

United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant QuarantineTESTS WITH SPRAYS FOR CONTROLLING GRASSHOPPERS
ON FARM LANDS IN NORTH DAKOTA AND TEXAS, 1950-51^{1/}By R. L. Shotwell
Division of Cereal and Forage Insect Investigations

Farm-scale tests of aldrin sprays and a single chlordane spray for the control of grasshoppers were made in 1950 in Bottineau County, N. Dak., and of aldrin, dieldrin, and toxaphene sprays in 1951 on the Bluebonnet Farm at McGregor, Tex. Bottineau County is in the extreme north-central part of North Dakota and is over 1,200 miles, or 16 degrees latitude, north of McGregor, which is in McLennan County in central Texas. The difference in climate between the two localities is indicated from the following data which are averages of records taken over 39 or 40 years.

	<u>Bottineau, N. Dak.</u>	<u>Waco, Tex.</u>
Average temperature (° F.)		
January - - - - -	1.5	48.6
July - - - - -	67.7	85.7
Annual rainfall (inches) - - - -	15.81	34.90
Growing season (days)- - - - -	112	250

Small grains and flax are the principal crops raised in Bottineau County, and corn and cotton in central Texas where the Bluebonnet Farm is located. Melanoplus mexicanus (Sauss.) and bivittatus (Say) are the important grasshopper species in the former and differentialis (Thos.), in the latter locality.

Such a diversity of farming and climate offered an excellent opportunity for studying the effect of insecticide sprays on grasshoppers under widely different conditions.

^{1/} This work was done in cooperation with the Division of Grasshopper Control of this Bureau and the Texas Agricultural Experiment Station, A. and M. College System of Texas. In North Dakota valuable assistance was rendered by farmers, the county agent of Bottineau County, members of the Federal Soil Conservation Service at Bottineau, and one commercial plane operator.

MATERIALS AND METHODS

The sprays used in Texas were prepared from ready made concentrates containing 6 pounds of aldrin or toxaphene or 2 pounds of dieldrin per gallon. Those used in North Dakota were made from concentrates containing either 2 pounds of aldrin or 8 pounds of chlordane per gallon. All the concentrates, except the aldrin used in Texas, contained an emulsifier. They were diluted in oil or water to suit available spraying equipment.

The dosages used at first were those that have generally given the best results--namely, aldrin 2 ounces, dieldrin 1 ounce, chlordane 1 pound, and toxaphene 1 1/2 pounds per acre. Late in the season, when the vegetation is taller and much less succulent or when barriers against migrating grasshoppers are set up to last 10 days or more, 3 to 4 ounces of aldrin, 2 ounces of dieldrin, 2 to 3 pounds of toxaphene, and 1 1/2 to 2 pounds of chlordane per acre have been used for more effective control.

The emulsion sprays were applied with a mist blower on a truck, a side-delivery nozzle being used. When driven at 7 and 10 miles per hour, this machine applied the spray in a swath 2 rods wide at the respective rates of 7 and 6 gallons per acre. In Texas in 1951 the blower was equipped with a USDA broadcast nozzle to apply the oil spray at a truck speed of 7 miles per hour, and the rate of application was 1 1/4 gallons per acre.

Where ground sprayers were used, they were calibrated to give the required dosage on the basis of the average maximum speed the truck could travel over an infested area. At this speed the entire area received the required dosage with a minimum waste of the insecticide. However, at reduced speeds, there were temporary increases in the rate of application, so that the total quantity applied exceeded the calculated dosage.

In all the aerial spraying in North Dakota in 1950, oil sprays were used at the rate of 1 gallon per acre. When applied by plane the average dosage of the insecticide closely approximated that calculated.

Before an infestation was treated, estimates were made of the grasshopper population and damage. The species present and their stages of development were also noted. After treatment a check was made every day or two to determine the effects of the spray and the need for further treatment. At various times grasshoppers were collected to establish the current hatching period, in order to provide additional data on the seasonal history of the important species.

TESTS IN BOTTINEAU COUNTY, N. DAK.

A 4-section block of farm land and fields on 25 farms in Bottineau County were utilized for testing aldrin and chlordane in 1950. Two farms south across the line in McHenry County were also used. The

block of farm land was 4 miles east of Maxbass and was called the Maxbass spray area. A quarter section on one farm 3 miles west of Westhope, where some special work was done, was called the Westhope spray area. Maps of these areas are shown in figure 1.

Much of the farm land in the county is in large blocks of 40 to 160 acres. In some of the sandy areas strip cropping is practiced to prevent soil blowing. Besides small grains an extensive flax acreage was planted in 1950.

Strip farming spreads grasshopper infestations throughout the field, as the strips of grain stubble after harvest become the egg beds of future infestations. These strips lie over the winter as stubble and the following summer are worked whenever the weather or the farmer's convenience permits. When worked, they are cultivated with a one-way disk which leaves the stubble and trash on the surface and the grasshopper eggs in about the same depth in the soil. Instead of preventing the eggs from hatching, disking hastens the process by leaving the surface bare of vegetation and largely unshaded. Past observations have shown the temperature of unshaded soil at egg depth, 1 to 2 inches below the surface, to be 10° F. higher than that of the shaded soil and that all the eggs hatch in the former but not in the latter situation. Cultivation also speeds the subsequent movement of young grasshoppers into nearby crops by destroying their food plants in the fallowed pieces of land. The strips are usually 10 rods wide, and the cropped strip is accessible to infestation for its full length on both sides.

On the other hand, block farming reduces the infestation to field margins, if the weeds or other food plants are kept down on fields being fallowed. The length of the margin is 2 miles for a 160-acre field and 1 mile for a 40-acre field. For strip farming this length is 17 miles for a 160-acre field and 4 1/2 miles for a 40-acre field.

By June 1, 1950, all farming in this part of North Dakota was at least a month late, owing to an unusually cold, snowy spring. When the deep snowcap covering the county finally melted late in May, every quarter section had its pot hole, or wet spot, until late in June, if not all summer. Small grain and flax were not harvested until late in September and October.

Melanoplus mexicanus and bivittatus were late in their seasonal development. Hatching began on June 4 and ended on July 24. Furthermore, it was estimated that, on the basis of the number of grasshopper eggs deposited in the fall of 1949, two-thirds of the threat to crops was dissipated by the spring and summer weather of 1950.

The percentage composition of the grasshopper populations was as follows:

	<u>In crops</u>	<u>In pasture</u>
<u>Melanoplus mexicanus</u> (Sauss.)	48.5	53.5
<u>bivittatus</u> (Say)	36.6	6.7
<u>femur-rubrum</u> (Deg.)	9.1	4.6
<u>packardii</u> Scudd.	-	17.3
<u>dawsoni</u> (Scudd.)	-	1.5
<u>angustipennis</u> (Dodge)	-	1.5
Other species	5.8	-
<u>Chorthippus longicornis</u> (Latr.)	-	6.1
<u>Ageneotettix deorum</u> (Scudd.)	-	4.3
<u>Phoetaliotes nebrascensis</u> (Thos.)	-	1.8
<u>Spharagemon collare</u> (Scudd.)	-	1.8
<u>Camnula pellucida</u> (Scudd.)	-	.9

On the Maxbass and Westhope spray areas the objective was to eliminate all grasshopper infestations, whereas on the 27 separate farms the problem was to eliminate all the grasshoppers threatening a particular field crop. Flax was threatened on all but two of these farms.

Grasshoppers damage flax by defoliating it and cutting off the bolls as the seed matures. Since yields as high as 20 bushels per acre will gross up to \$60 per acre at the current price, flax is a high cash crop. In 1949 toxaphene as a spray had given variable and unsatisfactory results in flax in this area when applied at the rate of 1 1/2 pounds per acre. Consequently, a study was warranted to determine the value of aldrin sprays under similar conditions.

Results on the Maxbass Spray Area

The Maxbass spray area was in a sandy "blow-dirt" district having a long history of grasshopper damage. The crops were small grains, sorghums, corn, flax, and alfalfa. Part of the cropland was farmed in strips; the rest of the area was in hay, pasture, and weedy wasteland, as shown in figure 1. Fallow and planted strips are shown only where extensive spraying was done. The areas marked "cropland" needed no control. If the fallow strips had been worked at the time of spraying, the planted strips had to be sprayed. If not, the stubble and not the planted strips had to be treated.

Table 1 summarizes the results of the spraying operations. Except for the 20-acre flax field, NE 1/4 of section 12, treated with 20 pounds of chlordane, all infestations were sprayed with aldrin in either oil or emulsion at the calibrated rate of 2 ounces per acre. The actual dosages of the aldrin varied slightly from this rate, as shown in the table.

Table 1. --Field tests with aldrin spray for controlling grasshoppers in 1950. Maxbass, N. Dak., spray area.

Section and quarter	Area in crops	Area sprayed	Insecticide used		Grasshoppers per square yard		Egg pods per square foot	
			Total	Dosage	Before spraying	After spraying	May	October
	Acres	Acres	Ounces	Ounces	Number	Number	Number	Number
Sec. 7:								
NW	70	10.0	32.0	3.2	1-60	1-	1.5	0.2 - 0
NE	80	0	0	-	1-	1-	1.5	0 - .2
SW	76	88.5	210.5	2.4	20-50	1-	2.0	.2 - 0
SE	60	61.5	146.9	2.4	25-50	1-	1.0	0 - 0
Sec. 18:								
NW	74	37.5	79.3	2.1	20-60	1-	1.0	.2 - .2
NE	57	55.5	106.9	1.9	20-60	1-	1.5	0 - 0
SW	20	21.0	46.7	2.2	20-60	1-3	0.5	0 - 0
SE	32	33.0	73.3	2.2	20-60	1-3	0.5	0 - 0
Sec. 12:								
NW	50	0	0	-	1-	1-6	1.0	0 - 0
NE	60	20 ^{1/}		-	1-15	1-	-	.2 - 0
SW	40	0	0	-	1-	1-6	1.2	.2 - 0
SE	91	124.4	271.9	2.2	20-300	1-3	1.5	.2 - 0
Sec. 13:								
NW	110	39.0	79.2	2.0	30-50	1-5	1.0	.2 - .6
NE	60	0	0	-	1-	1-	.5	0 - 0
SW	Weedy	160.0	320.0	2.0	30-300	1	1.0	0 - 0
SE	40	50.0	100.0	2.0	25-60	1-8	1.5	0 - 0
Total or average	920	700.4	1,466.7	2.15	15-70	0-2	1.15	.09- .06

^{1/} Treated with 20 pounds of chlordane.

A mist blower was used to apply the emulsion on 440.4 acres of weedy stubble or grain strips, weed patches, and margins. The side-delivery nozzle made it possible to cover the 10-rod wide strips by spraying from both sides and in both directions from the dead furrow in the middle without knocking down much grain. Some strips were so narrow that they could be covered by spraying only from the sides, provided the wind was not blowing. A boom sprayer, tractor-drawn, would have knocked down 5 to 10 percent of the small grain and been of little use in the weedy areas. A plane was used to apply an oil spray of aldrin on 199 acres of weeds and chlordane on the 20 acres of flax. Most of the area was sprayed between July 24 and 29 during clear, warm weather with no wind. Figure 3 shows the weather conditions during this period.

Populations of grasshoppers before the spraying averaged 20 to 30 per square yard in the strips of grain and stubble and 30 to 300 in the margins. They were mostly mexicanus and bivittatus in all stages of development but principally in the third and fourth instars.

Earlier on June 24, a 5-acre portion of a stubble strip on high ground in the center of the SE 1/4 of section 12 was sprayed with aldrin at the average rate of 1 1/2 ounces per acre. An infestation of 300 newly hatched nymphs per square yard at the time of treatment was reduced 80 percent, but hatching continued until July 20. The residual effect was noticeable up to July 3, or 9 days after application. The strip was sprayed again on July 26.

The outstanding spray job was that done on the weedy SW 1/4 of section 13 with a plane on July 18. This 160-acre infestation numbered 30 to 300 grasshoppers per square yard in a weedy cover 2 to 5 feet high. Of this tract 40 acres was a solid stand of sweetclover 4 to 5 feet high. Tall weeds and rough wet ground made it impossible to use the mist blower. The grasshoppers had commenced moving into and damaging crops adjacent to the quarter on four sides. An extra spray swath along the margins of these crops was laid down when the quarter was treated.

The aldrin on this quarter section was applied at the rate of 2 ounces in 1 gallon of oil per acre by a Cub J-3 plane equipped with a 40-gallon sprayer. The pilot flew 6 feet above the weeds. The landing strip was 4 miles from the field. It took 4 trips and 80 minutes, 6:40 to 8:00 p.m., to spray the 160 acres. In contrast, the best time with the mist blower mounted on a truck was 258 acres in 16 hours.

After 24 hours 90 percent of the grasshoppers were dead, and 48 hours later only occasional live grasshoppers were seen along the west and south section roads. Here some sick and freshly dead adults were observed on August 11, or 33 days after the quarter was sprayed.

In like manner a heavy infestation in 39 acres of weeds in the NW 1/4 of section 13 was wiped out on July 29. On August 21 an infestation of adults, 15 per square yard, in the 40-acre flax field, SE 1/4 of section 13

was sprayed by plane with 2 ounces of aldrin per acre. Bolls of flax were already being cut off by the grasshoppers. Mortalities were apparent 2 hours after the application and the infestation was wiped out in 2 days.

Over the entire four sections infestations were reduced to almost zero and 110 acres of flax saved from damage. The egg infestation was reduced from 1.15 pods per square foot in the spring to 0.09 pod in the fall (table 1). However, similar reductions were found in quarter sections or parts thereof not treated. Infestations did not develop in these places and no spraying was necessary. Much of the area was low, wet ground and some of the eggs did not hatch. Others hatched at times when inclement weather destroyed the newly hatched nymphs. Approximately 700 acres of the original 1,100 acres of infestation had to be sprayed. Although there is no proof that the reduction of infestation was due entirely to the spraying, the fall egg infestation might have been greater than the spring if no spraying had been done. The spraying removed any chance of grasshoppers being left to deposit eggs.

On July 25, 1951, a follow-up survey was made of the area. The grasshopper population numbered less than 1 per square yard for the entire four sections. Two farmers in the area said that they had not seen any grasshoppers that summer.

Results on the Westhope Spray Area

The NW 1/4 of section 31, shown in the upper right hand corner of figure 1, is part of a farm 3 miles west of Westhope. Between June 19 and July 22, 12 acres of shelter belt, 32 acres of alfalfa, and 27 acres of pasture within the quarter were sprayed with 138 ounces of aldrin with the mist blower.

Shelter belts of various kinds of trees and shrubs are common in this district and are sources of grasshopper infestations. On June 20, 25 percent of the grasshoppers had hatched along the eastern half of the shelter belt running east and west through the middle of the quarter. The population numbered 200 per square yard, consisting of first, second, and third instars of mexicanus, bivittatus, Dissosteira carolina (L.), and Camnula pellucida (Scudd.). One spray application at the rate of 2.8 ounces of aldrin per acre reduced this number to almost zero and held it there until July 6.

During these 16 days only newly hatched nymphs were observed, and they continued to sicken and die. Between July 6 and 13 newly hatched grasshoppers survived and a new infestation developed. A second treatment with aldrin at 2 ounces per acre wiped out the infestation.

Some of the best results, even in inclement weather, were obtained in the shelter belts where the growth of grass and weeds was heavy. There was no hurry about spraying these places, because the nymphs

remained in or close to the shelter belt long enough for the main hatch to take place.

On July 13, 16 acres in the middle of the 32-acre alfalfa field were sprayed with aldrin at the rate of 1 ounce per acre. The other 16 acres forming the east and west sides of the field were treated with 2 ounces per acre. The alfalfa was 4 to 8 inches high and had been cut once. The infestation in the alfalfa numbered 30 grasshoppers per square yard and in the bordering shelter belts, 60 per square yard.

Five days later the middle 16 acres showed a reduction in numbers of 65 percent and the side strips 80 percent. By August 1 the middle strip had a population of 3 grasshoppers per square yard, while the side strips had 1 per square yard. In the alfalfa the egg pods before hatching had averaged 2 per square foot, but not a single pod was found in either the alfalfa or bordering shelter belts in the October egg survey.

The 22-acre pasture in the northwest corner of the quarter section was also sprayed on July 13, at the rate of 1.3 ounces of aldrin per acre. The grass was 3 to 4 inches high and contained some weeds and short sweetclover plants. Before the spraying the grasshoppers numbered 30 per square yard. In 5 days there were still 18 grasshoppers per square yard concentrated in 7 acres of the eastern side. This pasture was sprayed again on July 22 with 2 ounces of aldrin per acre. By August 1 the average population was 3 grasshoppers per square yard. Two similar sprayings were made on the small pasture east of the flax field.

As shown in figure 1, the 15-acre flax field was bordered on three sides by treated shelter belts, pastures, and the alfalfa. The grasshoppers did no damage to the flax and the infestations were reduced to noneconomic importance. No infestations developed on this place in 1951.

Cool, rainy weather from June 20 to July 22 prevented the grasshoppers from being active, and quick, decisive results with heavy mortalities from the spraying were not obtained, as they were later elsewhere when the weather became warmer and drier and the grasshoppers showed greater activity.

Ground Sprays to Protect Flax and Other Crops

Besides the work done on the Maxbass and Westhope spray areas, ground spraying was done on nearby farms to eliminate threatening infestations. On two farms the mist blower was used.

On one of these farms an 80-acre sweetclover field bordered the full 3/10-mile length of a 35-acre flax field. Two-thirds of the sweetclover had been cut for hay, and a leafless stubble remained. The other third, which was next to the flax, was left for seed and stood shoulder high. Grasshoppers numbered 80 per square yard in the stubble field and 300 in the margins. In previous tests where toxaphene was used in sweetclover

stubble, some difficulty was encountered in trying to control grasshoppers with the recommended dosage. This field offered an opportunity for testing aldrin under such conditions.

Spray containing 3 ounces of aldrin per acre was applied on the afternoon of July 28 and the morning of July 29. Early on the morning of July 30, 1.37 inches of rain fell in the area, and again on July 31, there was 0.56 inch of rain. On August 1 the grasshoppers numbered 10 per square yard in the stubble and 5 in the standing sweetclover. By August 19 these numbers were further reduced to 4 per square yard in the stubble and fencerows and 1 in the uncut sweetclover. The farmer reported a marked residual effect for 9 days after the spray was applied in spite of the heavy rains. There was no grasshopper damage to the flax. In the fall survey the egg pods numbered 0.2 per square foot in the sweetclover field and its margins.

The second ground spray test was made on July 27. Aldrin was applied at the rate of 3 ounces per acre on a 60-acre weedy wheatfield farmed in strips of fallow and wheat that was headed out. The population of 50 grasshoppers per square yard, made up of third, fourth, and fifth instars of mexicanus and bivittatus, was reduced to zero by August 19. Since this second farm was within 3 miles of the first, it was subjected to the same heavy rains on July 30 and 31 but without any apparent effect on the results.

Aerial Sprays to Protect Flax

Cooperative tests were conducted on 24 farms in Bottineau County where both aldrin and chlordane in oil sprays were applied by plane. A local plane operator did the spraying and furnished the oil at a cost of \$1.15 per acre to the farmer. The Bureau of Entomology and Plant Quarantine furnished the insecticides. The plane was a Cub J-3 with the wing tips cut off square to prevent the spray from boiling up over the tips of the wings. The sprayer had a 40-gallon capacity. The plane was flown within 6 feet of the crop and this movement forced the spray down into the plant cover in a rolling fog.

Where a power or telephone line was along the edge of a field, the pilot first paralleled the line to the windward at about 15 to 20 feet elevation. This position allowed the spray to drift under the line and cover whatever margin there was along the edge. He flew the same swath again at 6 feet elevation to spray directly beneath the plane. If the rest of the field had to be sprayed in swaths perpendicular to the power or telephone line, he then continued to parallel the line for two or three more swaths into the field to make sure that that end of the field was adequately treated.

On the 24 farms a total of 630 acres of flax and 237 acres of alfalfa, sweetclover, small grains, and margins were sprayed with aldrin at the

average rate of 2.2 ounces per acre. Chlordane at 1 pound per acre was applied on 173 acres of flax and 71 acres of other crops. All this spraying was done to protect 900 acres of flax.

Infestations in the fields averaged 35 and in their margins 115 grasshoppers per square yard. These numbers were all reduced to less than 1 per square yard as a result of the spraying.

Before the spraying the damage to the flax, measured by the number of bolls on the ground, averaged 10 percent and was as high as 35 percent. The treatments stopped further damage and prevented severe-to-total losses.

The fields were treated between July 27 and September 9, so that the early spraying was done when the flax was in the late-bloom stage and the grasshoppers were late nymphs. At the time of the late spraying the flax was in the ripened-boll stage and all the grasshoppers were adults. The dosage of insecticide was not changed during the period, and there was no difference in the results between the early and late spraying. In six of the flax fields aldrin and chlordane were tested side by side with like results.

Among the spray operations on the 24 farms there were several that warrant special discussion. On one farm a 17-acre field of barley in the dough stage with an infestation of 150 grasshoppers per square yard was adjacent to a flax field that was also heavily infested. All the leaves of the barley had been stripped off and some damage to the heads was in progress. One application of aldrin on the barley and on the flax reduced the infestation to less than 1 grasshopper per square yard in 5 days, and no eggs were deposited.

On another farm a population of 75 grasshoppers per square yard in a 44-acre alfalfa field threatened not only the alfalfa but also a 60-acre flax field adjacent to it. This infestation was reduced to almost zero by one application of aldrin to the alfalfa, and both crops were protected.

On one farm there was a weedy roadway $\frac{3}{4}$ mile long with a strip of rye 5 rods wide along the north edge, comprising 14 acres altogether. This area was heavily infested with an average of 300 grasshoppers per square yard. The infestation bordered the ends of flax and small-grain strips to the south. One spraying on July 27, before any of the grasshoppers had moved more than 2 rods into these strips, wiped out all the infestation and prevented damage to the flax and small grain. This is a good illustration of what can be accomplished by treating marginal infestations while they are still concentrated on a few acres.

Another example was a quarter section containing 80 acres each in flax and sweetclover, shoulder high, infested with 25 adult grasshoppers per square yard. Ten percent of the flax was damaged. One application of aldrin over the entire quarter section wiped out the infestation in both crops. The results were so unbelievable to the owner that he walked diagonally across the 160 acres and then from one side to the

other to check on them. He did not see one live grasshopper, and only by counting the dead ones on the ground could he convince himself that the spray had actually eliminated the infestation.

Rains up to 1 1/2 inches fell during the spraying operations on the 24 farms. Hardly a treatment escaped the rain, and it frequently fell within a few hours after the insecticide was applied. However, only one application was necessary to reduce the infestation to zero.

Grasshopper damage up to 30 percent can occur in flax without being seen from the road or attracting the attention of the farmer. A closer examination to count the bolls on the ground is needed to show the severity of the damage.

Most of such crop loss can be prevented by spraying. The first spray should be applied early enough to eliminate all newly hatched grasshoppers in or near the flax, and a second to prevent reinfestation from some outside source. In 1950 the flax yielded as much as 20 bushels per acre in the general area of North Dakota where the tests were made, which meant up to \$62 per acre at the current price. The average 10-percent loss encountered during late spraying amounted to as much as \$6.20 per acre, which would justify an early spraying and a second spraying if necessary. The early spraying is usually done on a greatly reduced acreage and the probable over-all cost of treatment is about \$1.50 per acre.

In north-central North Dakota commercial airplane spraying has met with greater acceptance than the farmers' own use of ground equipment. There are several reasons why. Tractor-propelled boom sprayers knock down 5 to 10 percent of a small-grain crop if the grain is tall when treated. The worst grasshopper infestations are often concentrated in weedy places, where the ground is too rough or too wet for the use of ground equipment. Muddy fields also delay ground spraying. In a cultivated area spraying with a light plane is 5 to 10 times faster than ground spraying. The pressure of other farm work and the problem of calibrating a ground sprayer for different formulations of a single insecticide are added reasons why farmers would rather phone a good commercial operator to spray his grasshoppers than do it himself.

TESTS ON THE BLUEBONNET FARM, TEX.

The Bluebonnet Farm is a 17,483-acre tract of land obtained from the War Assets Administration by the Texas A. and M. College for conducting agricultural and livestock research and education. Figure 2 is a map of the farm, showing the locations of the 29 tests of aldrin and other sprays made in 1951. That was the fourth year of reclaiming this land, which had become heavily infested with Johnsongrass and grasshoppers, mainly differentialis, during the wartime period when it had been utilized as an ordnance plant. Most of the grasshoppers had been eliminated by vigorous

control measures over a period of 3 years. Enough infestation remained, however, for spray tests in which aldrin, dieldrin, and toxaphene were used.

The main objective of grasshopper control in this district is to protect cotton and other crops from differentialis, which hatches in the field margins and permanent pastures.

The new organic insecticides, mainly toxaphene spray, have supplanted the bran-sawdust bait as a control measure. Although good results had been obtained earlier in the season against grasshopper nymphs in green vegetation, the insecticides lost much of their effectiveness when hot, dry weather set in, the vegetation dried up, and the grasshoppers became adult. The main purpose of the 1951 work, therefore, was to determine what could be done about this loss of effectiveness.

The plan was to start spray operations and observations early and continue them into the season when hot weather could affect the results. Special efforts were then to be made to obtain the same good results produced in the early spraying, and also to determine the factors involved in the break-down of effectiveness. The general plan used was the same as in other farm-scale tests. Grasshoppers were collected from time to time to determine the composition and progress of the infestations.

In some tests two compounds or oil and emulsion sprays were used together.

Results of Early Spraying

The results of the early sprayings are shown in table 2 for each type of area sprayed. On 771 acres, 2,238 ounces of aldrin reduced populations of 12 to 77 grasshoppers per square yard to practically zero. In all but two tests, Nos. 10 and 19, this reduction was accomplished with one application in weeds and grass 4 to 24 inches high. In these tests the first application reduced the original numbers 85 and 25 percent, respectively. A second heavier application in each test reduced the remaining infestations to zero.

Grasshoppers were collected on the Bluebonnet Farm before the spraying, and in areas Nos. 10 and 19 again after one application of aldrin to determine what species persisted. The species collected are shown in table 3. Melanoplus differentialis was the dominant species before the spraying, but Hespereotettix viridis (Thos) and Paraidemona mimica Scudd. (a wingless grasshopper) became the dominant ones after the aldrin spray had killed large numbers of differentialis.

Although the sprayer was calibrated to deliver 2 ounces of aldrin per acre at a truck speed of 7 m.p.h., the average dosage in the early spraying was 2.9 ounces per acre. Much of the pasture was in rough, brushy bottom land, where travel was slower than planned for. This condition and failure to shut off the nozzle on frequent turns accounted for most of the heavy dosage.

Table 2. --Field tests with aldrin, dieldrin, and toxaphene sprays for controlling grasshoppers in 1951. Bluebonnet Farm, McGregor, Tex. Emulsion concentrates used unless indicated otherwise.

Insecticide and test No.	Period of operation	Area sprayed		Insecticide used		Grasshoppers per square yard	
		Type	Amount	Total	Average per acre	Before spraying	End of test
			Acres	Ounces	Ounces	Number	Number
Early Spraying							
Aldrin:							
1, 7, 9	May 3-18	Margin	48	112	2.3	60	0
5, 19	10-24	Roadway ^{1/}	21	60	2.9	77	0
10	21-29	Weed patch ^{1/}	32	126	3.9	40	0
12 ^{2/}	22	do.	7	16	2.3	60	0
16	28	R. R. grade	30	70	2.3	12	0
17	29	Fencerow	8	20	2.5	15	0
2, 6, 8, 11,							
14a, 15, 18	8-June 19	Pasture	584	1,742	3.0	58	1-
4 ^{2/} 13 ^{2/}	10-23	do.	41	92	2.2	45	0
Dieldrin:							
20, 21, 22	June 14-18	Margins	42	63	1.5	49	0
23	18	Fencerow	24	30	1.2	30	0
		Sweetclover	37	40	1.1	25	0
Toxaphene:							
3, 14 ^b	May 8-22	Pasture	18	29	1.6	49	0
14c ^{2/}	22	do.	16	24	1.5	40	0
Late Spraying							
Aldrin:							
25	July 13	Weeds	14	28	2.0	15	12
	16	do.	14	112	8.0	12	1-
26	6	Roadway	17	34	2.0	25	10
	14	do.	17	84	4.9	10	6
29 ^{2/}	17	do.	21	126	6.0	6	1
	17	Pasture	7	21	3.0	12	1
			16	96	6.0	12	1-
Dieldrin:							
24	July 13	Cotton	14	14	1.0	10	7
	16	do.	17	48	2.8	7	1-
28	16	Grass	10	28	2.8	5	1-
Toxaphene:							
27	July 16	Cotton	20	30	1.5	8	3
		Grass	6	18	3.0	7	1-

^{1/} Weedy places that had to be sprayed twice before the infestation was reduced to zero. See last column of table 3 for the species that persisted after the first treatment.

^{2/} Insecticide was mixed with oil.

LIBRARY
STATE PLANT BOARD

Table 3. --Percentages of various species of grasshoppers collected in the habitats included in spray operations, Bluebonnet Farm, McGregor, Tex., 1951

Species	Road-way	Margins of cotton	Pasture	Weedy area after spraying
<u>Ageneotettix deorum</u> (Scudd.)	3.2	0.3	1.6	6.9
<u>Boopedon gracile</u> Rehn	0	0	10.8	0
<u>Hesperotettix speciosus</u> (Scudd.)	10.3	.7	6.5	9.9
<u>Hesperotettix viridis</u> (Thos.)	.8	0	1.1	19.7
<u>Melanoplus confusus</u> Scudd.	.1	0	0	0
<u>Melanoplus differentialis</u> (Thos.)	84.7	95.9	67.4	19.0
<u>Mermiria maculipennis</u> Bruner	.5	2.8	4	4
<u>Oedipodinae species</u>	0	0	2.7	0
<u>Paraidemona mimica</u> Scudd.	0	0	4.4	38.1
<u>Phoetaliotes nebrascensis</u> (Thos.)	0	0	.9	0
Unidentified	.4	.3	.6	2.4
Number of specimens collected	1,109	288	1,604	422

In the early spraying the known residual action of the aldrin lasted up to 15 days. However, it was difficult to determine the residual effectiveness when most of the original infestation was wiped out in 3 or 4 days by the one application.

About 60 percent of the area sprayed early with aldrin was made up of pastures and margins adjacent to a cotton crop not over 8 inches high. The remainder was infested pasture land and roadways 1/2 to 1 1/2 miles from the nearest crop. Ordinarily remote infestations are not considered an immediate threat to a crop. They are therefore overlooked and remain a constant source of reinfestation. In these tests none of the infestations, whether adjacent or remote, were permitted to enter the cotton.

In the early spraying toxaphene was compared directly with aldrin. In three tests average nymphal populations of 40 to 49 per square yard were reduced to zero by one application. Residual action of toxaphene was noted up to 4 days, after which there were no grasshoppers left. The killing action of the aldrin was a little faster than that of the toxaphene, for aldrin reduced similar infestations to 1 or less per square yard in 3 days.

Both oil and emulsion sprays were used in the early aldrin and toxaphene tests Nos. 4, 12, and 14. The oil sprays had to be applied with the USDA broadcast nozzle in calm weather, because they will drift with any appreciable wind. With the small quantity used per acre, drifting would reduce the dosage and the effectiveness of the spray. Emulsion sprays were applied with the side-delivery nozzle, often in windy weather since such weather was the rule. There was no difference in results between the oil and emulsion sprays regardless of the insecticide or type of vegetation. The oil spray at 1 1/4 gallons per acre did not seriously burn the vegetation.

Dieldrin in the early spraying was applied on 103 acres at the average rate of 1.3 ounces per acre. Average populations of 25 to 49 grasshoppers per square yard were reduced to zero with one treatment. Some of the populations ran as high as 100 grasshoppers per square yard. For the first time cotton was sprayed directly to protect it from migrating fifth and sixth instars of differentialis. In central Texas this species goes through seven instars. Within 1 1/2 hours after the application there were many dead and dying grasshoppers and within 24 hours, all were dead. The dieldrin killed the grasshoppers faster than did either aldrin or toxaphene.

In test No. 20 the grasshoppers were moving from a 15-acre cut hayfield into a 50-acre cottonfield. The spraying of a barrier consisting of 3 rods of weedy grass margin and 25 rows of cotton--5 acres altogether--with 7 ounces of dieldrin wiped out the infestation in the barrier and all the grasshoppers moving in from the hayfield.

North across the road, in test Nos. 21 and 22, a 34-acre cottonfield was threatened on the north by grasshoppers from a harvested 25-acre oatfield and on the east by those from cut hayfields. The spraying of 37 acres of field margin, including 8 acres of cotton, with 56 ounces of dieldrin wiped out all infestations. On July 12 and 16 not a single grasshopper could be found in the cotton, its margins, or adjacent oat stubble or hayfields. In contrast, a cottonfield to the north, not treated early, had 10 adult differentialis per square yard over most of it on July 13 when it became test No. 24 in the late spraying. These results showed what early spraying could do.

The 23 tests made with aldrin, dieldrin, and toxaphene gave excellent control of grasshoppers in all stages of nymphal development from May 3 through June 18, or over a period of 47 days. All the worst infestations were reduced to practically zero. Maximum daily temperatures reached 95 and 100° F. on a few days, but there was no long period of hot, dry weather. Sufficient rain fell to keep the vegetation green. On June 20 operations were discontinued to await hotter and drier weather and adult infestations.

Results of Late Spraying

On July 6 a roadway and margin of a cottonfield were sprayed by the farm staff to protect the cotton from grasshopper damage, test No. 26, table 2 and figure 2. Aldrin in an emulsion spray was applied at the rate of 2 ounces of aldrin per acre on 17 acres of infestation numbering 25 grasshoppers per square yard. Only a 60-percent reduction in population was estimated after 4 days. This reduction was the first of the definitely poor results obtained with the dosages used earlier in the season. Two more treatments at 4.9 and 6 ounces per acre on July 14 and 17, respectively, were required to reduce this infestation to 1 grasshopper per square yard.

On July 13, test No. 25, in bone-dry sunflower weeds, head high, 2 ounces of aldrin per acre reduced a grasshopper population of 15 per square yard only 20 percent. A second application on July 16 at 8 ounces per acre reduced it to 1 or less per square yard.

In remote native weedy pasture, where there was still some green foliage, 3 and 6 ounces of aldrin per acre in an oil spray (test No. 29) reduced a population of 12 grasshoppers per square yard to 1 and 1 or less per square yard, respectively. In this test Boopedon gracile was the dominant species and was the first to disappear after the treatment. It showed a greater susceptibility to the poison than the other important species, which were differentialis, Hespereotettix viridis, H. speciosus, and Phoetaliotes nebrascensis.

In test No. 24, 1 ounce of dieldrin failed to give good results. An average dosage of 2.8 ounces per acre was required to secure the same results that an average of 1.3 ounces gave in early spraying.

In test No. 27 toxaphene at 1 1/2 pounds per acre reduced an infestation of 8 grasshoppers per square yard in cotton to 3 grasshoppers and at 3 pounds per acre reduced to 1 or less an infestation of 7 grasshoppers per square yard in Johnsongrass.

None of these insecticides were given a thorough study under hot, dry conditions because of the lack of infestation. Nevertheless, the results of the late spraying showed that there was a break-down in their effectiveness and that the break-down could be overcome by doubling, tripling, or quadrupling the dosages used in the early spraying.

THE EFFECT OF WEATHER ON CONTROL OF GRASSHOPPERS WITH ALDRIN SPRAYS

The failure of aldrin sprays in hot, dry weather in Texas in 1951 called for a study of the causal factors. The most obvious factor was the weather itself. Similar failures had been experienced in North Dakota in 1950 under cold, wet conditions.

When the effect of weather on the results of spray operations was analyzed, temperature and rainfall were given the most serious consideration.

Figure 3 shows the 1950 hatching curves for mexicanus and bivittatus in North Dakota and the 1951 curve for differentialis in Texas, plotted from the data gathered during the season's work in each area. The mean daily maximum air temperature and total rainfall for each 5-day period are shown in the form of a curve and a histogram for the season's work. The minimum effective hatching temperature of 60° F., below which no hatching takes place, and the temperature range of maximum grasshopper activity, 80° to 90° F., are also given.

In Bottineau County in 1950 cold, wet weather predominated, with daily maximum air temperatures mostly between 60° and 70° F. up to July 24. Spraying operations were begun on June 20, but adverse weather generally reduced the effectiveness of the sprays until July 24, when warmer weather set in with daily maximum temperatures above 80°. Occasional warm, clear days made it possible to get some good results in the first part of July, but most of the farm-scale spraying was done after July 24. From then on through August good results were obtained by selecting the best days for spraying.

In North Dakota 90 percent of the mexicanus and bivittatus grasshoppers had not hatched until the middle of July. There were no continuous hatching temperatures until after May 20. In other work it has been demonstrated that in the spring the number of degrees each day the maximum air temperature is above 60° F. has to total 150 to 200 before either species will start hatching. In Bottineau County in 1950 this total was 163 degrees by May 31 and 200 by June 5. The hatching curves for both begin close to these dates.

In Texas differentialis began to hatch about April 10. The number of degrees each daily maximum air temperature is above 60° F. has to total 600 to 700 before this species begins hatching. This total was 627 degrees by April 1 and 786 degrees by April 10. Ninety percent of the grasshoppers had hatched by May 13.

Good control of the grasshoppers in Texas was obtained with the sprays from May 3 to June 19, when daily maximum air temperatures in the 80's predominated. Wind and rain during this period interfered with spraying operations, but did not affect the results.

Poor kill of the grasshoppers was obtained when spraying was resumed on July 6 and in tests made from July 13 to 17. During this time there was no rain, the vegetation dried up, and maximum air temperatures above 95° or 100° F. were of daily occurrence.

Grasshopper control with insecticides was poor in North Dakota when maximum air temperatures below 80° F. predominated and in Texas when they were above 95°. Above or below 80° and 90° F. there is a decrease in activity until at temperatures above 100° or below 70° there is practically no voluntary activity on the part of the grasshoppers.

A poison generally becomes more effective as the activity of the insect increases. It is quite probable that the inactivity of the grasshoppers at the low temperatures in North Dakota and at the high temperatures in Texas checked the toxic action of the aldrin sprays at the low dosages used.

In Texas greatly increased dosages of the insecticides during the hot, dry weather gave good results, probably by increasing their contact or fumigating effect. They also increased the chance of an individual grasshopper getting a lethal dose during a period of inactivity and desultory feeding.

In North Dakota the seasonal histories of both mexicanus and bivittatus vary from year to year. Ninety percent of these grasshoppers will hatch by May 15 one year and not until July 20 another year. It has been found that daily maximum air temperatures in the spring are closely correlated with the hatching period and that 60 to 80 percent of the variation in this period is associated with a year-to-year variation in these temperatures.

In North Dakota sprays for grasshopper control are usually effective throughout July and August and into September without dosages being increased because temperatures seldom reach 95° to 100° F. Low temperatures in the season, however, are likely to reduce control appreciably. The proper timing of spray operations in relation to temperature is therefore essential to efficient control operations.

In Texas all of May and part of June can be utilized for spraying operations if daily maximum temperatures of 95° to 100° F. are not too common. This period should allow ample time for locating and controlling this species without the necessity of late spraying.

If for any reason it does become necessary to protect a cottonfield from grasshopper damage during hot, dry weather, apply 4 to 8 ounces of aldrin, 2 to 3 ounces of dieldrin, or 3 to 4 pounds of toxaphene per acre as a money-saving measure. The 1946 yield of cotton in Texas was 130 pounds per acre and the farm price was 33.7 cents per pound, making cotton a cash crop of \$43.81 per acre for that year. With the price of aldrin 20 cents and of dieldrin 40 cents per ounce, and of toxaphene 50 to 75 cents per pound, and the cost of aerial application \$1 per acre, spraying would be well worth while. Moreover, in most cases less than half the cottonfield requires spraying to protect the whole of it.

Caution. --Do not feed crops contaminated with any of these insecticides to dairy animals, to animals being finished for slaughter, or to poultry.

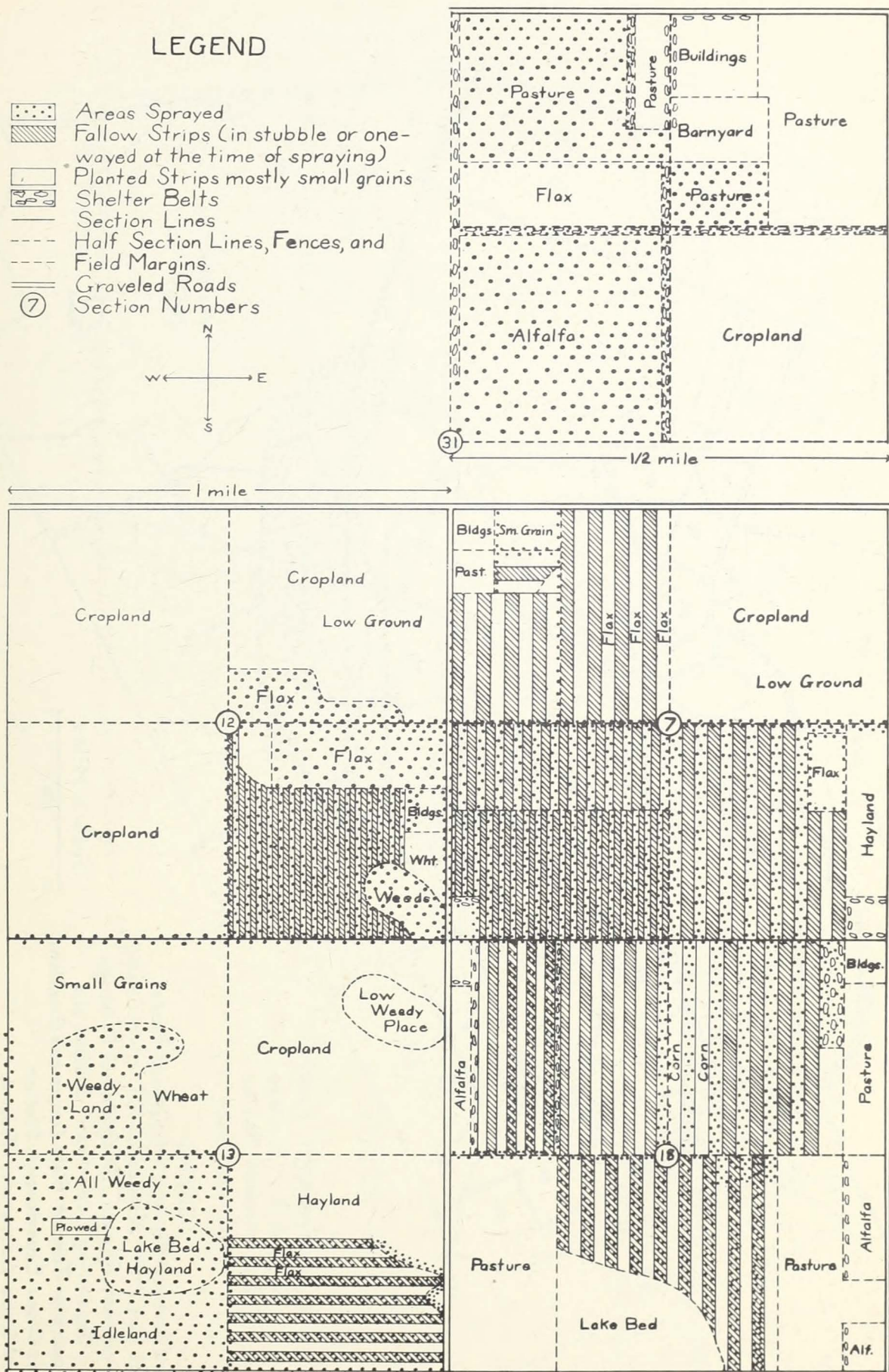


Figure 1. --Westhope (Sec. 31, upper right), and Maxbass (Secs. 12, 7, 13, and 18, lower part), N. Dak., areas, showing parts sprayed with aldrin for the control of grasshoppers in 1950.

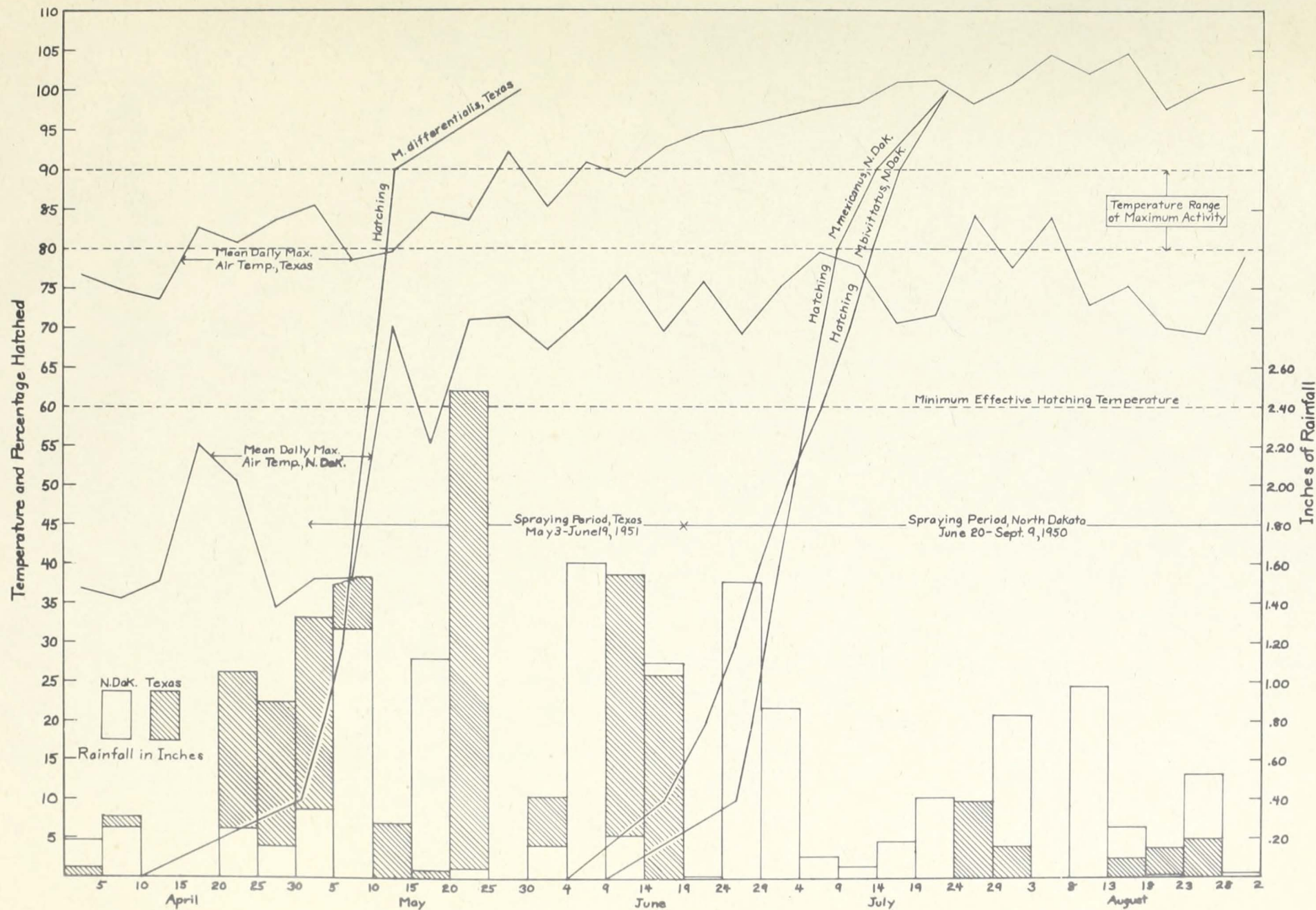


Figure 3. --Hatching curves of the dominant grasshopper species and curves of the daily maximum air temperature and rainfall for the spray areas at Maxbass and Westhope, N. Dak., 1950, and Bluebonnet Farm, Tex., 1951.

UNIVERSITY OF FLORIDA



3 1262 09239 6166