymphs<br>Diff. Nymphs | ------- | Vetch, good condition | ---- | ---- | 79.2 | 87.5 | 65.0 |
| | 1.0 | 0.9 | Mex. Nymphs | ------- | Native pasture | ---- | ---- | 88.6 | 90.9 | 90.9 |
| Toxaphene Spray | 1.0 | 0.76 | Mex. Nymphs<br>Diff. Nymphs | | Vetch, good condition | ---- | ---- | 74.7 | 88.0 | 78.0 |
| | 1.5 | 1.6 | Mex. Nymphs | 70°-79° | Alfalfa stubble | ---- | ---- | 78.9 | 100.0 | 99.3 |

* This table shows a series of tests which were made during the years 1946 to 1948, inclusive.

** Mex.—the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus*.
Diff.—the differential grasshopper, *Melanoplus differentialis*.
Biv.—the two-striped grasshopper, *Melanoplus bivittatus*.