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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 394 APRIL, 1929

DIVISION OF ENTOMOLOGY

BOLL WEEVIL CONTROL BY AIR-PLANE DUSTING

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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†As of January 1, 1929. *Dean, School of Veterinary Medicine.
**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

SYNOPSIS

The cotton acreage in Texas which has been protected against insects by airplane dusting increased from 3,000 acres in 1925 to approximately 50,000 acres in 1928, according to information obtained from five companies engaged in commercial dusting in Texas in 1928. In 1926 and 1927 investigations were undertaken of the work of controlling boll weevils by this method as conducted under the arrangements made between the farmers and the airplane corporations. Observations were made on three farms containing, respectively, 400, 1,200, and 2,700 acres of cotton, and were made in connection with the operations of three airplane corporations.

Increased yields varying from 63 to 206 pounds of seed cotton per acre were produced in all cases where conditions warranted the use of control measures. Three to five applications of calcium arsenate dust were made. The amount applied per acre per application was about as specified by the owners of the farms and in one case was nearly 8½ pounds. In each instance the amount exceeded 5 pounds or the usual recommendation for a per acre-application. The number of squares punctured by boll weevils was reduced 50 per cent 10 days after dusting started and after two applications had been made.

Good profits as a result of boll weevil control were made on the two largest farms and a much better profit should have resulted from work on the smallest farm.

In airplane dusting for boll weevil control it is especially important that information be obtained on the condition of the infestation at the beginning of dusting operations. This information should be used in directing the work of the airplane, as the expense increases rapidly when applications are made to areas where the infestation is not sufficient to justify the use of poison. For best results, it is also important that applications be made at 5-day intervals.

The cost of airplane dusting including the poison ranges from seventy-five cents to one dollar per acre per application. This method of applying dust should prove profitable for the cotton growers as well as the corporations where the infestation averages 15 per cent early in the season or 20 per cent later in the season, with weather conditions favoring increase in weevil injury.

Airplane dusting offers relief in those cases where owing to wet grounds teams and men cannot get into the fields at the proper time to maintain the necessary five-day intervals of application. Dusting is profitable if the infestation is thereby kept down or reduced when it would otherwise be high, provided, of course, the soil is rich enough to produce a good crop in the absence of weevil damage. Furthermore, the price of cotton must be high enough to justify the expense of dusting. As a rule small detached areas cannot be dusted by airplane as profitably as large areas.

Detailed information is presented in connection with the operations and recommendations are made for those who may wish to consider this type of insect control.

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BOLL WEEVIL CONTROL BY AIRPLANE DUSTING

F. L. THOMAS, W. L. OWEN, JR., J. C. GAINES, JR., AND FRANKLIN SHERMAN III*

During the past few years there has been considerable interest in the use of airplanes for distributing calcium arsenate on cotton to control leafworms and boll weevils.

The application of insecticide dusts by means of airplanes was first successfully accomplished by the Ohio Experiment Station in cooperation with the United States Air Service in 1921 when an outbreak of leaf-eating insects on catalpa trees was quickly controlled.

In 1922 the Bureau of Entomology of the United States Department of Agriculture inaugurated experiments in the use of airplanes for the purpose of applying insecticide dusts to cotton. At that time the purpose of the applications was the control of the cotton leafworm, and it was shown quite definitely that airplanes can be used economically to control this pest.

The next year experiments were started for controlling the boll weevil by means of airplane dusting. These experiments were carried out on a large scale, and according to Dr. L. O. Howard the results secured were very favorable, "showing that the airplane may be used to distribute poison efficiently, effectively, and profitably for the control of the weevil and leafworm as contrasted with the results of dusting with ordinary ground machinery." A great deal of attention was devoted to the problem and numerous devices for distributing the poison have been developed.

Though still in the developmental stage, airplane dusting for cotton insect control was declared by Coad in 1924 to be both successful and profitable and in these respects to have most decidedly passed the experimental stage. The same year this form of insect control began to be practiced on a commercial scale.

Rapid progress was made in the development and use of airplanes for distributing poison. During the season of 1925 more than 50,000 acres of cotton were dusted commercially by this method. This includes 3,000 acres in Texas treated for the control of leafworms. The work at that time in this state was carried on largely in the Lower Rio Grande Valley, near Corpus Christi, and in Wharton County. The growers were so well pleased with the results that many made arrangements to have their cotton dusted in 1926 in the event that leafworms again threatened, and some also stated that they desired applications of dust for control of the boll weevil.

*Resigned, September, 1927.

Much of the cotton-growing area in Texas is particularly adapted to the use of airplanes for applying dust to control leafworms, boll weevils, and possibly other insect pests. And since the cotton leafworm makes its appearance almost every year in the southern portions of the state, it was early foreseen that airplane dusting might soon become a rather common practice in certain sections.

A number of airplane corporations in Texas and elsewhere became interested in the possibilities to be derived from this type of service, and as a result the cotton acreage protected by airplane dusting has increased rapidly. In 1926, 12,000 acres were dusted, mostly for leafworm; in 1927, a boll weevil year, 43,000 acres were dusted; and in 1928, 48,000 acres.

Since large sums of money would be involved in the extensive operations which would be necessary in this type of work, it was realized that airplane dusting would have its limitations as well as great possibilities.

For these reasons it was believed by the Texas Experiment Station that investigation of this form of insect control as practiced in Texas between the contracting parties would be timely and helpful to those who might be interested in making arrangements in the future.

OBJECT OF THE INVESTIGATIONS

The object of the investigations reported in this Bulletin was threefold: (1) to determine the extent of boll weevil control obtained under the arrangements as carried out by the contracting parties; (2) to obtain information which can be used in advising cotton growers who may be interested in arranging for this type of insect control; and (3) to work in a constructive manner with the commercial airplane companies and to suggest such improvements in the system and methods used as might appear advisable or necessary in obtaining the most effective results in the most economical manner.

METHODS AND PROCEDURE

The first of the three investigations of commercial airplane dusting for boll weevil control was conducted on the plat basis; that is, representative plats one-half acre each in size were selected on various portions of the Roberts Farm. Observations were made in the cotton on these plats in determining the control obtained. There were six series of plats, each series containing an untreated plat, and all series being alike with respect to treatment given and observations made.

Each of the other two investigations was conducted on the basis of the farm as a whole. Observations were obtained at regular intervals on the extent of the boll weevil infestation throughout each farm and compared with similar observations obtained on the untreated or check area of each. The Rogers Farm had a check area of 5.59 acres and the J. O. Chance Farm 10.15 acres for comparison. While details with reference to yields are given, attention is directed to the comparison between the yield of the check on each farm and the area adjacent to the check.

In determining the extent of infestation, records were obtained at about forty points selected in representative portions of the farms and where general conditions were uniform. Every square that was large enough to permit easy examination was counted, until 100 squares had been examined and counted in the vicinity of each point. Each infested square as it was found and counted was pulled off and kept in the hand or pocket. After 100 squares had been examined, the infested squares were counted. The number of infested squares found was equal to the per cent of infestation which occurred in the vicinity of the point where the examination was made. By carefully noting on a map the per cent of infestation found at each point, definite and valuable information was obtained on the boll weevil conditions throughout the period of operations on each farm.

THE PLAN OF COOPERATION

In 1926 arrangements were made for cooperating with B. C. Roberts, banker and farmer of Wharton, Texas, and the Super Rhone Engine and Flying Corporation of Houston.

In 1927 opportunity was presented of cooperating with two other airplane companies and with farmers in other sections. Plans were made with George Chance, Bryan, Texas, and the Huff-Daland Company, Inc., Monroe, Louisiana, to carry on investigations in boll weevil control on the J. O. Chance Plantation. Similar arrangements were made with John D. Rogers, Navasota, Texas, and the Quick Airplane Dusters, Inc., Houston, Texas, to investigate boll weevil control on the Rogers Farm.

In each case it was agreed that the entomologists furnish the owners with definite information on the progress of the boll weevil infestation on the dusted areas and also to furnish any other records obtained which might be of interest to the growers. The growers permitted the entomologists to make any observations desired and allowed untreated areas varying from 3 to 10 acres to be left for comparison. The pilots of the planes cooperated in leaving certain areas untreated and the companies assisted in collection of the data with reference to the operation of the planes. A detailed report of the work as carried out at each place was given by the entomologists to the company concerned.

INVESTIGATIONS AT WHARTON*

Plan of Experiments

The 500-acre farm on which the investigations were conducted in 1926 is located in the eastern portion of Wharton County, South Texas, and near the Colorado River about fifty miles from the coast. Every year in this section the boll weevil is generally regarded as an important enemy of cotton production. The farm is flat and the soil conditions

*Data collected by W. L. Owen, Jr., and H. E. Parish.

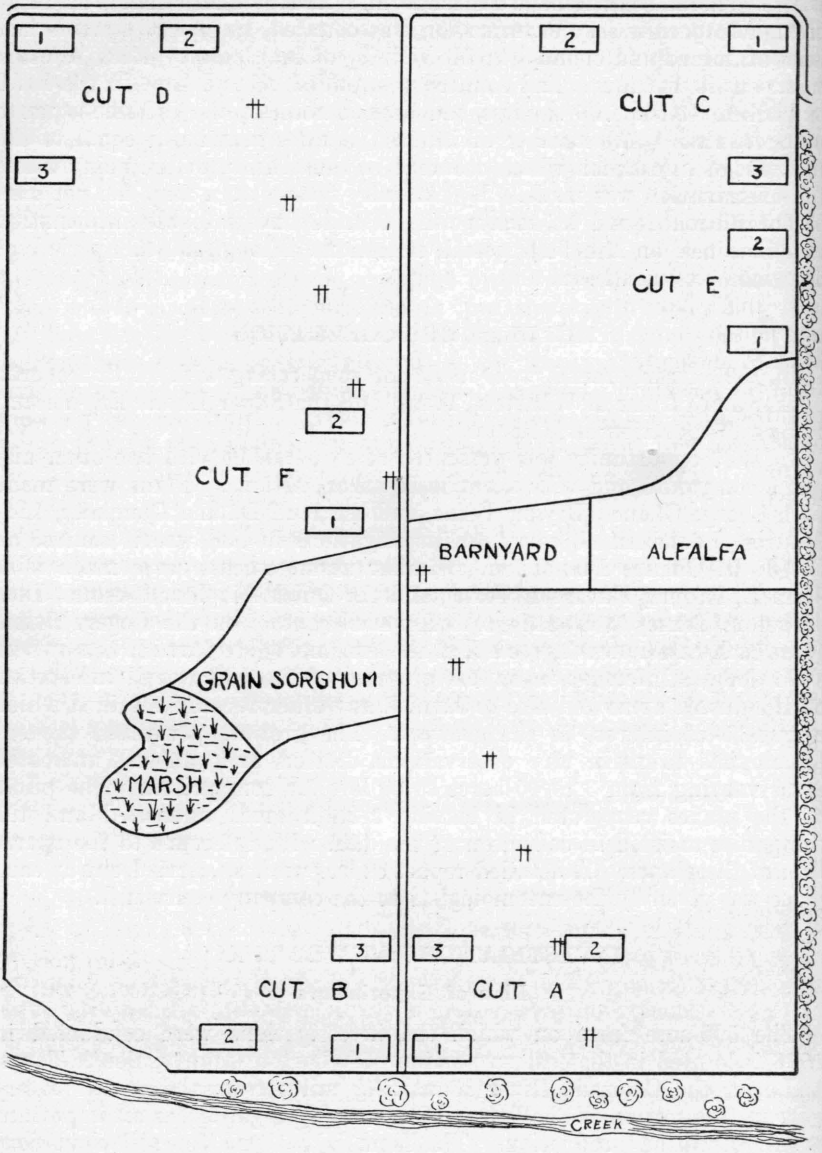

Figure 1.—Map of Roberts Farm. The numbers show relative location of experimental plats.

appeared to be as nearly uniform as could be expected. All the cotton was of the same variety and was planted between April 10 and 23.

In order to obtain a good representation of the boll weevil infestation on the whole farm, sixteen one-half-acre plats were laid off in six different cuts or fields. These cuts were distributed so that two were near each end of the farm and two near the middle (Figure 1).

The cuts on the ends of the farm each contained a series of three plats, and the two cuts near the middle of the farm each had two plats to a series. One plat in each of the six series was to be left untreated for comparison.

The untreated plats or checks were located so as to be protected as much as possible from the drift of dust when poison was being distributed. A distance of 400 to 600 feet separated the treated from the untreated plats in each cut, and ground machines were used for applying poison immediately around the untreated area, thus allowing the pilot to start dusting or stop, as the case might be, at a safe distance from the margin of the area to be left as a check.

Infestation records, including the number of adult weevils, per cent of squares punctured, total form counts and boll counts were made at regular intervals for the purpose of determining the progress of boll weevil activity.

The Airplanes Used at Wharton

The planes were assembled and equipped for dusting by the Super Rhone Engine and Flying Corporation of Houston. Each plane had a 120 h. p. Super Rhone Radial air-cooled motor and a hopper with a capacity for about 450 pounds of calcium arsenate.

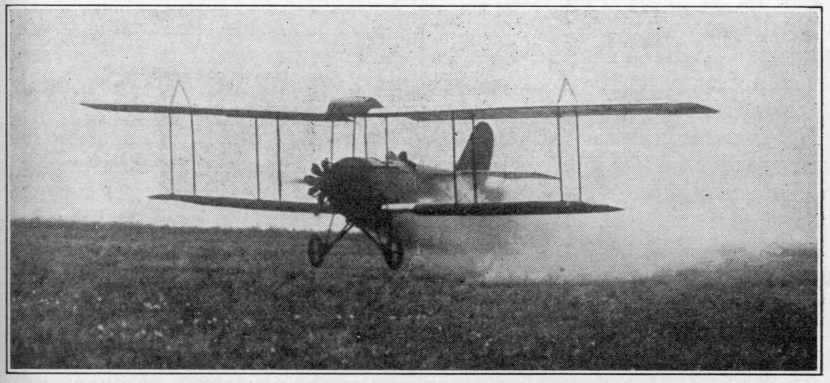

Figure 2.—Plane used on Roberts Farm at Wharton putting out a dust cloud. Note the "tripod" type of landing gear.

The hopper was placed inside the fuselage and in front of the pilot and was constructed so as to secure maximum capacity without interfering with the mechanical operation of the plane. It was V-shaped, the

point of the V being cut away to make an opening about 8 inches wide which extended across the width of the hopper. Through this transverse opening at the bottom of the fuselage, the dust was delivered. Attached to the length of the front margin of this opening was a semicylindrical piece of sheet metal having its convex surface to the front. This was for the purpose of protecting the opening from a direct blast of air, which might force the dust back up into the hopper and cause irregularity in the feed. Another purpose of this device was to obtain the effect of a partial vacuum by causing the air blast to pass a few inches below the opening, thereby causing the dust to be drawn out of the hopper and into the "slip stream" or air blast created by the propeller.

The apparatus for regulating dust delivery consisted of a sliding gate valve across the outlet at the bottom of the hopper. This gate was controlled by means of a hand lever, and could be opened or closed by the pilot to any desired width. Immediately above the opening in the base of the hopper was a light form of agitator consisting of two or more wires stretched diagonally between cross arms fitted to each end of the agitator shaft within the hopper. A gear box just outside the hopper connected the agitator shaft with a small propeller which provided the power for turning the agitator.

Development of the Infestation

A few boll weevils were noted early in the season but the infestation did not develop rapidly. Not until the first of August did it reach a stage that warranted the use of control measures. On July 29 the average infestation in the check or untreated plats of the Cuts A, B, E, and F showed about 7 per cent of the squares to be punctured. During the following week the infestation on the same plats practically doubled.

On the same date, August 5, the infestation in the check plats of the two cuts C and D on the north end of the farm was less than 1.5 per cent. It did not reach 10 per cent in Cut C until late in August and in Cut D the infestation did not go above 3 per cent the entire season.

These records indicated that application of poison for control of the boll weevil would not be needed on about 100 acres of the northern end of the farm where Cuts C and D were located, and that it was not advisable to begin dusting before the first of August on any of the plats.

In Figure 3 is shown a graphic representation of the increase in infestation on the untreated plats of Cuts A, B, E, and F in comparison with the infestation occurring on the six dusted plats in the same cuts. The infestation on the untreated areas continued to increase slowly, but did not reach alarming proportions at any time; the last record was taken August 22, showing 28.41 per cent of the squares to be punctured. On the dusted plats the infestation on the same date was 10.33 per cent.

Application of the Dust

Arrangement of work: The time when the dust should be applied and the quantity to be used was decided by the owners of the farm.

Four applications were made: July 27, August 2, 10, and 18. The third application made August 10 covered the entire farm including the check areas and was mainly for the purpose of controlling the leafworms. An average of 8.41 pounds of calcium arsenate per acre was applied at each of the four dustings, the quantity per application varying from $7\frac{1}{4}$ to $9\frac{1}{2}$ pounds per acre.

All the applications were made in the morning during the first three hours after it became light enough to permit safe flying. At that time the air was calm and moisture usually was present on the cotton plants. About 8 o'clock the wind would interfere and prevent satisfactory application of the dust.

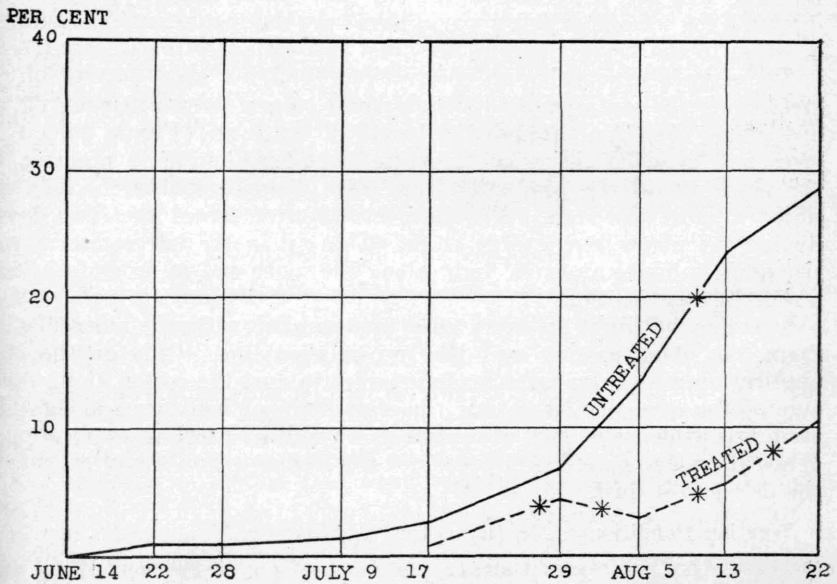

Figure 3.—The average boll weevil infestation on treated plats of cuts A, B, E, and F compared with that on untreated plats of the same cuts.

In order to make the first two applications the pilot flew each time from Houston to the farm at Wharton, a distance of 65 miles; on the other two occasions the plane was being used for dusting cotton on other farms in the same vicinity.

Flying method used in applying the dust: Three different pilots operated the planes for distributing the poison and some variation occurred in the manner in which the farm was dusted. Generally the application was made by flying the length of the farm beginning on one side and returning on the other. This method of dusting opposite sides of the field on each round trip and working toward a median line was continued until the area was covered. At other times the plane would

travel back and forth, laying down dust clouds that slightly overlapped, and working gradually from one side of the farm to the other. On one occasion the latter method was used, but instead of going the entire length of the farm, a distance of one mile, the pilot turned back when about half way. This maneuver allowed him to better mark the location of the dust cloud just laid down, and before it drifted too far as a result of the breeze. The last practice proved to be most satisfactory in obtaining uniformity of dust distribution under the conditions which occurred at Wharton.

There was considerable variation in the height above the plants at which the dust was delivered. This variation ranged from 5 to almost 50 feet. On two occasions the height was due to making applications during a fog when low flying would have been dangerous, and on another occasion to the inexperience of the pilot in dusting cotton.

There were practically no obstructions to flying except a border of trees along the south end and a high-power transmission line running in a diagonal direction through the length of the farm (Figure 1). The trees were avoided either by "zooming," suddenly climbing upward, or the plane would rise gradually from some distance within the field in order to clear the trees. The former maneuver forced the dust down among the plants at the edge of the field, but in the latter case it was necessary to make an extra flight along the south end in order to insure a thorough application.

The line of flight in every case was parallel with the sides of the farm, the plane passing over the transmission line. Only on the last application were extra trips made in order to dust the cotton along each side of the line. At that time the abundance of leafworms along this strip was evidence of lack of control as a result of previous applications. When the plane passed over areas not containing cotton the pilot cut off the delivery of dust.

Weather Conditions: In the case of the first two applications low fogs necessitated flying at a height of about 50 feet. On these occasions the distribution of the dust was so affected by the fog that only the cotton in a comparatively narrow strip received an application upon each flight. Instead of the dust being forced backward and downward among the plants as occurs under clear conditions, it behaved quite differently and was checked in its spread by the fog. It began to slowly settle or fall on the plants in drops of moisture which contained accumulated particles of the dust causing the plants to take on the appearance of having received an application of a coarse material. Apparently each particle of dust acted as a nucleus or center upon which moisture gathered and as the minute droplets of dust-laden moisture came into contact with other such droplets, they soon became heavy enough to fall, causing the cotton to appear as described above.

Under clear conditions the dust cloud was not only forced backward but downward among the plants and to each side spreading so as to cover a swath width of about 75 feet. If a slight breeze occurred, the

width was increased to 100 or 125 feet. On the last application made August 18, the breeze was so strong that the dust was blown half the width of the farm, much of it drifting into an adjacent pasture.

When the breeze was with the line of flight, it was necessary for the pilot to fly a little higher going with the wind than when flying against it.

Discussion of Results at Wharton

Careful records of the yields of all plats were taken. The average yield of the treated plats of cuts A, B, E, and F, was 1,117 pounds of seed cotton per acre, and that of the untreated plats of the same cuts was 1,054 pounds per acre. The difference of 63 pounds per acre in favor of the treated plats is not great enough to be considered as very profitable for airplane dusting in this instance although it does indicate that a measure of weevil control was obtained.

The records of boll counts between August 7 and 25 show an increase of 18 per cent on the treated plats as compared with 11 per cent on the untreated plats. The third treatment on August 10 was applied to the whole farm to control leafworms and all the plats were dusted. This application undoubtedly had an effect upon the results of the experiment as far as yields were concerned, but the applications which were made for the purpose of controlling boll weevils alone resulted in very little profit to the owner.

The principal reasons why the grower failed to make a larger profit as a result of airplane dusting at Wharton in 1926, may be stated briefly as follows:

1. The infestation records prior to August 5 do not indicate that control measures should have been applied before that date, although two applications were made, July 27 and August 2.
2. The infestation on about 100 acres of the northern end of the farm did not increase to a stage that would warrant the application of control measures at any time.
3. At no time was the cotton dusted at the proper interval of 5 days, the intervals in this case being 6 and 8 days.
4. All applications to the south end of the farm were only partially effective because of the altitude at which the pilot flew in order to clear the trees, rising gradually from within the field instead of "zooming" suddenly at the margin. This defect was increased because of the drift of dust due to the light south breeze.
5. Dust when applied by an airplane in low fog is not properly distributed among the plants for best results in boll weevil control.
6. The quantity of calcium arsenate used, 8.41 pounds per acre per application, was considerably in excess of 5 pounds, the amount usually recommended.

INVESTIGATIONS ON THE ROGERS FARM*

General Conditions

The Rogers Acala Cotton Seed Breeding Farm is located at Allenfarm on the Brazos River about 11 miles west of Navasota and consists of approximately 4,000 acres, 1,800 of which were planted to cotton of the Acala variety. The remainder of the farm was in pastures and grains.

Excellent hibernation quarters for boll weevils are found in the woods and hedges adjoining the farm. Following a rather heavy spring emergence in 1927 the weather conditions proved to be favorable for weevils and by the middle of July the rank-growing plants shaded the middle of the rows providing protection for fallen infested squares against the rays of the sun.

The owner, returning after an absence, found that weevils were so abundant on a large part of the farm that his cotton crop was in danger of severe injury.

The case had the nature of an emergency and arrangements were made with the Quick Airplane Dusters, Inc., Houston, Texas, to have the cotton dusted by airplane. Two planes equipped for dusting arrived on July 26 and began work the next day.

The farm presents practically no obstructions to the operation of airplanes. Only a few trees are present and the tenant houses are far enough apart to permit dusting between without difficulty. Most of these houses are small and little attention was paid to them, the pilot simply hopping over the shacks without even cutting off the flow of dust. When the pilot passed over corn or grain-sorghum fields which occurred at various places on the farm, the dust flow was cut off.

The landing place was a smooth, large, alfalfa field without obstructions, near the center of the farm and permitted landing from any direction.

Plan of Work and Experiments

The experimental work on the Rogers Farm covered all the cotton grown on the place and was both intensive and broad in its nature. It was believed that a large-scale experiment which was afforded by this opportunity on a typical Brazos River plantation, would enable conclusions to be drawn that would be of great practical value in carrying out the threefold object of the investigations.

Forty-one marked points, including four points on the check area, representing the various cuts or cotton fields were located as indicated on the diagram of the farm (Figure 4). In the vicinity of these points infestation records were taken at regular intervals by counting 100 squares and noting the per cent which were punctured. From these records it was possible to determine the effect of dusting upon the abundance of boll weevils and upon their activity in producing injury.

*Data collected by J. C. Gaines, Jr., and P. A. Cunyus.

In other words a good picture of boll weevil activity on all parts of the farm was available throughout the dusting operations. In order to avoid the experimental error which might result from the selection of a few points to represent the conditions in large fields, surveys were made on each cut. At numerous unmarked points 25 or 50 squares were counted on the same day as at the marked points and the per cent of punctured squares recorded.

To arrive at a determination of the value of treatments applied and the profit resulting, a check plat or untreated area is essential. On the Rogers Farm an area containing 5.59 acres was chosen and was located as shown in the diagram (Figure 4). The soil and the cotton were typical of that on the rest of the farm.

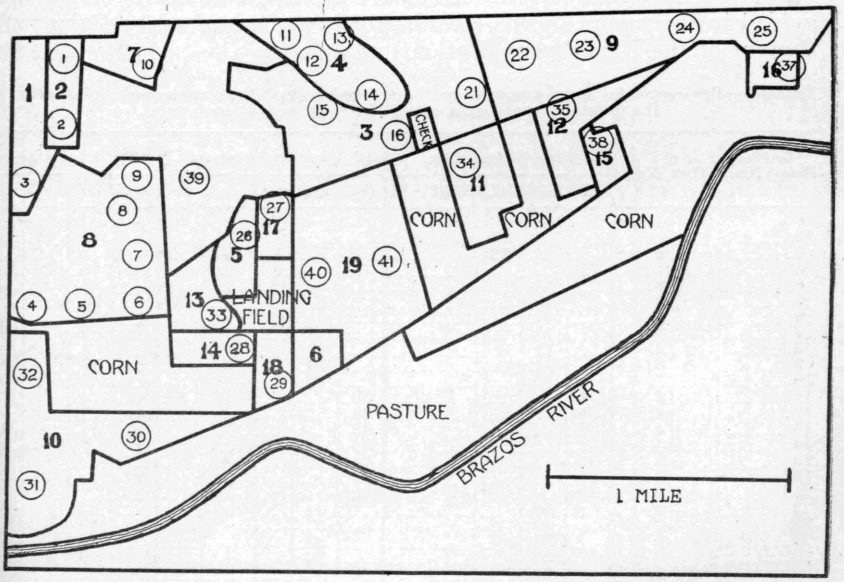

Figure 4.—Map of Rogers Farm. Locations of cuts are shown in heavy figures and the points where infestation records were obtained are indicated by light figures in circles.

The two planes were usually working at the same time and their operations were closely and carefully studied, a stop watch being used to aid in noting the actual dusting and flying time; attention was also paid to the act of loading.

The Airplanes Used on the Rogers Farm

Both the planes used on this farm were Standard J-1 manufactured by the Standard Aircraft Corporations. They were assembled and equipped for dusting cotton by the Quick Airplane Dusters, Inc., Houston, Texas.

Each plane had a 150 h. p. Hispano-suiza water-cooled motor, and a

fuel capacity for three hours flying. The wing spread was 42 feet 9 inches, giving the plane a lifting capacity of 800 pounds. The dust hopper was designed by G. C. Quick and was the same as that used at Wharton. The distribution and agitation of the dust were controlled in the same manner as in the airplanes used at Wharton.

Development of the Infestation

Infestation on the treated area: The infestation records were taken on the days when dust was applied and were carefully noted on a large map of the farm. This was available to the owner and the airplane pilots and proved very beneficial in conducting the work. The Quick Airplane Dusters, Inc., who contracted for the job of dusting the Rogers Farm, did not have an entomologist in their organization and were guided in their work by the records which were obtained by Gaines and Cunyus of the Experiment Station.

Table 1.—Per cent infestation recorded on the treated area at the various points indicated on the diagram, based on a count of 100 squares at each point.

Point No.*	Cut No.	First Infestation					Second Infestation					Third Infestation			
		7–27	7–28	7–29	7–30	7–31	8–1	8–2	8–3	8–4	8–5	8–6	8–7	8–8	8–9
1	2			17					7					8	
2	2			19					13					11	
3	1	51					42					37			
4	8		42					35					31		
5	8		45					33					22		
6	8		46					31					33		
7	8		15					11					9		
8	8		12					10					8		
9	8		41					32					19		
10	7		26					22					9		
11	4	36					30					12			
12	4	51					35					31			
13	4	56					46					21			
14	4	47					45					19			
15	3	36					24					7			
16	3	39					21					22			
21	3	39					25					15			
22	9		60					41							
23	9		43					37					19		
24	9		72					52					57		
25	9		31					22					10		
26	5		50				38					20			
27	17				14					20					
28	14				25					5					4
29	18				11					16					
30	10				39					28					10
31	10				42					27					14
32	10				35					21					8
33	13				45					23					4
34	11				36					19					12
35	12				17					9					2
36	12				38					22					9
37	16					27					40				12
38	15					26					16				16
Average infestation per point		36.14%					26.41%					16.48%			

*Points numbered 39, 40 and 41 not included, as they only received one application.

Table 1 is a record of the infestations on the treated area, taken by the point method. When this method was used, definite marked points

indicated by small figures on the diagram of the farm (Figure 4) were visited at regular intervals and 100 squares counted in the vicinity of each point.

The average infestation for the entire treated area at the time the first application was made was 36.14 per cent, ranging from 11 to 72 per cent. Five days after the first application of dust was made, an average of 26.41 per cent of the squares were punctured. From August 6 to 9, following two applications and ten days after dusting was started, the average infestation was 16.48 per cent, ranging from a minimum of 2 per cent to a maximum of 57 per cent. In ascertaining the extent of each of the first two infestations, 3400 squares were counted; in ascertaining the extent of the third infestation, 3100 squares were counted.

When the infestation was taken by the survey method 25 or 50 squares were counted at various unmarked points while walking through the cuts in somewhat of a circling course. Table 2 is a record of the infestation in the cuts as taken by the survey method.

Table 2.—Per cent of infestation recorded in the various cuts of the treated area by the survey method.

Cut No.	No. Acres	Squares Examined	First Infestation					Second Infestation					Third Infestation				
			7-27	7-28	7-29	7-30	7-31	8-1	8-2	8-3	8-4	8-5	8-6	8-7	8-8	8-9	8-10
1	60	500	33	....	....	....	....	24	....	....	....	....	12	....	....	....	....
2	40	300	....	....	28	....	....	....	....	20	....	....	....	....	8	....	....
3	163	2000	39	....	....	....	....	33	....	....	....	....	22	....	....	....	....
4	79	800	65	....	....	....	....	40	....	....	....	....	29	....	....	....	....
5	33	300	47	....	....	....	....	29	....	....	....	....	13	....	....	....	....
6	29	300	29	....	....	....	....	29	....	....	....	....	19	....	....	....	....
7	34	200	....	40	....	....	....	....	27	....	....	....	....	16	....	....	....
8	192	1800	....	37	....	....	....	....	26	....	....	....	....	13	....	....	....
9	128	1300	....	40	....	....	....	....	31	....	....	....	....	29	....	....	....
10	130	1200	....	....	....	37	....	....	....	....	23	....	....	....	....	12	....
11	50	400	....	....	....	35	....	....	....	....	22	....	....	....	....	13	....
12	50	400	....	....	....	24	....	....	....	....	19	....	....	....	....	7	....
13	20	200	....	....	....	38	....	....	....	....	25	....	....	....	....	9	....
14	30	300	....	....	....	....	6	....	....	....	....	18	....	....	....	....	6
15	25	300	....	....	....	....	15	....	....	....	....	16	....	....	....	....	10
16	20	200	....	....	....	....	34	....	....	....	....	33	....	....	....	....	21
17	25	300	....	....	....	14	....	....	....	....	14	....	....	....	....	....	....
18	35	400	....	....	....	14	....	....	....	....	17	....	....	....	....	....	....
Weighted averages			36.15%					26.97%					17.35%				

Importance of Infestation Records: A comparison of the two methods of taking infestations should be of particular interest to companies or corporations planning to control boll weevils through the distribution of poison by airplanes. It would be advisable for such companies to have in their employ entomologists whose business would be to go over the farm and take records of the infestation. With the information thus obtained, the grower and the airplane company can intelligently plan the work to be done and can better keep in touch with what is actually being accomplished. Because a knowledge of the boll weevil infestation is essential in successfully directing the movements and activity of airplanes which may be used in distributing poison, a brief comparison of the two methods is given in Table 3.

Table 3.—Comparison of the boll weevil infestations taken by two different methods on the same dates.

Method Used	Points Visited	Cuts Visited*	Area Covered*	Squares Examined	Average Infestation for Treated Area*		
					1st Infestation July 27–31	2nd Infestation August 1–5	3rd Infestation August 6–10
Point Method	34 on 1st and 2nd 31 on 3rd Inf.	17 on 1st and 2nd 16 on 3rd Inf.	1114 Acres on 1st and 2nd Inf. 1054 Acres on 3rd Inf.	3400 on 1st and 2nd Inf. 3100 on 3rd Inf.	36.14%	26.41%	16.48%
Survey Method		17 on 1st and 2nd Inf. 16 on 3rd Inf.	1114 Acres on 1st and 2nd Inf. 1054 Acres on 3rd Inf.	10900 on 1st and 2nd Inf. 10200 on 3rd Inf.	36.15%	26.97%	17.35%

*Cut No. 6 not included; no point located there.

In general, the infestation records as taken by the two methods are practically the same, although less than one-third as many squares were examined in taking the infestation by the point method as when taking it by the survey method. When the marked points, used in the point method, are properly placed and when they do not represent too large an acreage, they give a good idea of average conditions in the cuts, although the survey method of taking an infestation is obviously to be preferred if time permits.

A further comparison of the infestations as taken by the two methods shows that the greatest variations existing between them occur in the infestations for Cut Number One. This is a 60-acre cut and was represented by only one point located near one end. At least three points should have been located in this cut, which was in the corner of the farm. For large-scale operations there should be a point for every 25 or 30 acres when the infestations are taken by the point method.

Infestation on the Untreated Area: The infestation on the check or untreated area averaged 42.5 per cent on July 29th when first taken, 48.5 per cent five days later, and 51.5 per cent August 8th when taken the last time. Four points were used in taking these infestations, details of which are given in Table 4.

Table 4.—Per cent of infestation recorded on the check or untreated area, based on a count of 100 squares at each point.

Point No.	First Infestation July 29	Second Infestation August 3	Third Infestation August 8
17	51	55	53
18	42	49	51
19	36	38	39
20	41	52	63
Average	42.5%	48.5%	51.5%

Figure 5 shows a comparison of the average infestations on the treated and the untreated areas of the Rogers Farm.

Application of the Dust

At the request of the owner, all applications were made while dew was on the plants. Dusting usually began at daylight and ended about 7:30 a. m., when the breeze began to rise. When dusting the cotton, the pilots flew back and forth laying down a dust cloud in parallel swaths slightly overlapping and usually at right angles to the drift. The width of the swaths varied according to the drift, ranging up to 300 feet, the average width being between 70 and 100 feet. At this width there seemed to be a good distribution of dust when $6\frac{1}{2}$ pounds were applied to the acre.

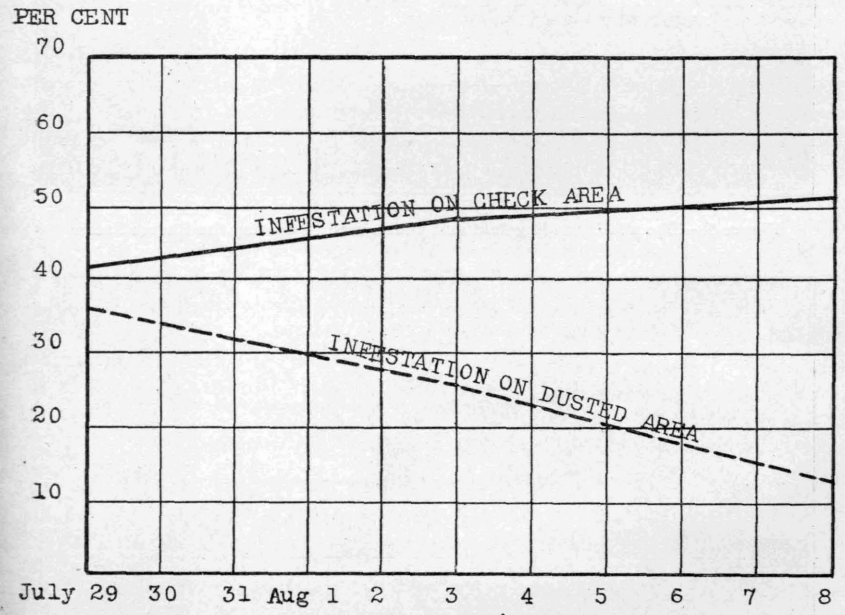

Figure 5.—The average boll weevil infestation on the dusted area of the Rogers Farm indicated by the broken line compared with the infestation on the check area, indicated by the solid line.

In order to insure a good application of the dust on all plants, the planes would not only zoom at the end of each swath, thereby forcing the dust downward among the plants at the edge of the field, but would lay down an extra swath around the cut.

The height of flying was 3 to 15 feet above the cotton, depending on atmospheric conditions; the flying speed was from 70 to 90 miles per hour.

In dusting the cotton on the Rogers farm the airplanes carried 300

pounds of calcium arsenate per load. It required from 10 to 21 minutes of flying time before the load was distributed. The actual dusting of cotton consumed only about one-fifth of the flying time, the remainder being used in turning at the end of each swath and in going from and returning to the landing field in the center of the farm.

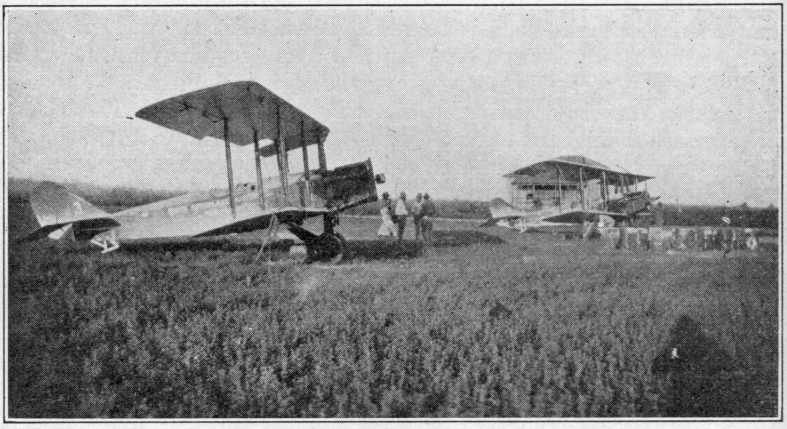

Figure 6.—The alfalfa landing field and planes used in dusting the Rogers Farm.

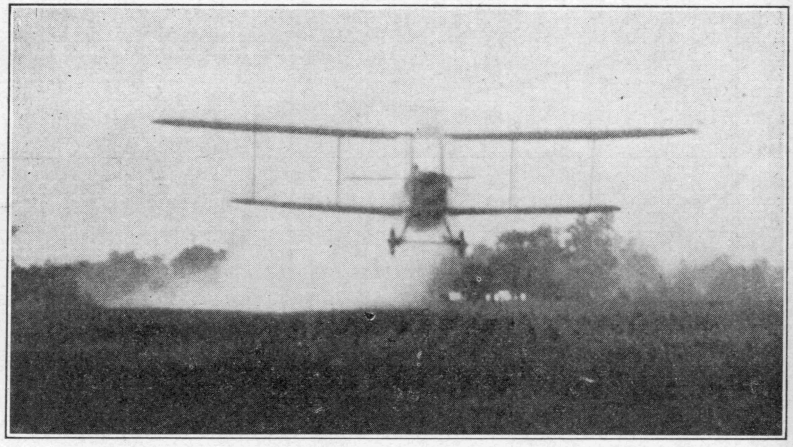

Figure 7.—Plane in operation. Note axle type of landing gear.

Tables 5 and 6 contain detailed records of the work carried on by each of the two planes and the weather conditions which occurred from July 22 to August 10. Airplane Number 3 was delayed at times because of agitator trouble; Plane Number 6 had no trouble and was not delayed at any time. Only one of the pilots had previous experience

in cotton dusting, but both did excellent work and attempted to give an even distribution of poison throughout, even going back over a field in some cases and flying at right angles to the course first taken in order to insure a thorough application.

Table 5.—Records of dusting operations of airplane No. 3.

Date, 1927	Cuts No.	Acreage Covered	Flying Time, Minutes	Calcium Arsenate Used, Lbs.	No. Lbs. Per Acre	Starting Time, A. M.	Direction of Wind	Amount of Dew
July 27	4, 5, 6	144	122	900	6.2	5:42	South	Heavy
July 28	9	128	60	900	7.0	5:24	South	Heavy
July 29								
July 30	10, 12, 13	200	114	1450	7.0	5:30	South	Heavy
July 31	15, 16	45	20	300	6.6	5:50	S. W.	Light
Aug. 1	4, 5, 6, 3 (part)	174	92	1250	7.0	5:37	S. W.	Medium
Aug. 2	9	128	97	900	7.0	5:34	South	Medium
Aug. 3	19	152	65	850	5.6	5:34	S. W.	Heavy
Aug. 4	10, 12, 13, 18	230	111	1450	6.3	5:39	South	Heavy
Aug. 5	14, 15, 16	75	50	500	6.6	5:29	North	Heavy
Aug. 6	4, 5, 6, 3 (part)	174	67	1050	6.0	5:33	S. W.	Medium
Aug. 7	9	128	68	900	7.0	5:24	South	Medium
Aug. 8	2 A	42	27	300	7.1	5:59	South	Medium
Aug. 9	10, 12, 13, 18	230	80	1500	6.5	5:41	South	Heavy
Aug. 10	14, 15, 16, 13	95	55	735	7.7	5:38	South	Medium
	Totals	1945	1028	12985				
	Average for 14 days				6.67	5:37		

Table 6.—Records of dusting operations of airplane No. 6.

Date, 1927	Cuts No.	Acreage Covered	Flying Time, Minutes	Calcium Arsenate Used, Lbs.	No. Lbs. Per Acre	Starting Time, A. M.	Direction of Wind	Amount of Dew
July 27	1, 3	220	118	1500	6.8	5:43	South	Heavy
July 28	7, 8	226	93	1450	6.4	5:30	South	Heavy
July 29	2A, 3A, 2	147	87	1150	7.8	5:38	S. E.	Heavy
July 30	1A, 11, 17, 18	200	114	1300	6.5	5:30	South	Heavy
July 31	14	30	18	180	6.0	5:54	S. W.	Light
Aug. 1	1, 3 (part)	190	82	1150	6.0	5:40	S. W.	Medium
Aug. 2	7, 8	226	97	1450	6.4	5:34	South	Medium
Aug. 3	2A, 3A, 2	147	77	900	6.2	5:33	S. W.	Heavy
Aug. 4	1A, 11, 17	170	115	1200	7.0	5:40	South	Heavy
Aug. 5								
Aug. 6	1, 3 (part)	190	72	1160	6.0	5:41	S. W.	Medium
Aug. 7	7, 8	226	86	1450	6.4	5:25	South	Medium
Aug. 8	3A	65	34	400	6.1	5:59	South	Medium
Aug. 9	11	50	20	300	6.0	5:46	South	Heavy
Aug. 10								
	Totals	2087	1013	13590				
	Averages for 13 days				6.51	5:39		

The records show that Plane Number 3 during 14 days of operation dusted 1945 acres of cotton in a total flying time of 1028 minutes (17.1 hours). This plane averaged working 1.22 hours per day, dusting 138.9 acres per day, or an average of 113.85 acres per hour, putting on an average of 6.67 pounds of calcium arsenate per acre.

Plane No. 6 during 13 days of operation dusted 2087 acres of cotton in a total flying time of 1013 minutes (16.8 hours). This plane

averaged working 1.29 hours per day, dusting 160.5 acres per day or an average of 124.4 acres per hour putting on an average of 6.51 pounds of calcium arsenate per acre.

Yield of Cotton on the Rogers Farm

On August 8 a record was taken of the number of bolls per plant on the treated area. At 17 points in ten cuts, a total of 1048 bolls were counted on 170 plants. The plants averaged 6.1 bolls each, ranging from a minimum of 2.1 bolls per plant in Cut Number 3 to a maximum of 8.4 bolls per plant in Cut Number 10.

The whole farm is devoted to the project of breeding and improving Acala cotton, and the yields of different cuts are carefully recorded. Careful surveys to determine the exact acreage in the different cuts on the farm had previously been made, and are included in Table 7, which also contains detailed records of the cotton yields on the main portion of the Rogers Farm.

Table 7.—Acreage and yield of cuts on dusted area of the Rogers farm.

Cut No.	Acres	Pounds Seed Cotton	Pounds Lint Cotton	Number of 500 Lb. Bales	Pounds Seed Cotton Per Acre	Pounds Lint Cotton Per Acre
1 and 2	100	70,326	22,975	45.95	703	229
3	163	130,517	40,860	81.72	800	250
4	79	49,991	15,751	31.50	632	199
5	33	16,970	4,595	9.19	514	139
6	29	15,290	4,596	9.19	527	158
7	34	23,138	7,214	14.43	680	212
8	192	110,795	35,087	70.17	577	182
9	128	91,520	26,624	53.24	715	208
10	130	103,931	30,487	60.97	799	234
11	50	37,290	11,095	22.19	745	221
12	50	33,074	10,092	20.18	661	201
13	20	16,530	5,291	10.58	826	264
14	30	15,820	5,070	10.14	527	169
15	25	16,150	4,425	8.85	646	177
16	20	9,750	3,148	6.29	487	157
17	25	30,070	10,250	20.50	1,202	410
18	35	24,516	7,892	15.78	700	225
Entire dusted area	1,143	795,678	245,452	491.87	696	215

Three applications of calcium arsenate were made on 1143 acres to control boll weevils. A total of 795,678 pounds of seed cotton was produced, the average being 696 pounds per acre. The smallest yield of 487 pounds of seed cotton per acre was made in Cut Number 16. The largest yield of 1202 pounds per acre was made in Cut Number 17. This cut was the breeding block, and it received special care and attention. Although included in Table 7, Cut Number 17 is eliminated from the following totals showing a comparison in yields of cotton on the dusted and untreated areas.

The average increase in production of cotton on 1118 acres was 79 pounds of lint per acre, which amounted to a total gain on this acreage of 176 bales of 500 pounds each due to dusting.

Table 8.—Comparison of cotton yields on dusted and untreated areas of Rogers farm, 1927.

	Acres	Pounds Seed Cotton	Pounds Lint Cotton	Pounds Seed Cotton Per Acre	Pounds Lint Cotton Per Acre
Dusted	1,118	765,608	235,202	684	210
Not dusted	5.59	2,675	735	478	131
Difference in favor of dusted area				206	79

In connection with the comparisons of yields, it is also interesting to note that the average production of each dusted field or cut was in every case higher than the yield of the untreated or check area. Furthermore, the dusted cotton of Cut Number 3, in which the check area was located, produced 119 pounds of lint per acre more than the cotton on the check area, where the boll weevils were not controlled.

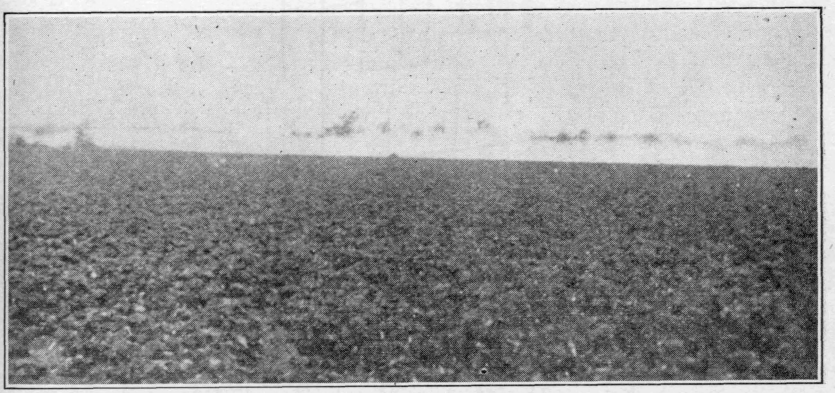

Figure 8.—Distant view of plane laying down a swath on the Rogers Farm.

These differences in yield in favor of the dusted cotton are larger than would ordinarily be expected, and if control operations had started two weeks earlier the differences would undoubtedly have been even greater.

The reasons for such large gains in yield in favor of the dusted cotton may be found in the rich, fertile soil of the Brazos River bottom and in the fact that the infestation of boll weevils was unusually heavy. Then, too, the applications of calcium arsenate were thorough and were made at the proper intervals.

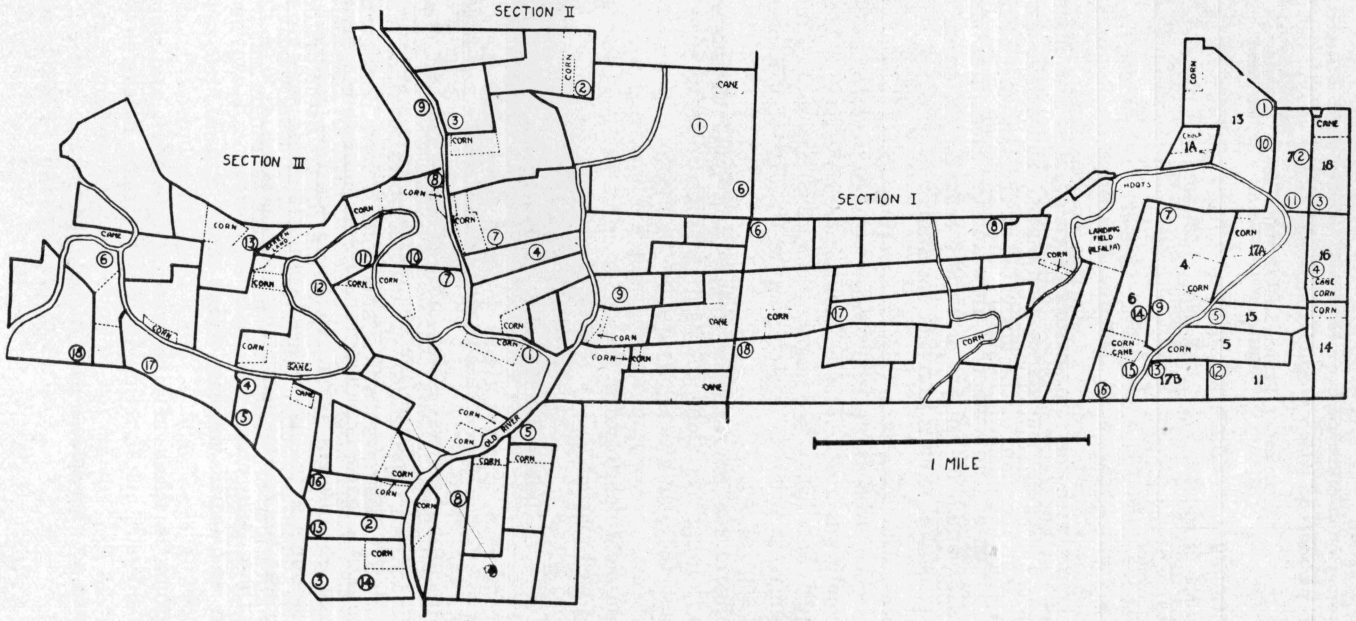

Figure 9.—Map of J. O. Chance Plantation. Locations of points where infestation record were obtained are indicated by numbers in the circles.

INVESTIGATIONS ON THE CHANCE PLANTATION*

General Conditions

The third place on which airplane dusting was observed and records taken was the J. O. Chance plantation, located in Burleson County on the west bank of the Brazos River about twelve miles from College Station. This plantation extends back from the river for more than four and one-half miles and, with the exception of a small portion of the western end, it consists entirely of river bottom land. The width is very irregular, some cuts or fields extending northward along creek bottoms for a considerable distance. Woods occur for three-fourths of the distance along the northern boundary and along one-third of the distance on the southern boundary. In 1927 this plantation had a little less than 3000 acres in cotton and about 400 acres in other crops.

The J. O. Chance plantation is typical of most of the Brazos bottom cotton farms, which are usually large holdings of good land capable of producing good crops of cotton under normal conditions. Whenever climatic conditions are favorable for the multiplication of boll weevils, severe injury and heavy loss result. On such farms or plantations it is easy to make a profit by dusting cotton when the conditions warrant the use of control measures.

Good hibernation quarters for weevils are found in the woods and pastures adjoining and along the banks of the two small streams which flow through the plantation. With more than a 5 per cent spring emergence of weevils, according to the records for this vicinity and with early cotton on which to work, the opportunity was good for an infestation to get well started.

Infestation Usually An Emergency

While conducting investigations in connection with the cotton flea hopper on this plantation, it was noticed that some of the cotton near the experimental plats was being injured and that boll weevils were multiplying rapidly. The attention of the owner was called to this condition and on July 7, at his request, infestation records were taken in representative fields on all parts of the plantation. Squares were examined at 57 different points and an average of 30.2 per cent was found to be punctured. There was no infestation in several cuts where the cotton was young or where it had been stunted as a result of overflow. In those cuts which were partially surrounded by woodland the infestation was nearly complete, being more than 75 per cent in some places.

Good ground machines of the traction type were available, but the owner considered this situation to be very much in the nature of an

*Data collected by Franklin Sherman III and C. J. Dodd.

emergency and believed that only airplane application of dust could save him from suffering heavy loss as a result of boll weevil injury.

By cooperating with a neighbor, George Chance, manager of the plantation, made arrangements with the Huff-Daland Dusters, Inc., of Monroe, Louisiana, and two planes arrived at the farm on July 11.

Large supplies of calcium arsenate were available on the plantation, but application of the dust was delayed two days while waiting for a supply of high-test gasoline to refuel the planes. This delay was practically the only one that held up the work on the Chance plantation.

A great majority of the requests for airplane dusting in Texas will undoubtedly occur only in cases of emergency and special precautions should be taken to avoid, if possible, anything which might contribute to a delay in the application of the dust. When the infestation is already high and the weather conditions are favorable for multiplication of the weevils, delays are costly and may mean the difference between profit and loss.

Plan of Work

The main reason for engaging in the work offered by airplane dusting on the Chance plantation was the opportunity to observe the activities of planes of the Huff-Daland Dusters, Inc. This firm was one of the largest and best equipped corporations conducting commercial cotton-dusting operations in Texas. Another reason was the opportunity presented for obtaining additional records of the work and results where commercial control of the boll weevil was attempted on a large scale.

Infestation percentages, bloom counts, and other records were taken at 45 points scattered throughout the cotton-growing area of the plantation, in addition to similar records taken at 12 points on the check or untreated area. It was inconvenient to have more than one untreated area for comparison. This was located near the eastern end of the plantation and contained 10.15 acres. Because of the location of the check and the length of the plantation, it was not expected that yields obtained on the check could be compared with those obtained on the whole plantation, but that comparisons would only be correct for that section in which the check area was located. The usual records were taken at regular intervals on the whole plantation, however, for the purpose of noting the condition in the infestations of the various sections where injury was apparent or where it might occur. In addition, detailed records of airplane operations were obtained.

The Airplanes Used on the Chance Plantation

The planes used on the J. O. Chance and neighboring plantations were manufactured by the Huff-Daland Dusters, Inc., Monroe, Louisiana. They were especially designed for dusting and were equipped with the Wright Whirlwind, 200 h.p., air-cooled motors. The fuselage of each was of all metal construction, and the wings were of the high-

lift type. Each plane carried a load of 500 pounds of calcium arsenate and was operated at a speed of 80-90 miles per hour.

The dust hopper was built inside the fuselage in front of the pilot's cockpit. It was filled through an opening at the top, which could be closed by means of a lid hinged in front. The dust in the hopper was constantly stirred just above the outlet at the bottom by a stout agitator driven by a small windmill propeller fixed on the lower wing of the plane. The opening through which the dust was delivered extended across the width of the fuselage and was opened or closed by a slide or feeder valve operated by the pilot, who also regulated the flow of dust so that the desired poundage per acre could be applied.

Beneath the fuselage and just in front of the dust outlet in the hopper there was a wide, slightly funnel-shaped Venturi opening or nozzle which served to increase and control the air blast just below the outlet. This opening was so constructed that it received the rush of air in the larger front portion. As the air was forced out of the narrower rear opening, in front of the dust outlet in the hopper, it was directed slightly downward and had an accelerated velocity. The result was a partial vacuum in a small space immediately below the dust outlet, facilitating the flow of dust and causing it to be caught in the tremendous blast from the Venturi nozzle and broken up into extremely fine particles. This type of nozzle aids in giving a thorough distribution of dust and in causing the poison to adhere to the cotton plants.

Infestation on Dusted and Untreated Areas

When the preliminary survey was made July 7, the infestation on the plantation, as noted above, averaged 30.2 per cent. In order to note the degree and progress of the infestation on the dusted area of the plantation as a whole, records were taken at 45 scattered points (Figure 9). In the vicinity of these points 100 squares were counted at intervals of about five days. The progress of this infestation as taken is recorded in Table 9. During the first two weeks after dusting began there was a general reduction in the punctured squares from 34.29 per cent on the first infestation to 12.51 per cent on the fourth, considering the plantation as a whole. The slight increase on the last or fifth infestation is undoubtedly due partly to weevil migration which had begun and to the fact that at 4 of the 45 points treatment had been needed, but dust applications had been either irregular or had not been started early enough. An interval of nine days or more had elapsed since the last application at three additional points.

In the check or untreated area of 10.15 acres, records were taken at 12 points. The average infestation on this area is shown in the graph (Figure 10) and is also compared with the infestation on the area dusted regularly on Section I and with the infestation on the dusted area of the plantation as a whole.

Table 9.—Records showing per cent of infestation and dates on which dust applications were made to various points on J. O. Chance Plantation.

	Point Number	1st Inf.		2nd Inf.			3rd Inf.			4th Inf.			5th Inf.			Dates of Dust Applications						
		July		July			July			July Aug.			Aug.			1st Appl.	2nd Appl.	3rd Appl.	4th Appl.	5th Appl.	6th Appl.	7th Appl.
		15	16	19	20	21	22	25	27	30	31	1	3	4	5							
		%	%	%	%	%	%	%	%	%	%	%	%	%	%							
SECTION I	1	45	..	34	..	..	25	..	..	22	..	..	48	..	..	7/14	7/19	7/24	.....	8/ 4	.....	.....
	2	57	..	38	..	..	20	..	..	6	..	..	9	..	..	7/14	7/19	7/24	.....	8/ 4	.....	.....
	3	12	..	9	..	..	13	..	..	5	..	..	15	..	..	7/14	7/19	7/24	.....	8/ 4	.....	8/15
	4	14	..	10	..	..	17	..	..	8	..	..	4	..	..	7/14	7/19	7/24	.....	8/ 4	.....	8/15
	5	40	..	23	..	..	8	..	..	6	..	..	6	..	..	7/15	7/19	7/24	.....	8/ 4	.....	8/15
	6	21	..	13	..	..	18	..	..	12	..	..	24	..	..	7/15	.....	.....	8/ 2	.....	8/10	.....
	7	29	..	21	..	..	13	..	..	17	..	..	28	..	..	7/14	7/19	7/24	7/29	8/ 4	.....	8/15
	8	45	..	30	..	..	22	..	..	13	..	..	6	..	..	7/15	7/19	7/24	7/29	8/ 3	8/10	.....
	9	19	..	16	..	..	11	..	..	7	..	..	13	..	..	7/15	7/19	7/24	7/29	8/ 4	.....	8/15
	10	.....	..	33	..	..	11	..	..	3	..	..	19	..	..	7/14	7/19	7/24	.....	8/ 4	.....	.....
	11	.....	..	34	..	..	11	..	..	11	..	..	41	..	..	7/14	7/19	7/24	.....	8/ 4	.....	.....
	12	.....	..	9	..	..	4	..	..	2	..	..	7	..	..	7/15	7/19	7/24	.....	8/ 4	.....	8/15
	13	.....	..	1	..	..	2	..	..	2	..	..	8	..	..	7/15	7/19	7/24	.....	8/ 4	.....	8/15
	14	.....	..	7	..	..	11	..	..	5	..	..	14	..	..	7/15	7/19	7/24	7/29	8/ 4	.....	8/15
	15	.....	..	13	..	..	10	..	..	13	..	..	10	..	..	7/15	7/19	7/24	7/29	8/ 4	.....	8/15
	16	.....	..	3	..	..	11	..	..	5	..	..	3	..	..	7/15	7/19	7/24	7/29	8/ 4	.....	8/15
	17	.....	..	11	..	..	9	..	..	7	..	..	8	..	..	.....	.....	7/28	8/ 3	.....	8/10	.....
	18	.....	..	43	..	..	23	..	..	39	..	..	40	..	..	.....	.....	7/28	8/ 3	.....	8/10	.....
SECTION II	1	.....	..	8	..	..	..	5	..	..	7	..	..	..	5	7/16	7/21	7/27	.....	.....	8/12	.....
	2	.....	..	22	..	..	18	..	..	19	..	..	31	..	28	7/16	.....	.....	8/ 2	.....	.....	.....
	3	.....	..	29	..	..	24	..	..	9	..	..	4	..	9	7/16	7/21	7/27	.....	.....	.....	.....
	4	.....	..	9	..	..	14	..	..	14	..	..	23	..	15	7/16	7/21	7/27	.....	.....	.....	.....
	5	.....	..	33	..	..	28	..	..	21	..	..	27	..	17	7/15	7/21	7/26	8/ 1	.....	.....	.....
	6	.....	..	23	..	..	15	..	..	6	..	..	2	..	7	7/16	7/21	7/27	.....	.....	8/10	.....
	7	.....	..	.....	..	..	35	..	..	10	..	..	1	..	10	7/16	7/21	7/27	8/ 2	.....	8/12	.....
	8	.....	..	.....	..	..	14	..	..	21	..	..	7	..	14	7/15	7/21	7/26	8/ 1	.....	.....	.....
	9	.....	..	.....	..	..	41	..	..	12	..	..	21	..	4	.....	.....	7/27	8/ 3	.....	8/10	.....
SECTION III	1	.....	40	..	24	..	..	17	..	..	11	..	..	4	..	7/16	7/22	.....	7/31	.....	.....	.....
	2	.....	8	..	10	..	..	3	..	..	5	..	..	2	..	7/15	7/20	7/25	7/31	.....	.....	.....
	3	.....	79	..	67	..	..	23	..	..	3	..	..	25	..	7/15	7/20	7/25	7/31	.....	.....	.....
	4	.....	26	..	16	..	..	8	..	..	1	..	..	8	..	7/16	7/21	7/26	7/31	.....	.....	.....
	5	.....	80	..	67	..	..	36	..	..	6	..	..	21	..	7/16	7/21	7/26	7/31	.....	.....	.....
	6	.....	46	..	35	..	..	33	..	..	22	..	..	10	..	7/16	7/21	7/26	7/31	.....	.....	.....
	7	.....	19	..	14	..	..	5	..	..	11	..	..	11	..	7/16	7/21	7/26	7/31	.....	.....	.....
	8	.....	48	..	26	..	..	11	..	..	20	..	..	8	..	7/16	7/21	7/26	7/31	.....	.....	.....
	9	.....	71	..	51	..	..	28	..	..	8	..	..	27	..	7/16	7/21	7/26	7/31	.....	.....	.....
	10	.....	.....	..	43	..	..	18	..	..	17	..	..	7	..	7/16	7/21	7/26	7/31	.....	.....	.....
	11	.....	.....	..	39	..	..	18	..	..	29	..	..	17	..	7/16	7/21	7/26	7/31	.....	.....	.....
	12	.....	.....	..	49	..	..	26	..	..	2	..	..	7	..	7/16	7/21	7/26	7/31	.....	.....	.....
	13	.....	.....	..	75	..	..	40	..	..	29	..	..	53	..	7/16	7/21	7/26	7/31	.....	.....	.....
	14	.....	.....	..	77	..	..	40	..	..	37	..	..	23	..	7/15	7/20	7/25	7/31	8/ 6	.....	.....
	15	.....	.....	..	51	..	..	18	..	..	14	..	..	7	..	7/15	7/20	7/25	7/31	.....	.....	.....
	16	.....	.....	..	5	..	..	2	..	..	2	..	..	6	..	7/15	7/20	7/25	7/31	.....	.....	.....
	17	.....	.....	..	35	..	..	42	..	..	7	..	..	11	..	7/16	7/21	7/26	7/31	8/ 6	.....	.....
	18	.....	.....	..	33	..	..	14	..	..	33	..	..	41	..	7/16	7/21	7/26	7/31	.....	.....	.....
Average		34.29		28.04			16.17			12.51			16.33			July 14–16	July 19–21	July 24–27	July 29 to Aug.3	Aug. 4–6	Aug. 10–12	Aug. 15

Relation of blooming of cotton to the infestation: The blooming of cotton also furnished a good index to the extent of boll weevil injury. Table 10 contains a record of the number of blooms found on 1200 plants in the check area and on an equal number of plants in dusted cotton a short distance away. The same plants in each area were examined for blooms as long as the records were taken.

Table 10.—Occurrence of cotton blooms on 1200 plants in each of dusted and untreated areas.

Untreated Area		Dusted Area	
Date	No. Blooms on 1200 Plants	Date	No. Blooms on 1200 Plants
		July 14.....	636
July 18.....	512	July 20.....	1,090
July 21.....	728	July 22.....	1,445
July 25.....	758	July 26.....	1,459
July 28.....	736	July 28.....	2,077
Aug. 2.....	575	Aug. 2.....	2,009
Aug. 5.....	334	Aug. 5.....	1,776

A comparison of these records and their relation to the infestation is shown diagrammatically in Figure 10. Attention is called to the fact that the largest number of blooms occurred at about the time the infestation was lowest and that the smallest number of blooms on the check area occurred when the infestation was highest.

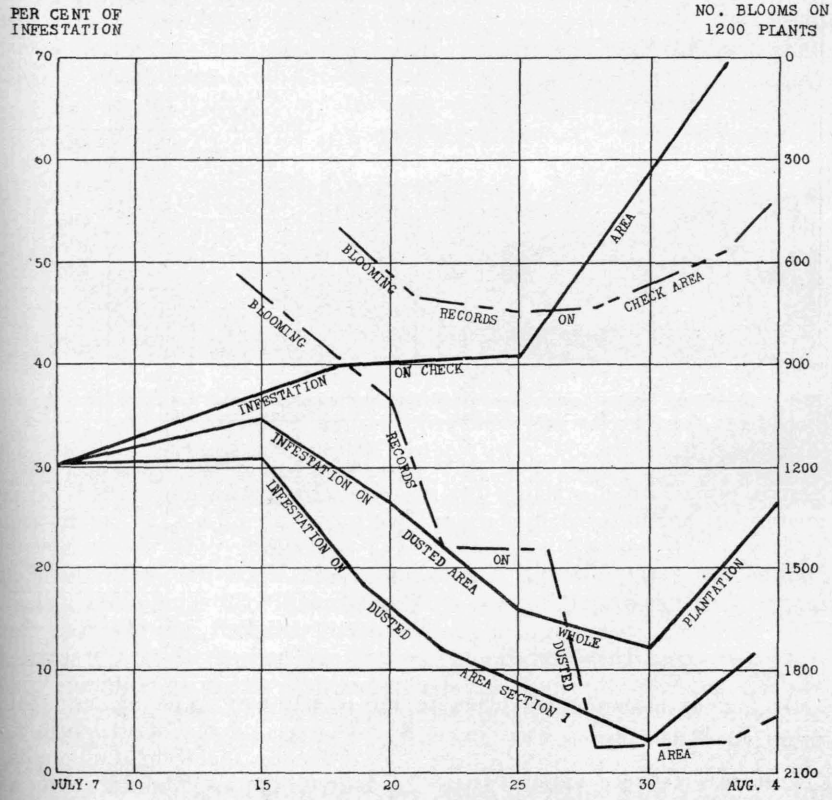

Figure 10.—Comparison of infestation records obtained on the dusted area of the plantation as a whole and on the area dusted regularly in Section I with the infestation obtained on the untreated check area. The blooming records on the treated and untreated areas are also compared and their relation shown to the infestation.

Application of the Dust

Area dusted and poison used: Two alfalfa fields were available for landing purposes. One was near the middle and the other near the east end of the plantation. By taking advantage of both of these fields the length of flights between loads was reduced, allowing time to be saved and the area to be dusted more rapidly.

Three to five applications for controlling boll weevils were made to approximately 2600 acres of the Chance plantation during the period July 14 to August 6. During 19 days of dusting on this place 51,700 pounds of calcium arsenate were used and a total of 8639 acre-applications were made. This averaged a little less than 6 pounds per acre and varied from 3.3 to 10.7 pounds per acre. The area covered each day averaged 454.68 acres, varying from 59 to 1110 acres.

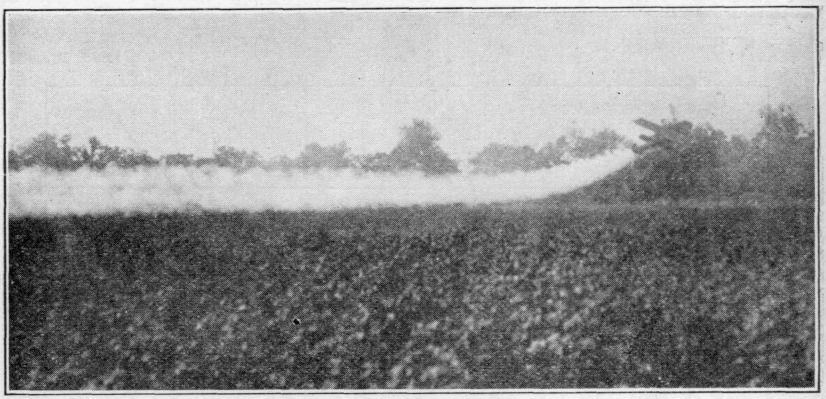

Figure 11.—Plane laying down a swath and just beginning to "zoom" so as to force the dust into the corner of a field on the J. O. Chance Plantation.

Most of the applications were put on early in the morning. Two planes, one of which was dusting an adjoining plantation, worked on an average of about two hours a day, beginning at 5:15 a. m., or as soon as it was light enough to see to fly and continuing until the dust cloud showed too great a drift. On one occasion, when the breeze held off longer than usual, dusting was continued until 8:30 a. m. After about 7:30 on bright days, even in the absence of wind, it was observed that as the air near the earth became warm and moved upward it carried with it much of the dust. A few times late-afternoon dustings were attempted, but air conditions were much less favorable than in early morning.

Intervals between applications: In general the applications were repeated every five days, but occasionally the pilot covered a larger or lesser area than on the previous application, which, accordingly, made the interval between dustings at several points either four or six days.

There were a few points where some of the applications were omitted. The dates on which applications were made to the various sections may be seen by referring to Table 9.

Thirty-nine of the 45 points selected as locations for the purpose of taking observations received the first three applications of dust. Five-day intervals or less occurred between the applications at all except seven of these points, at which one of the intervals between the dustings was six days.

The fourth application covered 32 points and omitted 13. The interval between the third and fourth applications was five days at 18 points, six days at 10 points, and seven days at one point. The infestation at the time of the fourth application was above 15 per cent at 12 of the 32 points and also at one point where the application was omitted.

The fifth application was made to nearly all points of Section I, the east end of the plantation, but to only 2 points on the remaining sections. At this time only five of the dusted points and 11 of those not receiving this application had infestations above 15 per cent. The interval between dustings where the fourth and fifth applications had been made was five days at one point and six days at five points.

The sixth and seventh applications were scattering and were for the purpose of controlling the cotton leafworms.

Width of swaths: The dust was laid down in parallel swaths as the plane flew back and forth. The width of these swaths varied considerably, even under the same conditions, especially when there was nothing to aid the pilot in regulating the distance between them. This variation was greatest in large fields where long swaths were laid down, even though an experienced pilot was doing the work. For example, 85 swaths showed a variation in width of from 35 to 250 feet; the average width was 98 feet. When the size of the fields is not too large, the pilot can gauge accurately enough his swath width, but unless aided by some marking device on large fields, the variations may be so great that there will not be a uniform distribution of the dust. The width of the swaths is governed to a large extent by atmospheric conditions at the time of dusting. Good coverage may be obtained with swaths as wide as 200 feet, but the usual width is about 100 feet.

Rate of dust delivery: The high-powered motor enabled the pilot to "zoom" sharply at the edges of the fields and to turn in the air preparatory to laying down another swath without using much extra time.

In order to determine the relative importance of time during dusting, records were taken on the operation of the plane and on the distribution of poison. A computation of the acreage covered by these loads showed that between five and six pounds of dust were being applied per acre.

A stop-watch was used in recording the exact time during which dust was flowing from the hopper and also in obtaining the loading time.

The short time required for the plane to take off and to taxi into position for loading was not recorded.

Table 11.—Time required for airplane operations.

Number Loads	Average Loading Time	Average Flying Time Per Load	Average Dusting Time Per Load	Average Number Swaths Per Load
11	3′ 5″			
33			4′ 45″	10
59		14′ 30″		

A glance at the records in Table 11 shows that just about one-third of the flying time is spent in actually dusting the cotton, the remainder being occupied in turning and flying from and back to the landing field. The time required for turning at the end of each swath was remarkably uniform, varying only from 27 to 33 seconds on more than 50 turnings.

The actual flying time recorded on fifty-nine 500-pound loads averaged 14 minutes 30 seconds. One load was put out in 8 minutes from the time of taking off to the time of landing, and the longest time required was 23 minutes.

Weather conditions: The weather during the entire dusting season was practically ideal for control operations. There was but one rain during the dusting period; this amounted to 1.7 inches within 24 hours and washed off all applications. The fields were very muddy, so that the use of ground machines would have been impossible for several days. Even the plane had difficulty in taking off from one of the landing fields, but this was accomplished under a reduced load, and thereafter the other field was used. The area dusted on the morning following this downpour was 533 acres.

The rainfall for this section during May was below normal. During June and July the rainfall was respectively 2.15 inches and 1.17 inches above normal, being recorded on 14 of the 61 days in the two months. The occurrence of these rains was the main reason for the heavy boll weevil infestation.

Fog delayed the work one morning.

Most of August was hot and dry, a fact which aided in reducing the infestation, especially where the cotton was not very rank.

Area Protecting Capacity of Airplanes

A series of records was obtained in connection with the acreage covered and the flying time consumed by the two planes which were being used to dust the Brazos bottom farms in 1927. The figures are for early-morning dusting only and are summarized in the following table.

One of the pilots dusted on 24 consecutive days, the other dusted on 25 out of 26 days. A few times the work was stopped because of the

danger of overheating the motors, but the area covered averaged a little more than 500 acres per day.

Table 12.—Acreage covered by airplanes and flying time during early morning applications, 1927

Plane No.	Period of Operations	Total Days Recorded	Total Acreage Covered	Acreage Dusted in One Day Minimum and Maximum	Total Flying Time for Period of Operations	Flying Time in One Day Minimum and Maximum
1	July 14 to Aug 6	22	8,730	100 to 738	30 hours 42 min.	19 min. to 2 hours 8 min.
2	July 14 to Aug. 8	22	13,501	100 to 990	41 hours 21 min.	59 min. to 2 hours 52 min.
Av.	July 14 to Aug. 8	22	11,115	505 acres per day	36 hours 1 min.	1 hour 38 min. per day

One airplane, of the type used in dusting operations on the Chance plantation, if kept in good condition, would be capable of dusting 3000 to 4000 acres and repeating the applications at five-day intervals, providing weather conditions were favorable.

The acreage dusted in a given time on farms containing small fields would be less than when applications are made to farms where the fields are large enough to permit long dusting flights.

Yields of Cotton on Chance Plantation

The acreage and yields of the various cuts in the east half of Section I are given in Table 13. All of these cuts received from three to five applications of dust for boll weevil control.

The check or untreated area, also in the east half of Section I, produced 807 pounds of seed cotton or a little more than half a bale of lint per acre. This cut, unlike the others in this section, had previously been devoted to alfalfa production and, therefore, the soil was in good condition for cotton to grow.

The detailed records of yields for the various cuts in the east half of Section I show that the production of only two of the cuts (Nos. 11 and 18) fell below the average yield per acre of the check or untreated area. Poor soil conditions in these two cuts were evidently responsible for the low yields produced, since the maximum infestation did not exceed 13 per cent in either cut. This indicated that the boll weevil was not responsible for the low yields in Cuts 11 and 18.

Cut 13, nearest the check area, had a yield averaging 27 pounds of lint per acre more than the check. The increase per acre on the other dusted areas varied from 7 to 52 pounds of lint, and on the east half of Section I the average gain was 83 pounds of seed cotton or 21 pounds of lint per acre.

Table 13.—Acreage and yields of cuts, including the untreated area, in the east half of Section I of the Chance Plantation.

Cut No.	Acreage	Total for Cuts		Per Acre Yield	
		Pounds of Seed Cotton	Pounds of Lint Cotton	Pounds of Seed Cotton	Pounds of Lint Cotton
1A check	**10.15**	**8,191**	**2,597***	**807**	**256***
4	54.5	50,403	14,900	925	273
5	24.5	19,697	6,500	804	265
6	52.5	51,588	15,250	983	290
7	30.5	26,568	8,015	871	263
11	32.0	21,270	6,830	665	213
13	58.5	51,060	16,540	872	283
14	26.5	25,798	8,155	973	308
15	18.5	17,217	5,325	931	288
16	23.0	21,416	6,780	931	295
17a 17b	66.5	62,966	20,040	947	301
18	28.0	21.449	6,710	766	240
Average gain per acre				83	21

*Figures based on ratio and gin turn-out for Section I.

GENERAL CONSIDERATIONS

Tabular Summary of the Three Investigations

The information obtained while conducting the three separate investigations presented in this Bulletin is summarized in Table 14.

The Time to Begin Airplane Dusting in Texas

When boll weevils are puncturing 10 per cent of the squares in a field, the owner should realize that it is time to consider control measures, especially if weather conditions are favorable for weevil multiplication. A 10 per cent infestation early in the season is far more significant with respect to possible future injury than a similar infestation in August.

Natural control of the boll weevil, due to hot, dry weather in summer, occurs to a greater extent in Texas than in any other Gulf State. The average rainfall at 16 Weather Bureau Stations in Central Texas during the period of June, July and August varied from 2.60 inches to 16.99 inches in the ten years from 1919 to 1928, inclusive. The normal precipitation at these stations for the three months named is 7.90 inches. Boll weevil injury has not been generally severe except when the rainfall has been above the normal, a condition which has occurred six times in the ten-year period.

Since a large area can be dusted quickly by means of airplanes, and since weather conditions in Texas may change for the better, it would

Table 14.—Summary of the airplane investigations for boll weevil control.

Location	Airplane Company	Period of Airplane Applications	Number of Applications	Acreage Dusted	Number of Acre-Applications	Dosage Per Acre, Pounds	Amount of Poison Used, Pounds	Number Days on Which Dust was Applied	Flying Time, Hours	Intervals Between Applications	Area Protecting Capacity of Airplane, Acres	Average Infestation			Gain in Seed Cotton Per Acre on Dusted Area
												Beginning	End on Check	End on Dusted Area	
												%	%	%	Pounds
Roberts Farm at Wharton	Super Rhone Engine and Flying Corp., Houston, Texas	1926 July 27 to Aug. 18, incl...	4	400	1600	8.41	13456	6	.....	6 and 8 days	1200	7	28.41	10.33	63*
Rogers Farm near Navasota	Quick Airplane Dusters, Inc., Houston, Texas	1927 July 27 to Aug. 10, incl...	3	1143	3429	6.51	22322	14	28¾	5 days	1200	36.14	51.5	**16.48	206
J. O. Chance Plantation near College Station	Huff-Daland Dusters, Inc., Monroe, La.	1927 July 15 to Aug. 4.....	3 to 5	2736	8639	5.86	51700	19	25	Average 5 days	3500	34.29	69.1	16.33	83

*On ¾ of area, but no gain on ¼ of area.
**Infestation after two applications; no later infestations obtained.

not be advisable for the owner who is considering control measures to send for an airplane until the infestation is 15 per cent or unless the infestation is general over a large acreage. If it is the latter part of the season, it would be well to delay until 20 per cent of the squares are being punctured. Where reliance is placed in ground machinery for distributing the dust, control measures may well begin when the infestation is 10 per cent, and wherever ground machines are available they could be employed in early dusting to good advantage. This is especially important on the margins of a field surrounded by woodland.

General Principles Concerning Reduction of Infestation

Where dust applications have been properly made to control boll weevils, the uniformity of the results has been remarkable. On both the Rogers Farm and the J. O. Chance Plantation, where a total of nearly 12,000 acre-applications were made, the per cent of infestation ten days after the dusting was started and after two applications had been made, or on the date the third application was due, was approximately half as much as when the first application was made. In other words, two applications of calcium arsenate by means of airplanes reduced the boll weevil infestation 50 per cent. A third application would generally be necessary to reduce the infestation to a safe margin of control when the initial infestation averages 20 to 30 per cent. Three applications may be sufficient for bringing under control an infestation that in the beginning averages 30 to 40 per cent, but in most cases four applications will be advisable and profitable to the grower. Not less than four applications should be made when the initial infestation is found to average 40 to 50 per cent. When the infestation is above 50 per cent, the fight is long drawn out and often unsuccessful, but under ideal conditions five applications can be expected to reduce an infestation to about 15 per cent unless migrating weevils from untreated farms are numerous. This migration by adult weevils usually begins the latter part of July and increases in extent during August. The greatest benefit derived from dusting cotton where a high infestation occurred was that the weevils in those areas were prevented from spreading to other cotton.

The importance of making a big share of the cotton crop before weevil migration begins has been realized by most farmers. Therefore, when weevils are known to be injurious in any section, the farmers of that section should keep a close watch of the conditions on their own farms and not delay too long when control measures are warranted.

Usually punctured squares first appear in the fields near those places where conditions were favorable for the weevils to find shelter the preceding fall. Such places may be at the edges of woodlands, fence rows or near buildings. Where examinations of the squares are made and weevil injury is found severe enough to justify dusting, then it is advisable and usually profitable to poison the cotton around the edges of woodlands or other favorable shelter before the infestation becomes wide-

spread. Where large holdings are involved, such a procedure may save considerable outlay for poisoning later in the season.

In 1928 airplanes were used on several plantations in the Brazos River bottoms for poisoning the cotton around the edges, particularly near woods. Three to five applications or 750 acre-applications of this type were made early in July to 250 acres on the Chance Plantation and, in addition, 100 acres were dusted by ground machines. By taking this action, the weevil infestation was reduced and did not increase during the remainder of the season sufficiently to justify other applications. As a result, a top crop was made. The business-like grower not only realized a good profit, but had the advantage of being in immediate contact with an airplane company in case further work might be needed. Several growers on the larger plantations in the Brazos River bottoms decided to adopt this practice as a policy.

Advantages of Airplane Dusting

As a general rule, airplane dusting for boll weevil control would not be practical for the small farmer unless his cotton acreage was adjacent or close to other cotton where dust would be applied.

Airplane dusting has several distinct advantages where used on large cotton farms and when the boll weevil infestation warrants the use of control measures. Several advantages shown in this method of boll weevil control are the following:

1. Quick protection for a large acreage.
2. Easier for applications to be made at the proper intervals; muddy fields do not delay the work.
3. The objectionable night work necessary in covering large acreages when poison is applied by other methods is eliminated.
4. Teams and labor needed for the operation of ground machinery can be diverted to other farm work.
5. Better adapted than ground machines for dusting tall and rank-growing cotton.
6. In communities where boll weevils are only occasionally injurious, the airplane can be obtained during the years of more serious injury, thereby obviating the need for investment in machinery which would ordinarily be held in storage some years without being used.

Cost of Airplane Dusting

Many factors must be taken into account by the corporation when figuring the cost of airplane dusting. The more important items of cost are the following:

Constant Factors	Variable Factors
Interest on the investment	Distance of operations from headquarters of corporation
Depreciation on the motor and plane	Size of area to be dusted
Insurance against damage	Distance of landing field from dusting operations
Reserve equipment	Character of area to be dusted
Entomological advice	Number of applications
Pilot and mechanic	Operating expenses
Overhead	Poison used

There has been a wide range in the charges that have been paid by farmers for airplane dusting, depending upon the variable factors listed above and upon the type of service offered by the corporation as indicated by the list of constant factors. The minimum charge which is believed to have been asked in Texas for airplane application of dust was 25 cents per acre-application, but that company was unable to carry out its share of the contract. This price is undoubtedly too low for reliable service. The maximum charge, according to data available, was $1.00 per acre for one application only. This was required of farmers who did not enter into contracts when the services of the corporation were obtained, but who desired dust applied after the work started in the community. In both cases the farmers supplied the poison.

In general, the cost of dusting on cotton farms in Texas has been from 75 cents to $1.00 per acre-application, including the cost of poison. Three applications, which are usually necessary, would, at these rates, cost $2.25 to $3.00 per acre. An increase in production of 15 to 20 pounds of lint per acre, with cotton selling at 15 cents per pound, would pay for these applications.

CONCLUSIONS AND RECOMMENDATIONS

Commercial airplane dusting for boll weevil control as conducted in Texas has been successful in reducing the infestation and increasing cotton production, according to careful observations and detailed records made in connection with the work of three different corporations covering a period of two years.

One of the principles in controlling boll weevils by means of calcium arsenate dust is to make the applications every fifth day. In the application of dust by means of airplanes the same principle holds good and best results will be obtained where the intervals between applications do not exceed five days. When washed off by rain within 24 hours, the application should be repeated.

In cases where the infestation is high and a large acreage is to be covered, or where weather conditions have interfered with the proper application of poison, late-afternoon or evening dusting may be justified. Early-morning applications are to be preferred, however, as the atmospheric conditions are usually more favorable for flying and for distributing the poison.

An airplane that has a Venturi opening or nozzle is capable of distributing the dust more effectively than a plane not so equipped. According to the United States Bureau of Entomology, the Venturi is also a factor in producing an increased power of adherence in the calcium arsenate dust when it comes in contact with the cotton plants.

In this type of work it may be necessary for the pilot to make a forced landing in a cotton field and, therefore, the "split type" or "tripod" landing gear is an advantage. Considerable resistance would be offered by large cotton to the plane with an axle type of landing gear.

The height of flying depends on atmospheric conditions. A good dis-

tribution of poison can be obtained at heights of 5 to 25 feet above the cotton.

In the operations connected with airplane dusting time is a very important factor. The work is planned on a big scale and when anything occurs to upset the schedule, large areas are generally involved and suffer from boll weevil injury in proportion to the time lost.

The fact that an application is not delayed following rains is one of the big advantages in the use of airplanes for dusting cotton. At such times the rich alluvial soil of river bottom farms is in such condition that ground machinery cannot be used for several days.

Since a large amount of work can be done in a short time and since the cost of operation is heavy, all efforts should be directed toward speeding up the work after the planes arrive.

Supplies of gasoline and poison should be on hand. The airplane company should arrange for the gasoline and oil. Unless the airplane company agrees to supply poison, the farmer should have a sufficient quantity on hand to keep the work going. A crew of at least three men should take care of loading the poison and allow the pilot to rest or check over his motor before starting with the next load.

Those experienced in airplane dusting recognize that the proper method of making dust applications to cotton fields is to fly back and forth in parallel swaths 75 to 150 feet wide, letting the swaths or strips slightly overlap. Only an experienced pilot can make an application that will obtain the best results in boll weevil control. He should know the instant when to allow and when to shut off the flow of dust. If either of these acts is delayed or premature, then considerable poison will be wasted or a portion of the cotton will be left untreated. In order to avoid leaving any untreated cotton it is a good practice, in addition to "zooming," for the pilot to make an extra flight around the edges of the field.

It may be necessary, when distributing dust, for the pilot to fly along beside a pasture in which live stock are feeding. In such cases the stock should be removed to another pasture, if possible, or care should be taken to see that the animals do not graze for several days in the zone where the poison drifted. Several instances have occurred where cattle became sick as a result of arsenical poisoning, but recovered after being removed. One instance of poisoning occurred which resulted in the loss of two dairy cows.

It would be advisable for all companies undertaking airplane dusting for boll weevil control to employ a man whose business would be to go over the farm to be dusted and obtain records on the extent of the infestation. With a knowledge of the infestation at the beginning of dusting operations, the grower and the airplane company can intelligently plan the work to be done and, when the taking of infestation records is continued, can better keep in touch with what is actually being accomplished. Without such advice the number of applications may be insufficient to produce the best results or poison may be dis-

tributed on areas where it is not needed or possibly some infested areas may be entirely neglected.

The cotton growers should by all means become familiar with the approved method of determining the extent of the boll weevil infestation as previously described. A short time spent in making such a determination on his own farm at weekly intervals beginning the latter part of June or early in July will provide definite information on boll weevil conditions.

With the increasing desire of cotton growers for airplane application of dust to areas of medium size, it would appear advantageous for companies or corporations planning this type of business to have a local headquarters within an hour's flight of an area where the service is used. Extra parts and reserve equipment or personnel would be within easy reach, thus making it more economical for the handling of acreage of medium size. Such an arrangement might encourage many early requests for dust applications on cotton at the edge of woodlands, where the boll weevil infestation usually begins.

The question of obtaining airplanes for use in dusting cotton is limited to those communities where the acreage to be dusted or the number of acre-applications to be made is sufficient to justify the transfer of equipment and personnel from corporation headquarters to the seat of operations. When arrangements for airplane dusting can be made, it should prove profitable for the grower as well as the corporation where the boll weevil infestation averages 15 to 20 per cent with weather conditions favoring increase in weevil injury. These percentages apply particularly to conditions in Texas where hot, dry weather is not uncommon in summer. After the work has been begun, applications should be repeated at the proper intervals until the average infestation has been reduced to 15 per cent or less. The profits depend on the control obtained where the infestation would otherwise be high during the season, on soil conditions, on the size of the area dusted, on its proximity to corporation headquarters, and on the price which cotton may command.